Independent Peer Review of the NMFS Study and Report on:

Predictive Modeling of North Atlantic Right Whale Population

Prepared on behalf of the Center for Independent Experts (CIE)

by

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Executive Summary

The Linden 2020 report ably fulfills its stated purpose of using population projection models to illustrate how human-caused mortality and uncertainty in reproduction threaten the long-term persistence of North Atlantic Right Whale (NARW). In doing so, it appears to use the best data available for this task. It also employs a relatively simple, but demographically sound, population stage structure model with parameters fitted to the data using a "best practice" Markov chain Monte Carlo approach. The scenario analyses are informative and clearly demonstrate the potentially devasting consequences of current human-caused mortality associated with fisheries activities on the ability of NARW to survive through this century.

Although the Linden 2020 report is scientifically sound as it stands, I think it can be strengthened through revisions that take into account the following recommendations.

The report:

- should clarify whether all possible sources of NARW sightings and census data have been used in the analysis,

- should clarify whether all possible sources of NARW mortality data have been used in the analysis,

- needs to include a very clear statement of its primary scientific conclusions,

- should provide some comment on the utility of using agent-based models to assess the future viability of the NARW in the event that the population becomes increasingly threatened with the danger of extinction over the coming century,

- should undertake some form of model forecasting evaluation, even if the analysis is confined to assessing how well years 2014-2018 are predicted by the model when fitted to the 1990-2013 data,

- needs to clarify whether the scenario analyses incorporate only demographic stochasticity or whether they incorporate model parameter uncertainty as well, and

- should include a justification for the scenario analyses considered.

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. As part of fulfilling this mandate, NMFS often seeks scientific peer review of their work and publications by independent reviewers. This is such a review organized under the purview of the Center for Independent Experts (CIE).

NMFS is currently developing a biological opinion, as required by Section 7 of the Endangered Species Act, on the continued operation of ten fisheries in the Greater Atlantic Region (GAR) that impact the north Atlantic Right Whale (NARW). The intent of this opinion is to ensure survival of the NARW which is currently at precipitously low levels and in danger of extinction this century from the impacts of fisheries operations in the GAR.

The materials made available to the CIE scientific peer review team by NMFS on March 17, 2020, are the following (See Appendix 1 for abstracts of the two scientific papers listed under point 3 below):

1. The following draft report dated March 16, 2020:

   Linden 2020: Linden, D. W. Population projections of North Atlantic right whales under varying human-caused mortality risk and future uncertainty.

2. The R code used in the modeling study reported in Linden 2020.

3. The following two papers that were included in the Statement of Work as background documents.

   Pace et al. 2017: Pace III RM, Corkeron PJ, Kraus SD. State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution. 2017 Nov;7(21):8730-41.

   Corkeron et al. 2018: Corkeron P, Hamilton P, Bannister J, Best P, Charlton C, Groch KR, Findlay K, Rowntree V, Vermeulen E, Pace III RM. The recovery of North Atlantic right whales, *Eubalaena glacialis*, has been constrained by human-caused mortality. Royal Society open science. 2018 Nov 7;5(11):180892.

4. The following paper is of equal importance to my review.

   MGG 2018: Meyer-Gutbrod EL, Greene CH. Uncertain recovery of the North Atlantic right whale in a changing ocean. Global change biology. 2018 Jan;24(1):455-64.

The purpose of the Linden 2020 report, as stated in the first paragraph of its Introduction, is to use "…population projection models (Caswell 2001) to illustrate how human-caused mortality and uncertainty in reproduction lead to varying predictions about the long-term persistence of NARW." The method used seems to be precisely the same method presented in some detail in Pace et al. 2017 (though not stated clearly enough in this reference to easily understand every aspect of it). This method is rooted in the demographic modeling studies of NARW carried out two decades ago (Caswell, Fujiwara, & Brault, 1999; Fujiwara & Caswell, 2001) and uses a Bayesian, state–space formulation to estimate model parameter values using Markov chain Monte Carlo (MCMC) methods (Denwood 2016).

A simplified three stage (calf, juvenile, adult) version of the Pace et al. 2017 model, was used by Corkeron et al. 2018 to carry out a comparative analysis of three populations of the Southern Right Whale (SRW Oz, SAf and Am—see the paper for more details), and NARW. They found that NARW has been growing much more slowly over the past few decades than these three populations of SRW. Of these populations, NARW is the only one that has been on the decline for the past decade, likely due to mortality from anthropogenic sources.

In contrast to Corkeron et al. 2018, MGG 2018 presents an analysis based on a 7-stage model that differentiates between male and female juvenile and adults, and divides females into juvenile, adult, calving and post-calving stages. Most importantly, it argues that a recent northward range shift in the NARW's primary prey species, has likely led to a reduced resource base for the NARW population and increased exposure of NARW to anthropogenic sources of mortality. Further, this change has greatly increased NARW risk of extinction in this century.

My peer evaluation of the analysis undertaken in Linden 2020 is provided in the next section, followed by a Conclusion and Recommendation Section, with a "Bibliography of materials provided for on the review" and a "Copy of the CIE Performance Work Statement" attached hereto as Appendices 1 and 2 respectively.

Description of Reviewer's Role in the Review Activities

The activities undertaken for this review comprised:

1. A review of background materials including Pace et al. 2027 and Corkeron et al. 2018 (see Appendix 1).
2. A review of the draft status review report, Linden 2020, including attending and participating in a March 30, 2020 webinar and Q and A session with NMFS scientists involved in the review.
3. Preparation of this CIE report according to instructions listed in the Performance Work Statement included as Appendix 2.

Summary of Findings

Questions posed in Terms of Reference

In the terms of reference (see Annex 2 of Appendix 2), reviewers were asked to address three questions, as numbered and repeated in roman boldface type in this section, with my response provided immediately following a restatement of these three questions. After answering these questions, I have taken the liberty of raising a number of additional issues that I think are important to my review of Linden 2020. In my answers to the three questions and in the additional comments that follow, I make statements that I have extracted to constitute the basis of my recommendations on how Linden 2020 might be revised. These are highlighted in boldface italics in this section, listed in the Executive Summary and also listed in the Conclusion and Recommendation section. This may seem like overkill, but as the author and publisher, Robert Collier, said: "Constant repetition carries conviction."

Q1. Based on the scientific information presented in the report, does this analysis consider all of the best available data? If not, please indicate what information is missing and if possible, provide sources.

In the methods section of Linden 2020, Linden states that NARW sightings data were collected during 1990–2018 were used to fit a state-space mark-recapture model presented in Pace et al. 2017. These data were collected by the North Atlantic Right Whale Consortium (https://www.narwc.org/). Since Pace et al. 2017 used these data collected over the period 1990-2015 (i.e., 26 sampling periods—one each year), Linden 2020 used an additional three years of data (2016-2018) beyond those used in Pace et al. 2017, which Linden states includes the most recent available at the time the analysis was undertaken. Since I am not immersed in right whale studies, I assume these are the best NARW census data available anywhere. I am not aware of any other groups that may be collecting comparable data.

From a 2019 "Data Sharing and Use Protocols Agreement" that I managed to locate online, it mentions that the NARW Consortium Databases, established in 1986, includes among its members the University of Rhode Island, the New England Aquarium, and the Center for Coastal Studies, Woods Hole Oceanographic Institution. It also refers nonspecifically, to other organizations but not specifically to organizations from other North Atlantic seafaring nations, including Canada, UK, Norway, Denmark, Iceland or Sweden. Thus, I wonder to what extent efforts have been made to obtain data that may have been collected by groups within Canada and these European countries. ***It should be clarified in the Linden 2020 report whether all possible sources of NARW sightings and census data have been used in the analysis.***

Similarly, it is not clear from Linden 2020 that there are no other sources of NARW mortality than those used in study. I have no reason to believe there are, but again a clarification of this point would be useful. Thus: ***It should be clarified in the Linden 2020 report whether all possible sources of NARW mortality data have been used in the analysis.*** Beyond this point, the various assumptions made about injury and mortality data reported in footnotes on page 5 appear to be the most reasonable under the circumstances.

Q2. Is the period (2010-2018), the appropriate period for the assessment? If not, please indicate what period should be used and why that period is more appropriate.

In Linden 2020, a state-space mark-recapture model was fitted to NARW sightings data during the period 1990–2018, and then checked with a fit of this same model reported in Pace et al. 2017 to the same data, but over the more limited period of 1990-2015. In short, the fit provided by Pace et al. 2017 was updated in Linden 2020, using sightings for the years 2016-2018. Linden 2020 states that the new fit "… matched closely with the 1990-2015 estimates in [Pace et al. 2017]," but no visual or tabular comparison of these two fits was provided in Linden 2020.

Convincing documentation and peer-reviewed scientific studies exist reporting a regime shift in seasonal sea surface temperature in the Gulf of Maine and Georges Bank (MGG 2018, listed in the Background section above). As a knock-on effect, this led to a 2012 shift in the Gulf of Maine zooplankton community (Morse et al. 2017), which is the primary prey species of NARW. This regime shift has been shown to coincide with a noticeable shift in NARW habitat use (Davis et al. 2017) and hence NARW distribution, exposing individuals to higher anthropogenic sources of mortality (Record 2019). This shift also coincides with the decline in NARW population size this past decade (Pace et al. 2017).

Linden uses the sentiment (stated in Linden 2020) "there is no information available to suggest when a shift in the zooplankton community may occur again" to justify his choice of the 2010–2018 time period parameters (as reported in Supplement 1 to Linden 2020) for the different mortality rate scenario study projections undertaken in his report. Based on the peer review studies referred to above (i.e., Morse et al. 2017, Davis et al. 2017 and Record 2019), this choice is the obvious and appropriate one to make.

Q3. In general, are the scientific conclusions in the reports sound and interpreted appropriately from the information? If not, please indicate why not and if possible, provide sources of information on which to rely.

Unfortunately, I could not find a clear statement in Linden 2020 of the primary scientific conclusions implied by the results of the scenario analyses presented in the report. ***Thus, the Linden 2020 report needs to include a very clear statement of its primary scientific***

conclusions. The primary scientific conclusion of the report is captured in Linden 2020, Fig. 8. This figure clearly shows that if no risk reduction measures are implemented, then the probability that the NARW population will continue its decrease over the next 50 years is close to certain. Furthermore, if risk is mitigated by 40% (i.e., the number of deaths due to anthropogenic sources is reduced by 40% compared with the observed number of deaths over the past 9 years) the conclusion is that a population decline over the next 50 years is almost as likely as a population increase. A further important conclusion of the study is that without Canadian participation in reducing anthropogenic sources of individuals over the next 50 years, the US on its own will be unable to stem the current decline unless the US mitigation is close to 100% effective (viz., the 80% level is insufficient). I believe the above conclusions to be appropriately interpreted, but whether they are sound is an issue that I confront next.

Additional Comments

To answer the issue of whether the implied conclusions of Linden 2020 are sound, we need to address the following issues:

1. *How good are the data?*

   In addressing question Q1 above, I accepted the premise that the data used in Linden 2020 are the best available. But even if this is true, this fact would not necessarily imply that these data enable us to construct models that are adequate to addressing all important questions at hand (Getz et al. 2018). This issue is broached in addressing the next question.

2. *How appropriate is the model to address the question at hand?*

   The analysis presented in Linden 2020 certainly provides a stark contrast between doing nothing and taking action to reduce mortalities at the 40% to 100% levels (stepping through 6 levels). This analysis thereby provides a "relative effects" comparison of mortality reductions in the US fishery alone, as well as the US and Canadian fisheries together, even if the predictions of the actual growth or decline rates associated with these mortality reductions are not completely accurate. It should be noted that the report does not provide any insights into what it might take from a management point of view to achieve these levels. Such an analysis, I assume, is beyond the purview of Linden 2020 because it requires the incorporation of fisheries operations and logistics processes as they impact whale ranging and feeding behavior, as well as needing to incorporate socio-economic factors. In the future, quantitative assessments of the type reported in Linden 2020, may be able to

take advantage of data that is rich in individual-specific information obtained through monitoring the movement and biological states (reproductive, physiological, health, social) of known individuals. These will be accomplished through remote sensing technologies able to use the physical features of individuals to identify them using machine learning AI technologies. Compartmental models of the type used in Linden 2020 are not able to use such data and will need to be replaced by individual or agent-based models that are becoming more utilized as data sets containing information on individuals become more widely available (McLane et al. 2011, Piacenza et al. 2017. Revilla 2019). It is not clear to me at this time whether or not sufficient individual information is available to justify switching from a compartmental modeling approach to an agent-based modeling approach to make the kinds of assessments reported in Linden 2020. However, individual-based models are certainly much more appropriate to use than compartment models when populations are small (Lacy 2000). ***Thus, it would be useful if the Linden 2020 report provided some comment on the utility of using agent-based models to assess the future viability of the NARW as this population becomes increasingly threatened with the danger of extinction over the coming century.***

3. *How good is the model estimation process?*

   The model parameter estimation approach taken in Linden 2020 draws upon MCMC methods that are the current "best-practice" for fitting such models and follows the same procedures, using similar models, to those that have been peer reviewed in the literature, including in the context of modeling NARW (Caswell et al. 1991, Fujiwara and Caswell 2001, Pace et al. 2017, Corkeron et al. 2018) and other right whale populations. Thus, for the given model and the available data, the methodology used is certainly completely appropriate (where the latter is interpreted in the context of Larsen et al. 2016).

4. *How confident can we be in the model predictions?*

   As mentioned above, the analysis undertaken in Linden 2020 likely provides good insights into the relative differences to NARW growth or decline as mortality rates are reduced from no action to 40%, 50%, 60%, 70%, 80% and 100% reductions due to US and to joint US-Canadian fisheries operations and ship collisions. However, although model estimation methods used in the report follow "best practices," the report provides no assessment of the validity of model forecasts in the sense of "model output corroboration" (Augusiak et al. 2014). One way to carry out this corroboration is to fit the model to part of the data set and then see how well the model predicts another part of the data set. This is a little tricky under the

assumption that background environmental conditions underwent a regime shift in 2010, but it would still be useful to see how well the model is able to predict the last 5 years of the data when fitted to the first 24 years. ***Thus, the Linden 2020 report should undertake some form of model forecasting evaluation, even if the assessment is confined to predicting years 2014-2018.*** Of course, this forecasting is in the context of stochastically generating confidence intervals for the predictions. Which raises another issue. Uncertainty enters models in the context of process uncertainty (Modeling incertitude: Is the model appropriately formulated?), observation uncertainty (Measurement incertitude: How accurate are the data?), demographic uncertainty (Intrinsic variability: births and deaths have a random component akin to throwing dice and obtaining an outcome with a given probability). In forecasting the impacts of mortality reduction in NARW, it is not entirely clear to me if stochastic simulations include only demographic uncertainty, or if parameter uncertainties were also incorporated into the model (i.e., not only is the simulation Monte Carlo, but the parameter values used in each simulation are also drawn from an appropriate distribution. ***Thus, the Linden 2020 report needs to clarify whether the scenario analysis incorporates only demographic stochasticity or whether it incorporates parameter uncertainty as well.***

5. *How appropriate is the scenario analysis?*

I think the scenario analysis is entirely appropriate and illustrates very nicely the effects of reducing anthropogenic mortality in the US and in the US and Canada. It makes complete sense to consider the US alone, since this is a US Government report, as well as a US-Canada collaboration, since the potential exists for a two-country agreement on how to best to protect NARW. However, it would be good to see some discussion of this reasoning in the report, as well as a justification for excluding sources of mortality that may be caused by the fishing and shipping activities of other countries. ***Thus, it would be useful if the Linden 2020 report contained a better justification for the scenario analyses considered.*** It would also be useful to see some discussion in the report on iterative modeling and data assessments that should take place in the context of adaptive decision making (Dietze et al. 2018) that is critical to ensuring mitigation measures are and remain on track.

Conclusions and Recommendations

My overall impression of the Linden 2020 report is that it is generally clearly written and informative, but that additional details, as suggested in my list of recommendations, would serve to strengthen it. The report accomplishes what it sets out to do, which I see as informing the reader on levels of mitigation surrounding mortality reductions that are needed to protect the NARW from steady decline over the next two decades. The report, however, provides no insights into how fisheries management practices might achieve such reductions in practice. Presumably this later aspect is outside the purview of the report.

I think that the report can be strengthened considerably, by revising it to address the recommendations embedded in the above text. For clarity, these are rephrased and listed below.

The Linden 2020 report:

- should clarify whether all possible sources of NARW sightings and census data have been used in the analysis,
- should clarify whether all possible sources of NARW mortality data have been used in the analysis,
- needs to include a very clear statement of its primary scientific conclusions,
- should provide some comment on the utility of using agent-based models to assess the future viability of the NARW in case the population becomes increasingly threatened with the danger of extinction over the coming century,
- should undertake some form of model forecasting evaluation, even if the analysis is confined to assessing how well years 2014-2018 are predicted by the model when fitted to the 1990-2013 data,
- needs to clarify whether the scenario analyses incorporate only demographic stochasticity or whether they incorporate model parameter uncertainty as well, and
- should include a justification for the scenario analyses considered.

Additional References

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Davis, G. E., M. F, Baumgartner, J. M. Bonnell, J. Bell, C. Berchok, J. B. Thornton, S. Brault, et al. 2017. Long-Term Passive Acoustic Recordings Track the Changing Distribution of North Atlantic Right Whales (*Eubalaena Glacialis*) from 2004 to 2014. *Scientific Reports* 7 (1): 1–12.

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McLane, A.J., Semeniuk, C., McDermid, G.J. and Marceau, D.J., 2011. The role of agent-based models in wildlife ecology and management. *Ecological Modelling*, *222*(8), pp.1544-1556.

Morse, R. E., K. D. Friedland, D. Tommasi, C. Stock, & J. Nye. 2017. Distinct Zooplankton Regime Shift Patterns Across Ecoregions of the Us Northeast Continental Shelf Large Marine Ecosystem. Journal of Marine Systems 165: 77–91.

Piacenza, S.E., Richards, P.M. and Heppell, S.S., 2017. An agent-based model to evaluate recovery times and monitoring strategies to increase accuracy of sea turtle population assessments. *Ecological Modelling*, *358*, pp.25-39.

Record, N. R., J. A. Runge, D. E. Pendleton, W. M. Balch, K. T. A. Davies, A. J. Pershing, C. L. Johnson, et al., 2019. Rapid Climate-Driven Circulation Changes Threaten Conservation of Endangered North Atlantic Right Whales. *Oceanography* 32 (2): 162–69.

Revilla, E., 2019. Individual and Agent-based Models in Population Ecology and Conservation Biology. *Population Ecology in Practice*.

Appendix 1: Bibliography of Materials Provided for Review.

1. **Linden 2020**: Linden, D. W. Population projections of North Atlantic right whales under varying human-caused mortality risk and future uncertainty.

2. **Linden Rcode:** The R code used in the modeling study reported in Linden 2020.

3. **Pace et al. 2017**: Pace III RM, Corkeron PJ, Kraus SD. State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution. 2017 Nov;7(21):8730-41.

Abstract. North Atlantic right whales (*Eubalaena glacialis* Müller 1776) present an interesting problem for abundance and trend estimation in marine wildlife conservation. They are long lived, individually identifiable, highly mobile, and one of the rarest of cetaceans. Individuals are annually resighted at different rates, primarily due to varying stay durations among several principal habitats within a large geographic range. To date, characterizations of abundance have been produced that use simple accounting procedures with differing assumptions about mortality. To better characterize changing abundance of North Atlantic right whales between 1990 and 2015, we adapted a state–space formulation with Jolly-Seber assumptions about population entry (birth and immigration) to individual resighting histories and fit it using empirical Bayes methodology. This hierarchical model included accommodation for the effect of the substantial individual capture heterogeneity. Estimates from this approach were only slightly higher than published accounting procedures, except for the most recent years (when recapture rates had declined substantially). North Atlantic right whales' abundance increased at about 2.8% per annum from median point estimates of 270 individuals in 1990 to 483 in 2010, and then declined to 2015, when the final estimate was 458 individuals (95% credible intervals 444–471). The probability that the population's trajectory post-2010 was a decline was estimated at 99.99%. Of special concern was the finding that reduced survival rates of adult females relative to adult males have produced diverging abundance trends between sexes. Despite constraints in recent years, both biological (whales' distribution changing) and logistical (fewer resources available to collect individual photo-identifications), it is still possible to detect this relatively recent, small change in the population's trajectory. This is thanks to the massive dataset of individual North Atlantic right whale identifications accrued over the past three decades. Photo-identification data provide biological information that allows more informed inference on the status of this species.

4. **Corkeron et al. 2018:** Corkeron P, Hamilton P, Bannister J, Best P, Charlton C, Groch KR, Findlay K, Rowntree V, Vermeulen E, Pace III RM. The recovery of North Atlantic right whales, Eubalaena glacialis, has been constrained by human-caused mortality. Royal Society open science. 2018 Nov 7;5(11):180892.

Abstract. North Atlantic right whales (NARW), *Eubalaena glacialis*, were nearly exterminated by historical whaling. Their abundance slowly increased up until 2010, to a

maximum of fewer than 500 whales, and since then they have been in decline. We assessed the extent to which the relatively slow increase demonstrated by NARW was intrinsic, and how much could be due to anthropogenic impacts. In order to do so, we first compared calf counts of three populations of Southern right whales (SRW*), E. australis*, with that of NARW, over the period 1992–2016. By this index, the annual rate of increase of NARW was approximately one-third of that of SRW. Next we constructed a population projection model for female NARW, using the highest annual survival estimates available from recent mark–resight analysis, and assuming a four-year calving interval. The model results indicated an intrinsic rate of increase of 4% per year, approximately twice that observed, and that adult female mortality is the main factor influencing this rate. Necropsy records demonstrate that anthropogenic mortality is the primary cause of known mortality of NARW. Anthropogenic mortality and morbidity have limited the recovery of NARW, and baseline conditions prior to their recent decline were already jeopardizing NARW recovery.

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

Predictive Modeling of North Atlantic Right Whale Population

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. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf). Further information on the CIE program may be obtained from www.ciereviews.org.

Scope
NMFS is required to use the best available scientific and commercial data in making determinations and decisions under the Endangered Species Act (ESA). Under section 7 of the ESA, federal agencies must consult with NMFS when any project or action they take might affect an ESA-listed marine species or designated critical habitat. We are currently undergoing section 7 formal consultation on the continued operation of ten fisheries in the Greater Atlantic Region. These fisheries include fixed gear fisheries. Formal consultation results in NMFS developing a biological opinion. The intent of a biological opinion is to ensure that the proposed project or action will not reduce the likelihood or survival and recovery of an ESA-listed species. The effect of these fisheries on North Atlantic right whales, an ESA-listed species, is being assessed in the current consultation. This includes

the impact of entanglement in vertical lines on the population. To help in this analysis, NMFS has developed a predictive model to evaluate how reductions in serious injury and mortality will affect the population trajectory of female North Atlantic right whales. It is critical that the information, analysis, and determinations in the section 7 consultation be based on the best available information on North Atlantic right whales. Therefore, the CIE reviewers will conduct a peer review of the scientific information in the North Atlantic right whale model based on the Terms of Reference (TORs). Given the public interest, it will be important for NMFS to have a transparent and independent review process of the model used in the consultation.

Requirements

NMFS requires three (3) reviewers to conduct an impartial and independent peer review in accordance with the PWS, OMB guidelines, and the TORs below. The reviewers shall have a working knowledge and recent experience in at least one of the following: (1) population modeling and/or (2) quantitative ecology. In addition, large whale science experience is preferred.

Tasks for Reviewers

1) Review the following background materials and reports prior to the review meeting:
Pace III, R.M., P.J. Cockeron, S. D. Krause. 2017. State-space mark-recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution. 7:8730-8741 . DOI: 10.1002/ece3.3406
Corkeron, P., Hamilton, P., Bannister, J., Best, P., Charlton, C., Groch, K.R., Findlay, K., Rowntree, V., Vermeulen, E. and Pace III, R.M., 2018. The recovery of North Atlantic right whales, *Eubalaena glacialis,* has been constrained by human-caused mortality. *Royal Society open science*, 5(11), p.180892. DOI: 10.1098/rsos.180892

2) 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 NMFS Project Contact.

3) 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**.

4) Deliver their reports to the Government according to the specified milestones dates.

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 May 2020. The CIE reviewers' 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	Deliverables and Milestones
Within two weeks of award	Contractor selects and confirms reviewers
No later than two weeks prior to the review	Contractor provides the pre-review documents to the reviewers
March 2020	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; and (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 Contact:
Ellen Keane
ellen.keane@noaa.gov
NMFS, Greater Atlantic Region
55 Great Republic Drive, Gloucester, MA 01930

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:
    1. Appendix 1: Bibliography of materials provided for review
    2. Appendix 2: A copy of the CIE Performance Work Statement

Annex 2: Terms of Reference for the Peer Review

1. Based on the scientific information presented in the report, does this analysis consider all of the best available data? If not, please indicate what information is missing and if possible, provide sources. When considering this question, please keep in mind the context in which the model was developed as provided in the model documentation. The model is not designed to consider all factors that may impact the population.
2. Is the period (2010-2018), the appropriate period for the assessment? If not, please indicate what period should be used and why that period is more appropriate.
3. In general, are the scientific conclusions in the reports sound and interpreted appropriately from the information? If not, please indicate why not and if possible, provide sources of information on which to rely.