Independent peer review report on "A predictive model of discarded catch that leverages self-reporting and electronic monitoring on commercial fishing vessels"

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Center for Independent Experts

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Executive Summary

Activities

A predictive model for Northeast multispecies groundfish fishery discarded catch was reviewed by a Center for Independent Experts (CIE) review panel. The working paper title is "A predictive model of discarded catch that leverages self-reporting and electronic monitoring on commercial fishing vessels". Each reviewer in the panel was expected to produce an independent review on the statistical analyses used to address the objectives of providing reasonably accurate and precise estimation of groundfish discards on Electronic Monitoring (EM) vessels and comment on the uncertainty sources in the analysis. The modelling framework after peer review is expected to be used for determining the minimum review rate of groundfish EM program in the future. Some pre-review background documents were provided before the review (listed in Appendix 1). The review was a desk review and the reviewers participated a webinar on September 9, 2021, arranged by the National Marine Fisheries Service (NMFS) project contacts Dr. Daniel Linden and Dr. Michael Lanning. The working paper done by Dr. Daniel Linden from Greater Atlantic Regional Fisheries Office (GARFO) was briefly discussed with the review panel during the webinar. I then prepared this review report based on the working paper provided, the webinar discussion, and the Performance Work Statement (Appendix 2).

Main review processes and findings

The models developed in the working paper are based on a new EM program for Northeast multispecies fishery, and the EM program provides opportunities to evaluate the reliability and accountability of catch reporting in the multispecies fishery. The work aims to estimate discards based on the Vessel Trip Reports (VTR) self-reported data by estimating the relationship between EM observations and VTR reported discards, and to evaluate the precision and accuracy of the estimated discards based on VTR data given alternative EM review rates (Linden 2021). The applied models and simulation framework provide the tools for the EM data to be used as a calibration to estimate discards based on the VTR self-reported discards.

The study is based on a 4-year EM program from 2017-2020 in the Northeast multispecies groundfish fishery. Twelve groundfish species from four types of gears were considered in this study. The four types of gears are otter trawl, sink gillnet, bottom longline, and handline. There are some concerns in the modelling, mainly arising from the factors considered in the discard models, the error structure, and the model structure used. I find that the modelling framework can be used for setting review rates and estimating discards for groundfish vessels in the future.

Given the data available and the modelling framework developed by Dr. Linden, I support the framework as the best available science to be used for EM review rate for discard estimation consideration.

Main recommendations

Below I list the major recommendations that may improve the existing modelling and statistical analyses in estimating discard based on EM data and the VTR self-reported discard data, and in recommending the percentage review rate in EM.

- The existing three models used to describe the relationships between EM discards and VTR discards considered year, species, and vessel effects. It's unclear why some effects are considered in the intercept or the slope but not the others. A model selection process may be provided to address the effects being used in the generalized linear mixed effect models.

- The existing three models may consider factors such as fishing season, gear type used, potential species misreporting, and species correlation based on the data patterns observed in the figures of discards over time in a year and discards of each vessel. A model selection procedure that considers these potential effects should improve discards modelling, public communication, and fisheries management.

- I suggest that the observations of commissions, i.e., trips with VTR reported discard >0 but EM observed discard = 0, be explored in the future. It may be worthwhile to look at species with similar morphology to see whether these observations are because of misreporting or species misidentification.

- Alternative model error structures, such as lognormal, may be considered since the discards data are measured in pounds not in numbers. The Poisson probability distribution has been found to have limitations in capturing overdispersion in count data (Hougaard et al. 1997).

- Multivariate models based on species may be considered so that effects that are common to each species and those only to some species can be modelled well, and the levels of uncertainty to each species can be considered as well (Hadfield 2010; Park and Beretvas 2020). It would be nice to explore whether such alternative model structures can decrease discard estimation bias and CV under the same % of EM review rate.

1. BACKGROUND

The working paper "A predictive model of discarded catch that leverages self-reporting and electronic monitoring on commercial fishing vessels" was reviewed by a CIE review panel. Each reviewer in the panel was expected to review the models and analyses in the working paper and provide an independent peer review on the statistical analyses used to address the objectives of providing reasonably accurate and precise estimations of groundfish discards on Electronic Monitoring (EM) vessels and comment on the uncertainty sources in the analysis. The modelling framework after peer review is expected to be used for determining the minimum review rate of the groundfish EM program in the future, and may be used by the New England Fishery Management Council (NEFMC) and other interested persons for developing discard monitoring and estimation programs. The review was a desk review and the reviewers participated in a webinar on Sept 9, 2021, arranged by the NMFS project contacts Dr. Daniel Linden and Dr. Michael Lanning. The review panel members include Drs. Joseph Powers, Coby Needle, and Yan Jiao (me).

According to the Performance Work Statement (PWS) scope description, "… Given the implications of this new monitoring approach, it is important that the methods represent the best available science and are statistically sound. Therefore, the CIE reviewers will conduct a peer review of the statistical modelling based on the Terms of Reference (TORs) referenced below. Given the public interest, it will be important for NMFS to have a transparent and independent review process of the model used in this assessment." Also, in the Background "… 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." As a review panel member, I was provided with pre-review background documents (Appendix 1) and a draft working paper before the webinar and participated in the webinar Meeting on Sept 9. During the webinar, the working paper author Dr. Daniel Linden from GARFO shortly explained his work and discussed some questions with the review panel.

As a CIE reviewer, my duty was to evaluate the models and statistical analysis used in the working paper with respect to the TORs (in Appendix 2). This report provides the findings and recommendations of the independent review that was undertaken by me in accordance with the CIE PWS.

2. ROLE OF INDIVIDUAL REVIEWER

My role as a CIE independent reviewer was to conduct an impartial and independent peer review in accordance with the PWS and the predefined TORs herein.

The pre-review background materials and the working paper were made available to the review panel before the scheduled webinar. I read all the documents that I received prior to the webinar. The review was a desk review, and no travel was required. During the webinar, Dr. Linden briefly introduced the working paper, and the panel asked some

background questions and questions on the models for clarification. I was able to ask questions for clarification on the data usage and model development.

This report reflects my summarized findings and recommendations according to the predefined TORs. This review report is formatted according to my interpretation of the required format and content described in Appendix 2.

3. SUMMARY OF FINDINGS RELATIVE TO TORs

The working paper aims to estimate total discard by leveraging self-reported discard from Vessel Trip Reports (VTR) with the electronic monitored discard and by treating the EM discards as true discards. The study is based on a 4-year EM program from 2017-2020 in the Northeast multispecies groundfish fishery. 12 groundfish species from 4 types of fishing gears were considered in this study. Discard monitoring and estimation influence the quality of the catch estimation, which further influences stock assessment quality and fisheries management. The product is not to estimate discard using EM system but to evaluate the relationships between EM observed discard with the self-reported discard and to explore the relative precision and accuracy given alternative EM review rate. This modelling framework can be used for setting EM review rates and estimating accurate discards for groundfish vessels in the future.

Below I provide the summary of findings for the discarded catch predictive model, in which the weaknesses and strengths are described in accordance with the TORs.

3.1. Do the statistical analyses address the objectives of providing reasonably accurate and precise estimation of groundfish discards on EM vessels?

Yes, with caveats. The data included and models used were well documented. The overall framework is appropriate for recommending a review rate to meet the Northeast Multispecies FMP objectives and goals but balance the cost to the industry and NMFS.

The model selection process may be improved to better estimate the discard based on the VTR data. It is unclear why year and/or species effects are considered in the intercepts of the submodels but vessel effect is considered in the slope of the submodels. The models described in the text do not seem to match the model results in the appendix. For example, the species effect is treated as random in the intercepts in all the three models and the vessel effect is considered as a random effect in all the slopes of the models, but results are not shown in Supplementary 1. The year effect reported in the results of Supplementary 1 is a bit confusing also.

a. Are the statistical models adequately described?

Yes, with caveats. Three models were developed or included in the working paper and they are the Gamma hurdle model (GHM), zero-inflated Poisson model (ZIP), and a simpler Poisson regression model (PM). The Poisson regression model

performed the best based on the model selection criteria used in the working paper, i.e., Bayesian R^2 and Leave-one-out (LOO) adjusted R^2. Some other widely used Bayesian model comparison criteria may also be used in performance comparison, such as DIC and WAIC (Gelman et al 2014a, 2014b; Hooten and Hobbs 2015).

Some descriptions in the text may be enhanced with further details. For example, it said, "we tested 2 formulations of the Poisson discard model:…". I assume that in both cases the slope of the model is with vessel effect. Also, the complexity on the slopes of the three models were not explored and compared as done for the intercepts, but no explanation was provided. Since here two Poisson regression models are described in the cross validation simulation section, it would be better to provide model fit measurement in Table 3 for both Poisson models.

b. Do the statistical models adequately fit the data?

Yes, with caveats. The observations of omissions and commissions seem not well fitted, however, because these observations are on low discard observations, they may not play an important role when evaluating the review rate based on bias and CV of the total discard. A couple of species, such as FLDAB (American plaice) and FLGS (witch flounder), are always with negative bias while HADD (haddock) always has a positive bias. These are among the species with high discards. Also, figures 4, 5 and 6, which are about the model fitting, are not cited and described in the text.

c. Is the complexity of the statistical models justified?

Yes, with caveats. The models used the discard self-reported from VTR as the independent variable and EM observed discard as the dependent variable. The GHM and ZIP considered year and species as random effects for the intercept of the probability equation but only considered species for the positive catch equation. The slopes of all the submodels and models only considered the vessel as a random effect. It would be nice to have a model selection procedure to address questions such as why the fishing season is not considered, why the random effect considered in the intercept and the slopes of the regression models are not the same. A modelling process that starts from simple models and moves to alternative complex models will make the recommended model more convincing.

d. Are there alternative models that would be preferable in terms of estimation performance and computational efficiency?

Based on the figure that shows the cumulative discard data pattern across days and species (Figure 1), I recommend that the fishing seasonal pattern be considered in the model before disregarding it. I also suggest that the gear effect be considered before ignoring it (Figure 3). The EM program is from multiple types of gears including trawl, longline, handline, and gillnet. It should be worthwhile to look at gear effect when estimating discard based on the VTR reported discard and when recommending EM video review rate. Again, a more rigorous model selection

process would not just consider the discard data probability distributions but also the variables or factors that may matter in the “true” discard.

Alternative error distributions may be considered since the discards are reported in pounds, not in the number of fishes. The dispersion of the Poisson distribution may be limited unless overdispersion is considered in the modelling (Hougaard et al. 1997). I also wonder about the influence of using posterior median instead of posterior mean when discard observation values are small when using a Poisson distribution, which is the recommended model in the working plan.

3.2. Have the sources of uncertainty and caveats in the analyses been adequately described? Given the objectives and the performance of presented models, are there additional potential sources of uncertainty that can be quantified and should be incorporated?

Yes, this TOR was addressed adequately in general, although further exploration and documentation are suggested.

The working paper addressed VTR self-reported discard uncertainty by linking it to the EM observations. The model selection uncertainty was based on Bayesian R^2 and LOO adjusted R^2. However, the question of how the variables with fixed and random effects were selected should be addressed and a variable selection process should be provided to better address model selection uncertainty. The uncertainty on commissions, i.e., trips with VTR reported discard >0 but EM observed discard = 0, needs to be explored in the future. For example, is it possible to look at the species with similar morphology to see whether commissions occur because of species misreporting? Such work may also be addressed through a multi-variate generalized linear model in which species with misspecifications may show negative correlations in covariance.

Given the objectives and the performance of the presented models, the working paper successfully leverages discards from VTR and EM records, developed a simulation framework to demonstrate the bias and CV changes given 10% to 50% EM review rates. It also successfully shows that the Poisson simple model with only a species random intercept effect decreased the bias comparing with the VTR estimates without the model under the same % of EM review rate. I suggest that further exploration on the discards of the species that are always biased positively or negatively, and the discards with strong seasonal patterns. Some of the vessels have much lower discards, which may occur because such vessels were using different gears comparing with the vessels with extremely high discards. By including such considerations, the % rate that needs to be reviewed may be further decreased to meet the FMP objectives and goals, and the systematic bias may disappear.

4. CONCLUSIONS AND RECOMMENDATIONS RELATIVE TO TORs

I support the modelling and simulation framework used in the working paper to reach the program objectives and goals. I suggest considering further explorations on the potential predictors and effects, alternative probability distributions, and potential model structure variations. Below I organize my conclusions and recommendations based on the two TORs.

Recommendations based on TOR 1:

The statistical analyses addressed the objectives stated in the working paper. Its cross-validation simulation analysis provides the needed framework and results to recommend the appropriate % of review rate in EM monitoring program that meets the intended goals and objectives of Amendment 23 of Northeast Multispecies FMP.

The statistical models are described well but a model selection process should be considered to address whether effects from the season, gear, alternative probability distributions, and alternative model structure better fit the data and decrease the bias when estimating discard based on a % of EM review rate and the VTR reported discard. The observations of commissions need to be further considered as to the reasons for such phenomena and potential models to address them.

I suggest multivariate generalized linear models be considered as an alternative model structure if species discard reporting may not be fully independent among species (Hadfield 2010; Bürkner 2017; Park and Beretvas 2020). I also suggest that probability distributions such as lognormal may be considered since the discards are in pounds and not count data while the dispersion of Poisson distribution may not be large enough.

I also suggest that season and gear may be considered in the model construction since the discards of different species shown different seasonal patterns. Some vessels have very low discards which may be because of the gears used. The working papers did not show the gear-specific discards but rather showed the vessel-specific discards. Further details on the gear specific species-specific discard should help to understand the gear effect on the discards.

Recommendations based on TOR2:

I suggest that the model selection uncertainty be addressed not only based on Bayesian R^2 and LOO adjusted R^2 with the selected effects, species, year, and vessel, but also should address how the variables with fixed and random effects were selected. A variable selection process should be provided to address model selection uncertainty.

I suggest that the observations of commissions, i.e., trips with VTR reported discard is >0 but EM observed discard = 0, be explored in the future. It may be worthwhile to look at the species with similar morphology to explore whether these observations occur because of misreporting or species misidentification.

I also suggest that further exploration on the discards of the species that are always biased positively or negatively, the discards with strong seasonable patterns, and the discards from a possible gear effect. Some of the vessels have much lower discards, which could occur because such vessels were using different gears comparing with the vessels with extremely high discards. By including such considerations, the % rate needs to be reviewed may be further decreased to meet the FMP objectives and goals, and the systematic bias may disappear.

5. ACKNOWLEDGMENTS

I would like to thank the coordinator and working paper author Dr. Daniel Linden, and the other reviewers, Drs. Joseph Powers and Coby Needle, for their respectful and productive discussions during the webinar.

6. REFERENCES

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Park, S. and Beretvas, S.N. 2020. The multivariate multiple-membership random-effect model: An introduction and evaluation. Behavior Research Methods. 52:1254-1270.

Appendix 1: Bibliography of materials provided for review

Document of the model for review:

Linden, D.W. 2021. A predictive model of discarded catch that leverages self-reporting and electronic monitoring on commercial fishing vessels. *Working paper*

Pre-review *Background documents:*

Thorson, J.T. 2018. Three problems with the conventional delta-model for biomass sampling data, and a computationally efficient alternative. Canadian Journal of Fisheries and Aquatic Sciences, 75(9), 1369-1382.

Venables, W.N., & Dichmont, C.M. 2004. GLMs, GAMs and GLMMs: an overview of theory for applications in fisheries research. Fisheries research, 70(2-3), 319-337.

Appendix 2

Performance Work Statement

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

A predictive model of discarded catch that leverages self-reporting and electronic monitoring on commercial fishing vessels

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

Estimation of total catch in a commercial fishery is important for stock assessment and effective management decision-making, as dictated by the Magnuson-Stevens Act. A primary challenge of catch estimation lies in the largely unknown portion of catch that is discarded at sea rather than retained. Catch can be discarded for multiple reasons related to regulatory compliance (e.g., species and/or size retention prohibited) and non-compliance (e.g., illegal actions incentivized by quota limitations). While the retained portion is recorded by multiple information streams, discard estimation typically relies on a sampling of trips that carry a human at-sea observer. Low sampling rates may still achieve adequate precision (e.g., coefficients of variation < 30%) but rely on a random selection to ensure a representative sample, as with any survey design. In the absence of representative samples, estimators of discarded catch will be biased.

Amendment 23 of the Northeast Multispecies (i.e., groundfish) Fishery Management Plan (FMP) seeks to improve the reliability and accountability of catch reporting in the commercial groundfish industry. Justification for the amendment came from evidence that current monitoring approaches fail to

[1] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2005/m05-03.pdf

adequately ensure compliance with regulations and may incentivize behavior that degrades the accuracy of catch estimation; evidence included differences in vessel fishing activity related to the presence/absence of a human observer on a given trip (i.e., observer bias). The proposed solutions involve increased and/or enhanced monitoring that maximizes the value of collected information while minimizing costs to the industry and NMFS. Electronic monitoring (EM) systems provide opportunities for unbiased estimation of catch by combining 100% video surveillance of vessel fishing effort with a random selection of video reviewing, removing the opportunity for observer bias. Pilot programs in the Northeast have suggested that consistent catch handling and self-reporting by vessels can allow for low (~20%) video review rates, enabling a framework of monitoring that achieves the intended goals and objectives of Amendment 23.

Here, we illustrate a modeling approach that leverages Vessel Trip Reports (VTRs) with EM video review to generate accurate estimation of groundfish discards on EM vessels. We fit and compared multiple generalized linear mixed and delta/hurdle models to estimate the relationship between EM-reviewed discards and VTR-reported discards, E(EM) ~ f(VTR + …). The models accommodated nuances of the data (e.g., zero inflation) and variation according to groundfish species, vessel/trip attributes, and changes in data availability during the fishing season. We used data from 2017–2021 on EM trips that were fully reviewed including 31 vessels, >1,100 sub-trips, and >3,500 hauls. The data were subset to explore review rates ranging towards 1% and to identify thresholds of reasonable precision, which depended on the model structure used. This modeling framework will be used for groundfish EM vessels during FY2021 and beyond.

Given the implications of this new monitoring approach, it is important that the methods represent the best available science and are statistically sound. Therefore, the CIE reviewers will conduct a peer review of the statistical modeling based on the Terms of Reference (TORs) referenced below. Given the public interest, it will be important for NMFS to have a transparent and independent review process of the model used in this assessment.

The specified format and contents of the individual peer review reports are found in Annex 1. The Terms of Reference (TORs) of the peer review are listed in Annex 2.

Requirements
NMFS requires three reviewers to conduct an impartial and independent peer review in accordance with this Performance Work Statement (PWS), OMB Guidelines, and the ToRs below. The reviewers shall have working knowledge and recent experience in **statistical modeling, with applications to fisheries management and/or quantitative ecology**. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Tasks for reviewers
Each CIE reviewers shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

1. <u>Pre-review Background Documents:</u> Review the following background materials and reports prior to the review:

Thorson, J. T. (2018). Three problems with the conventional delta-model for biomass sampling data, and a computationally efficient alternative. *Canadian Journal of Fisheries and Aquatic Sciences*, 75(9), 1369-1382.

Venables, W. N., & Dichmont, C. M. (2004). GLMs, GAMs and GLMMs: an overview of theory for applications in fisheries research. *Fisheries research*, 70(2-3), 319-337.

Approximately, two weeks before the peer review, the NMFS Project Contacts will send by electronic mail or make available at an FTP site to the CIE reviewer all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contacts will consult with the CIE on where to send documents. The CIE reviewer shall read all documents in preparation for the peer review.

2. Webinar: Additionally, approximately two weeks prior to the peer review, the CIE reviewers will participate in a webinar with the NMFS Project Contacts and other staff to address any clarifications that the reviewers may have regarding the ToRs or the review process. The NMFS Project Contacts will provide the information for the arrangements for this webinar.

3. Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the PWS and ToRs, and shall not serve in any other role unless specified herein. Modifications to the PWS and ToRs cannot be made during the peer review, and any PWS or ToRs modifications prior to the peer review shall be approved by the Contracting Officer's Representative (COR) and the CIE contractor.

4. Contract Deliverables: Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the PWS. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Place of Performance
Each CIE reviewer shall conduct an independent peer review as a desk review; therefore, no travel is required.

Period of Performance
The period of performance shall be from the time of award through October 2021. Each reviewer's duties shall not exceed 10 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	Milestones and Deliverables
Within two weeks of award	Contractor selects and confirms reviewers
Two weeks prior to the review	Contractor provides the pre-review documents to the reviewers.
Within two weeks prior to the review	Reviewers participate in Webinar.

August 2021	Each reviewer conducts an independent peer review as a desk review
Within two weeks after review	Contractor receives draft reports
Within two weeks of receiving draft reports	Contractor submits final reports to the Government

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.

Project Contacts

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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 report shall include the following appendices:

a. Appendix 1: Bibliography of materials provided for review

b. Appendix 2: A copy of the CIE Performance Work Statement

Annex 2: Terms of Reference for the Peer Review

The reviewers will provide a scientific peer-review of the following document:

Linden, D.W. 2021. A predictive model of discarded catch that leverages self-reporting and electronic monitoring on commercial fishing vessels. *Working Paper*

The reviewers will provide input on the following questions:

1. Do the statistical analyses address the objectives of providing reasonably accurate and precise estimation of groundfish discards on EM vessels?

a. Are the statistical models adequately described?

b. Do the statistical models adequately fit the data?

c. Is the complexity of the statistical models justified?

d. Are there alternative models that would be preferable in terms of estimation performance and computational efficiency?

2. Have the sources of uncertainty and caveats in the analyses been adequately described? Given the objectives and the performance of presented models, are there additional potential sources of uncertainty that can be quantified and should be incorporated?