Center for Independent Experts (CIE) External Independent Peer Review

Catch Estimation Methods Webinar

July 30, 2018

Dr. Noel Cadigan

Centre for Fisheries Ecosystems Research
Marine Institute of Memorial University of Newfoundland
St. John's, NL. Canada

Executive Summary

The SWFSC Catch Estimation team presented an extensive amount of results in response to the short-term requests arising from the methodology review panel (RP) during 28-29 March 2018. All requests were addressed except: *Request #8. Provide self-test documentation (simulated data) for example models*. Much improved model diagnostic plots were provided. However, I conclude that additional research is still required to

1. develop diagnostic plots to assess model bias; that is, if proposed models systematically under- of over-predict the data in some situations (e.g. strata);
2. to determine if and how additional two-way interactions terms (e.g. Species:Port and Species:Gear) should be included in the model;
3. data-based methods to assess the plausibility of CALCOM and model-based estimates of landings.
4. simulation test model-based catch estimates.

This research is required to demonstrate model robustness and reliability, and to demonstrate why estimates based on the new method are improvements over current data-borrowing estimates. Also, a model applied to more recent data may need further refinements and will need additional review.

A more appropriate multivariate statistical distribution should be used to model port-sampling data, and this could have impacts on model selection, catch estimation, and uncertainty evaluation.

Background

The National Marine Fisheries Service (NMFS) and the Pacific Fishery Management Council (PFMC) held a methodology review panel (RP) during 28-29 March, to evaluate and review a new methodology under development by the Southwest Fisheries Science Center (SWFSC) for partitioning landings reported as aggregated categories of fish into species-level estimates of landed catch. The new methodology proposed by the SWFSC scientists involved a hierarchical modelling approach to estimate the species composition of catches in un-sampled strata, and to quantify uncertainty in historical landings. The main focus of the peer review in March was to evaluate the efficacy of the new methodology as applied to California data, in light of the larger objective of whether or not to recommend that the method be used to revise historical catch estimates. The RP specified several short-term requests to the SWFSC Catch Estimation team. The one-day webinar on July 30 reviewed progress on these short-term requests.

Participation of an external, independent reviewer was considered to be an essential part of the technical review process of the proposed SWFSC methodology. I was specifically requested to participate in the Webinar because I had the requisite expertise and I am familiar with the methodology under development by the SWFSC Catch Estimation team (having served on the March 2018 Methodology RP). I was required to be an active and engaged participant throughout the webinar discussions and able to voice concerns, suggestions, and improvements while

respectfully interacting with the RP (which mostly had the same members as the March 2018 review) and the team.

The CIE reviewer was contracted to complete and deliver the following tasks:

1. Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

2. Participate during the methodology review webinar and conduct an independent peer review in accordance with the ToRs (Annex 2).

3. Contribute to and participate in the finalization of a report of the methodology review that will be prepared by the Panel Chair.

4. The CIE reviewer shall submit an independent peer review report addressed to contractor. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Role of reviewer

Reports were provided by Mr. John DeVore on July 18, 2018, which I reviewed prior to the July 30 webinar. These reports were made available via an ftp site provided by the Pacific Fishery Management Council. These documents are listed in Appendix 1. I participated in the webinar. I recorded important results and conclusions during the meeting and provided these notes to the meeting chairperson for consideration in developing the webinar review panel report, which was unavailable before this CIE peer review report was due.

This report is structured according to my interpretation of the required format and content described in Annex 1 of Appendix 2.

Summary of findings

***Request #1**. As a diagnostic template, for each sampled stratum compare the posterior predictive distributions at the 68th, 95th, and 99th percentiles with the current observed species proportions (create fully stratified versions of tables 2 and 3 in the Grunloh et al. methods documentation). With each row, include sample sizes and associated landing weights with a graphical display to highlight problems and outliers (circle size proportional to landing weights).*

These diagnostic plots were provided for the 68th and 95th percentiles. It was not explained why the 99th percentile diagnostics were not provided, although I presume this was because the team felt they had little diagnostic value. Various levels of aggregation were used in producing these plots. The most dis-aggregated plots were for each species, port, gear, year, and quarter. These were what the RP requested in the March review, although they were difficult to interpret because of the often

small samples sizes at this high level of stratification. On their own these diagnostics plots may not be useful for assessing model fit and possible mis-specification, but these plots could be useful in "drill-down" exercises to help understand possible lack of fit in higher aggregated diagnostic plots, such as those also provided by the SWFSC team: species-gear-year, species-year, and just species or port or gear or year or quarter.

The team also provided MAD (Mean Absolute Deviation) diagnostics of model predictive accuracy, which was the absolute difference in the fraction of observed species counts within the model prediction intervals minus the nominal level of prediction intervals. The diagnostics were weighted by the size of the landings in the strata.

The posterior predictive distribution plots and MAD diagnostic plots were also provided to compare multiple models (e.g. different treatments of year-quarter interaction terms) using different plotting colors for each model in the figures.

I conclude that this request from the March RP was addressed satisfactorily. However, I did not find that the diagnostic plots were very helpful for detecting if there were serious model mis-specifications for some parts of the data. This aspect of statistical inference (i.e. model diagnostics plots) is often difficult and I usually look at many types of diagnostic plots when I try to convince myself that my model is well specified. The diagnostic plots provided by the team were focused on prediction interval accuracy. I agree that this is an important aspect of the model fit to investigate. However, an issue that the diagnostics provided by the SWFSC team do not provide direct information on is model bias, which will be a concern for anyone wishing to use the results of the catch estimation model. I suggest that some type of diagnostic plot be developed to assess if proposed models systematically under- of over-predict the data in some situations (e.g. strata). This may indicate important model mis-specification.

Request #2. The diagnostic template should be developed for each of the sensitivity runs (vary across a range of plausible time models and priors and limit to the top 2-3 market categories)

The SWFSC team did this, and I found the model comparison plots using different colors for different models very useful. For many species, there does not seem to be much model sensitivity (estimates or uncertainty intervals) in catch predictions. However, for species with very sparse data there could be model sensitivity in catch estimates.

The team provided sensitivity analyses for several choices of priors on the M4 time random effect variance parameter. The priors did not have much effect on catch estimates or prediction intervals when there was enough data.

Request #3. Explore an alternative time block: an extension of 1983 and 1984 to the first time block

The team addressed this request by showing diagnostic plots for a particular model formulation (M4) and then applied it to data for three time periods: 1978-82, 1978-83, and 1978-84. The M4 model was chosen as it usually resulted in a low values of DIC and WAIC for various market

categories. The model results seemed fairly insensitive to these choices of time blocks, although there were some indications that prediction accuracy increased as the length of the time block increased, which I did not understand. The MAD summary diagnostics did not seem comparable for the different time blocks, possibly because the data set changes in each block. Similarly, the DIC and WAIC fit statistics are not comparable for different data sets, which is well known.

The rationale for this request was so that the RP could assess how well the modelling approach may perform when applied to shorter time periods, as will occur when the model is used with data more recent than 1990. The additional results provided by the SWFSC team for the webinar did not completely address this issue. I conclude that a model applied to more recent data may need further refinements and will need additional review.

Request #4. Explore various two-way interactions (beyond the current explorations; e.g., Species:Port and Species:Gear)

The team explored models with the inclusion of species:port and species:gear interaction terms. This was through the comparison of model fit statistics (i.e. DIC and WAIC), diagnostic plots, and comparisons of landings estimates from M4 models with and without these interactions terms. The team concluded that Species:Gear and Species:Port interactions may be appropriate, and the strength of the dependence seemed to depend on market category. In future research they indicated they will explore methods to include both interactions with species and ports and gears. The interaction analyses seemed "preliminary", and I conclude that this is still a useful area for additional research.

Request #5. Redo the modeling of the early time block without southern CA ports. Explore spatially and temporally (i.e., alternative time blocks)

This was done. Most results presented at the webinar were based on models that only included ports north of point conception because of the lack of sample data in the early time block from the southern California ports.

Request #6. Compare alternative ComX outputs and the current time series of estimated catches.

The team developed expanded landings estimates (by year and by year:gear) from the early time period, summing across market categories 250, 253, and 269. This was done for various model formulations, and helpful comparisons of landings estimates for different model formulations were shown on the same plot using different colors. Often the CALCOM landings values were within the model prediction intervals, but not always. It was difficult for the RP to conclude if this was a good thing or not. The team indicated that they will further explore some alternative and purely data-based estimation of landings for some strata aggregations as another strategy to assess the plausibility of CALCOM and model-based estimates of landings. I conclude that this will be useful future research.

Request #7. Provide a summary table of species' sample sizes in each market category by time block.

These tables were provided for market categories 250, 253, and flatfish and elasmobranches. The tables were informative about the sparseness of sample data for some species and time blocks.

Request #8. Provide self-test documentation (simulated data) for example models.

The team did not provide this information.

Other Issues

Alternative and perhaps more appropriate statistical models for the port-sampling data are beta-regression and Dirichlet-regression models in which the species-fraction of total sampled weight is modelled rather than modelling the integer weights using a counting process, which is an unusual way to model such data. The proposed Beta-Binomial catch estimation model treated each species sample integer catch-weight as independent Beta-Binomial random variables. Even if we conclude that a counting process is appropriate for these data, modelling them as independent random variables is not strictly appropriate because it does not explicitly account for the negative correlations in the data that are caused by the fixed-sized sampling constraint (i.e. two 50 pound cluster samples). For the combined samples, the sum of all species catch weights must be 100 pounds and therefore the catch weight of a particular species must be negatively correlated with the catch weight of at least some other species. I think an important consequence of not using a more appropriate multivariate distribution is less reliable goodness-of-fit (or model selection) statistics (e.g. DIC or WAIC). I demonstrated this for the AIC statistic in my CIE report for the March review panel.

Conclusions and Recommendations

Request #1. As a diagnostic template, for each sampled stratum compare the posterior predictive distributions at the 68th, 95th, and 99th percentiles with the current observed species proportions (create fully stratified versions of tables 2 and 3 in the Grunloh et al. methods documentation). With each row, include sample sizes and associated landing weights with a graphical display to highlight problems and outliers (circle size proportional to landing weights).

This request from the March RP was addressed satisfactorily. However, I did not find that the diagnostic plots were very helpful for detecting if there were serious model mis-specifications for some parts of the data. I suggest that some type of diagnostic plot be developed to assess if proposed models systematically under- of over-predict the data in some situations (e.g. strata).

Request #2. The diagnostic template should be developed for each of the sensitivity runs (vary across a range of plausible time models and priors and limit to the top 2-3 market categories)

This request was addressed satisfactorily.

Request #3. Explore an alternative time block: an extension of 1983 and 1984 to the first time block

This request was addressed by showing diagnostic plots for a particular model formulation (M4) when applied to data for three time periods: 1978-82, 1978-83, and 1978-84. The model results seemed fairly insensitive to these choices of time blocks. However, I conclude that a model applied to more recent data may need further refinements and will need additional review.

Request #4. ***Explore various two-way interactions (beyond the current explorations; e.g., Species:Port and Species:Gear)***

Some analyses were provided on models with these interaction terms which indicated that these terms are useful to include. However, I conclude that this is still a useful area for additional research.

Request #5. ***Redo the modeling of the early time block without southern CA ports. Explore spatially and temporally (i.e., alternative time blocks)***

This request was addressed satisfactorily.

Request #6. ***Compare alternative ComX outputs and the current time series of estimated catches***

This request was addressed. Often the CALCOM landings values were within the model prediction intervals, but not always. It was difficult for the RP to conclude if this was a good thing or not. Further research is required on methods to assess the plausibility of CALCOM and model-based estimates of landings.

Request #7. ***Provide a summary table of species' sample sizes in each market category by time block***

This request was addressed satisfactorily.

Request #8. ***Provide self-test documentation (simulated data) for example models***

This request was not addressed.

Other Issues

A more appropriate multivariate statistical distribution should be used to model port-sampling data, and this could have impacts on model selection, catch estimation, and uncertainty evaluation.

Appendix 1: Bibliography of materials provided for review

Methodology Review Panel Report: Catch Estimation Methodology Review. National Marine Fisheries Service (NMFS), Southwest Fisheries Science Center (SWFSC), Santa Cruz, California. 28-29 March 2018.

Improving Catch Estimation Methods in Sparsely Sampled, Mixed Stock Fisheries. N Grunloh, E.J. Dick, D. Pearson, J. Field, M. Mangel. Presentation slides.

Center for Independent Experts (CIE) External Independent Peer Review. Independent Peer Review of Catch Estimation Methods in Sparsely Sampled Mixed Stock Fisheries. March 28-29, 2018. Dr. N. Cadigan.

Panel.sampledata.mcs650to999.xlsx

Panel.sampledata.mcs245to271.xlsx

Panel.sampdata.flatfish.skates.xlsx

Appendix 2: CIE Statement of Work

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

Catch Estimation Methods in Sparsely Sampled Mixed Stock Fisheries Review Supplement

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[1]. Further information on the Center for Independent Experts (CIE) program may be obtained from www.ciereviews.org.

Scope

During 28-29 March 2018 in Santa Cruz, CA the National Marine Fisheries Service and the Pacific Fishery Management Council convened a methodology review panel to review and evaluate a new methodology under development by the Southwest Fisheries Science Center (SWFSC) for partitioning landings reported as aggregated categories of fish into species-level estimates of landed catch. Dr. Noel Cadigan served as an external reviewer on the methodology review panel, which specified several short-term requests to the SWFSC Catch Estimation team. The one-day webinar will follow-up on these short-term requests to the SWFSC team, which are included below in the "Terms of Reference for the supplemental peer review".

Requirements

NMFS requires Dr. Noel Cadigan to prepare for and participate in a one-day webinar aimed at addressing the short-term requests prepared during the March 2018 Catch Estimation Methodology Review Panel. Dr. Cadigan's specific participation is crucial to this webinar for the following reasons: he has the requisite expertise and he is familiar with the methodology under development by the SWFSC Catch Estimation team (having served on the March 2018 Methodology Review Panel). Bringing in a new reviewer at this time would entail considerable extra time and effort to familiarize him/her with the SWFSC's new methodology. The CIE reviewer shall be an active and engaged participant throughout the webinar discussions and able to voice concerns, suggestions, and improvements while respectfully interacting with the Review Panel (which will have the same members as the March 2018 review) and the team.

Tasks for reviewers

This CIE reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein:

List task(s)/assignment(s) that will be expected of Dr. Cadigan.

1. Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2. Participate during the methodology review webinar and conduct an independent peer review in accordance with the ToRs (Annex 2).
3. Contribute to and participate in the finalization of a report of the methodology review that will be prepared by the Panel Chair.
4. The CIE reviewer shall submit an independent peer review report addressed to contractor. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Place of Performance

The CIE reviewer is participating in a webinar, therefore no travel is required.
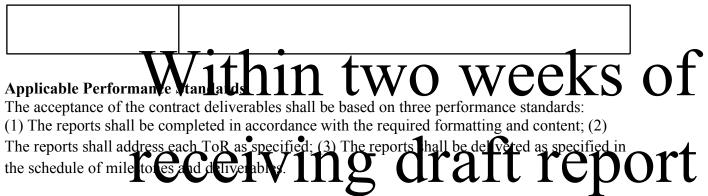
Period of Performance

The period of performance shall be from the time of award through September 2018. The reviewer's duties shall not exceed **5** 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.

Within two weeks of award	Contractor confirms reviewer participation
Within three weeks of award	Contractor provides background documents to the reviewer

July 31 2018	Reviewer participates in the webinar
Within two weeks after webinar	Contractor receives draft report

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

Since this is a desk review travel is neither required nor authorized for this contract.

Restricted or Limited Use of Data

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

NMFS Project Contact

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Annex 1: Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of
   the findings and recommendations, and specify whether or not the science reviewed is the
   best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the

Individual Reviewer's Role 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.

3. The reviewer's report shall include the following appendices:
   a. Appendix 1: Bibliography of the background materials provided for review
   b. Appendix 2: A copy of the CIE Performance Work Statement

Annex 2: Terms of Reference for the supplemental peer review

Catch Estimation Methods in Sparsely Sampled Mixed Stock Fisheries Review Supplement

The following tasks were identified as Short-term requests to the SWFSC Catch Estimation team during the March 2018 Catch Estimation Methodology Review. Members of the team will present all available responses to these requests at a one-day webinar during July-August 2018. Dr. Cadigan is requested to comment on the extent to which the team provides satisfactory responses to these items and suggest how the team could further advance their proposed methodology.

Request #1. As a diagnostic template, for each sampled stratum compare the posterior predictive distributions at the 68th, 95th, and 99th percentiles with the current observed species proportions (create fully stratified versions of tables 2 and 3 in the Grunloh et al. methods documentation). With each row, include sample sizes and associated landing weights with a graphical display to highlight problems and outliers (circle size proportional to landing weights).

Rationale: The Team provided broad-scale summary metrics (e.g., MSE and DIC) for evaluating the goodness-of-fit of the different model forms and structures. Fine-scale diagnostics are needed to help identify aspects of the data that are not adequately addressed by the different models. The diagnostic template will provide a mechanism for fine-scale exploration of goodness-of-fit.

Request #2. The diagnostic template should be developed for each of the sensitivity runs (vary across a range of plausible time models and priors and limit to the top 2-3 market categories).

Rationale: Application of the diagnostics across a wide range of models will form a test of how well the diagnostics illustrate whether the models capture important structural features that are thought to be embedded in the data.

Request #3. Explore an alternative time block: an extension of 1983 and 1984 to the first time block.

Rationale: The panel expressed concerns about how the model would perform when applied to shorter time periods, as will occur when the model is used with data more recent than 1990.

Results from the above recommendation could be compared to the results from the current two time blocks (1978-1982; 1983-1990) to explore how fits to data from the late period degrade when the model for the late period is based on fewer years of data. Also, comparisons of the two forms of blocking serve as a sensitivity evaluation of the selection of the block boundary, which was chosen on a fairly arbitrary basis.

Request #4. Explore various two-way interactions (beyond the current explorations; e.g., Species:Port and Species:Gear).

Rationale: The Team did not have time to search across the multitude of possible interaction terms that they could have included in the model. From various anecdotal comments made during the review it seemed likely that the model would benefit from the inclusion of other interaction terms. Explorations with the diagnostic template may suggest potentially beneficial terms.

Request #5. Redo the modeling of the early time block without southern CA ports. Explore spatially and temporally (i.e., alternative time blocks).

Rationale: The available dataset does not have any sample data in the early time block from the southern CA ports. It was unclear how this lack of data influenced the model results. The requested analysis will clarify the situation.

Request #6. Compare alternative ComX outputs and the current time series of estimated catches.

Rationale: It would be informative to see the landings estimates corresponding to the additional models developed in response to the above requests. The landings estimates can be generated for a small set of illustrative species and do not need to be comprehensive.

Request #7. Provide a summary table of species' sample sizes in each market category by time block.

Rationale: The requested information will assist in understanding where there are gaps in the available data that the model is filling in by means of its pooling structure.

Request #8. Provide self-test documentation (simulated data) for example models.

Rationale: Results from this analysis will provide a demonstration of model performance under best-case scenarios, where the data being analyzed exactly conform to the assumptions of the statistical model. The analysis will serve to verify (or refute) that the model performs as expected.

Supplemental Catch Estimation Methodology Review

Pacific Fishery Management Council
Large Conference Room
7700 N.E. Ambassador Place, Suite 101
Portland, OR 97220
Online Webinar
Telephone: 503-820-2280
July 31, 2018

This is a meeting of a Pacific Fishery Management Council-sponsored methodology review with remote attendance via webinar (see webinar information below). There will also be a public listening station at the Pacific Council office (address listed above). This meeting is open to the public and public comments will be accepted at the discretion of the Chair.

A suggestion for the amount of time each agenda item should take is provided. All times are approximate and subject to change. At the time the agenda is approved, priorities can be set and these times revised. Discussion leaders should determine whether more or less time is required, and request the agenda be amended.

To Attend the GoToWebinar:

1. Use this link: https://www.gotomeeting.com/webinar
2. Click "Join a Webinar" in the top right of page.
3. Enter the Webinar ID: 531-002-459
4. Please enter your name and email address (required)
5. You must use your telephone for the audio portion of the meeting by dialing this TOLL number 1-914-614-3221
6. Enter the Attendee phone audio access code 953-706-939
7. Enter your audio phone pin (shown on screen after joining the webinar)

System Requirements

- PC-based attendees: Required: Windows® 7, Vista, or XP
- Mac®-based attendees: Required: Mac OS® X 10.5 or newer
- Mobile attendees: Required: iPhone®, iPad®, Android™ phone or Android tablet (See the GoToMeeting Webinar Apps)

TUESDAY, July 31, 2018 – 8:30 A.M.

A. Call to Order
1. Call to Order and Introductions   Dave Sampson, Panel Chair
2. Approve Agenda
3. Rapporteur Assignments
4. Summary of March Review   Dave Sampson

4. Review Terms of Reference   Dave Sampson
   (8:30 a.m., 0.5 hours)

B. *Presentation of Diagnostic Templates*
   1. Diagnostics for Each of the Sensitivity Runs
      (Requests 1 and 2) [1]   Nick Grunloh and E.J. Dick
   2. Discussion
      (9 a.m., 0.75 hours)

C. *Presentation of Summary Tables of Sample Sizes in Each Market Category by Time Block*
   1. Summary Tables Presentation (Request 7) [a]   Don Pearson and John Field
   2. Discussion
      (10:15 a.m., 0.25 hours)

Break (10:30 a.m., 0.25 hours)

D. *Exploration of Alternative Time Blocks*
   1. Revised Modelling of the Early Time Block Without
      Southern California Ports (Requests 3 and 5) [a]   Nick Grunloh and E.J. Dick
   2. Discussion
      (10:45 a.m., 1.25 hours)

Lunch (12 p.m., 1 hour)

E. *Exploration of Various Two-Way Interactions Beyond the Previous Explorations*
   1. Two-Way Interactions (e.g., Species:Port, Species:Gear)
      (Request 4) [a]   Nick Grunloh and E.J. Dick
   2. Discussion
      (1 p.m., 1 hour)

F. *Compare Alternative ComX Outputs and the Current Time Series of Estimated Catches*
   1. Comparison of Outputs (Request 6) [a]   Nick Grunloh and E.J. Dick
   2. Discussion
      (2 p.m., 1 hour)

Break (3 p.m., 0.25 hours)

G. *Example of Simulation Self-Test from Past Work*
   1. If Possible, Provide a Simple Example (Request 8) [a]   Nick Grunloh and E.J. Dick
   2. Discussion
      (3:15 p.m., 0.75 hours)

H. *Panel Discussion*
      (4 p.m., 1 hour)

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[1] The request numbers in the topics refer to the numbered list of requests specified in the terms of reference for the supplemental methodology review.

ADJOURN

PFMC
07/18/18