Center for Independent Experts (CIE) Independent Peer Review of North Atlantic Right Whale Population Viability Analysis

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Executive summary

The suite of models used to conduct the population viability analysis of North Atlantic right whales use modern modeling methods, are based on the best available data, and include all major factors known to affect this population. The models fit well to available data, and represent the best available science to predict risks to this population, and estimate the impact on the population of changes to prey availability, entanglement with fishing gear, ship strikes, and noise. The framework presented should be able to adjust to a variety of current and future threats, new data, and updates to management. Additional scenarios would improve the validation of the model, as follows: (1) Conduct and present diagnostics to demonstrate that the model fits are not biased near the end of the period of available data. (2) Include a regime shifts scenario that is able to mimic the periods of good and bad years for North Atlantic right whales, with some probability of future increases in the population that match past observed rates of increase. (3) Use a consistent period of time to model calving rates and injury and mortality rates. (4) Include a scenario where future calving rates are not driven by an uncertain relation between the prey abundance index but are resampled from past observed calving rates. (5) For simulations into the future, initialize the population based on individual probabilities of being alive at the end of the historical model, rather than multinomial draws.

None of these recommendations are likely to change the overall conclusions of the viability analysis paper: North Atlantic right whales are currently declining precipitously; this decline is largely due to entanglement injuries, with contributing factors including ship strikes and poor prey availability and abundance; and these declines can be reversed if entanglement is reduced by 25-50%.

Background

North Atlantic right whales are a small, endangered, population of whales whose numbers were recovering in abundance since protection from whaling in 1935. Abundance increased steadily from from 270 in 1990 to 483 in 2010, before a prolonged period of decline to the present abundance of 368 in 2019 (NOAA 2021). The recent period of decline appears to be driven by a combination of low calf production (likely due to a prolonged period of poor prey availability) and high mortality due mostly to entanglement with fishing gear, with deaths from ship strikes an additional contributing factor. In the population viability analysis reviewed here, the authors (Runge et al. 2022) have created an individual-based population model that can be projected forward to predict the probability of the population falling below threshold abundance levels (quasi-extinction), measured in terms of “proven” females, i.e. those observed with calves. They examine the effect of different levels of gear entanglement, ship strikes, and prey availability on the viability of North Atlantic right whales.

Description of individual reviewer’s role in the review activities

I am one of three reviewers chosen by the Center for Independent Experts to conduct a desktop review of the population viability analysis for North Atlantic right whales (Runge et al. 2022). I am a professor at the University of Washington who works on assessments of fisheries and large whale populations, among other topics.

Major points

1. The assessment model used (Pace et al. 2017, Pace et al. 2021) and population viability analysis (Runge et al. 2022) employ modern methods, include comprehensive sets of data, and include

all factors known to affect this population. The models fit well to the available data, and represent the **best available science** for conducting a population viability analysis of North Atlantic right whales.

2. **Retrospective diagnostics** could be provided to assess any bias in the final years of the model. Mark-recapture models sometimes estimate survival that is biased low in the last few years of the model. For example, an earlier model of this population (Fujiwara & Caswell 2001) estimated mother survival of 0.63-0.78 during 1990-1995, while the most recent model estimates adult female survival to be >0.95 during 1990-1995 (Pace et al. 2017). This bias does not appear to affect the current model, however, as can be seen by comparing abundance estimates for 2010-2015 (Pace et al. 2017) with those for 2010-2015 in the latest version (Runge et al. 2022). A formal comparison of estimates of abundance from each successive annual model across common years, would be a good model validation check.

3. None of the model scenarios appear capable of reproducing the observed trends in the population between 1990 and 2010, since they are focused on projecting 2010s conditions into the future. During 1990-2010, the population grew from 270 to 483 (Pace et al. 2017) at a rate of 2.95% per year, at a rate allowing it to double in size every 24 years. Similar increases are likely in the 1970s and 1980s (e.g., Caswell et al. 1999). However, the projection model predicts zero probability of the population doubling in size even in a longer period of 35 years. Furthermore the 1990-2010 period also included a number of years with low estimated survival, low calf production, and high numbers of reported deaths (Caswell et al. 1999, Fujiwara & Caswell 2001), similar to that estimated since 2010. To fill this gap, I recommend including a **“Regime shifts” scenario**, which models the environment as alternating periods of good times and bad times. It appears that there have been four regimes since 1990: early 1990s (good), late 1990s (bad), 2000s (good), and 2010s (bad), thus to mimic this kind of interplay, regimes could be modeled by picking a random duration (e.g. 5-15 years), and quality (good or bad) in the proportions observed during 1990-2019 (roughly 2/3rd good years, 1/3rd bad years). In the good times, prey abundance is high and situated geographically as it was in the earlier period, resulting in high calving rates and crucially also having North Atlantic right whales shifted in space resulting in low levels of mortality from entanglement and ship strikes. Bad and good regimes need not alternate, thus if 2-3 good periods were strung together, the population would have a reasonable probability of doubling in size in less than 35 years.

4. In the baseline model (section 6.1), **inconsistent time periods** are used for prey-influenced calving rates (2010-19) and for injury and mortality rates (2014-19). This is a critical assumption because estimated mortality jumps sharply in 2014 from low rates (Figure 5), and 2017 (17 reported deaths) is the only year since 1990 with more than 7 reported deaths (Pace et al. 2021). Manufactured rope breaking strength increased in the mid-1990s (Knowlton et al. 2016), and a regime shift in food availability and right whale distribution occurred in 2010, resulting in a shift in right whale distribution away from existing grounds in 2010, and into more northerly areas in 2015 (Meyer-Gutbrod et al. 2021). Although there is certainly a case to be made for choosing different time periods that respectively include low average calving rates and high average mortality rates, the underlying causes of both are most likely the regime shift in 2010, and I therefore recommend that a consistent time period (2010-19) should be used to calculate both average prey-influenced calving rates, and average injury and mortality rates.A clear plot is

needed in the paper of the effects of the five key scenarios on historical and projected proven female survival and calving rates, including uncertainty. The five scenarios (six if the regimes model above is added) are the baseline, 25% and 50% reduction in entanglement, 25% reduction in ship strike risk, and prey levels at the 1990-2009 levels.

5. The model that predicts calving rates in the future relies heavily on the relationship between the *Calanus* prey abundance index and observed calving rates (Figures 7-8 in Runge et al. 2022). However, comparing the model predictions for calving rates from this relationship (Figure 8) with the actual observed calving rates (Figure 6, Pace et al. 2017) reveals considerably different patterns of calving rates over time. Notably, calving rates were generally high from 1990-1997, and low in 1998-2000, but in the Calanus predictions in Runge et al. (2022), calving rates are uniformly low during 1990-2000 — as low as in 2010-2019. For a start, Figures 7-8 should include the observed data on both plots so that the reader can better evaluate whether the model predictions are realistic. Secondly, it would be worth running a scenario based on empirical resampling of calving rates (i.e., random draws of calving rates) during different regimes (1990-1997, 1998-2000, 2001-2011, 2012-2019), rather than relying entirely on the relationship between the Calanus index and calving rates. In fisheries, identified relationships between environmental conditions and recruitment are often illusory when used to predict outcomes in future decades (Myers 1998).
6. The method used to initialize individuals in each class in year 0 of the forward simulations needs revision (Section 5.4), although this is unlikely to change the predicted outcomes of the model. It is described as "our retrospective reproduction model does terminate the time series with an estimate (1 or 0) of the alive state of each individual. We summed the terminal alive states according to the 18 classes of animals and derived proportions for each sex, age, and stage class. The posterior distribution of these proportions served as a multinomial probability from which a random draw of size N_hat (the posterior estimate from the state space model) was used to initialize the number of individuals in each class in year 0." I believe this is incorrect, but the distinction is subtle and tricky to explain. The key is that uncertainty resides at the individual level—the probability that each individual is alive or dead at the end of the retrospective time period (2019) and start of the simulations. To simplify, consider the case where there are 4 individuals in 2 classes (the sexes), with these probabilities of being alive: male 1.000, male 1.000, female 1.000, female 0.5. A multinomial draw would sample 3 or 4 individuals with probability 2/3.5 male and 1.5/3.5 female, and might result in a population of 2M2F, 4M0F, 1M3F, 2M1F (actual random multinomial draws). Clearly this is far more variable than the truth which should consist only of 50% probability of 2M1F and 50% probability of 2M2F. Therefore, instead, each starting point should be defined based on a random Bernoulli (binomial with n=1) draw for each individual in the population, with probability of success being the posterior probability of that individual being alive. Or, even more simply, each forward simulation could be based on one posterior draw of the individuals from the retrospective reproduction model, which would maintain the covariances among parameters in creating a starting population.

Minor points

p. 2 The first two paragraphs are somewhat duplicative. I suggest defining proven females (females previously detected with calves) and quasi-extinction (risk of falling below 50 proven females), and then starting the second paragraph with "We also explored scenarios that only partially remove threats, including the degree of entanglement risk…"

p. 14 first para: the estimates of female survival in these two papers are opposite, with Fujiwara & Caswell (1999) finding declining and low female survival, while Pace et al. (2017) found high female survival with no declining trend. A comment is needed here to clarify which scenario is currently thought to be most plausible and/or the reference to the outdated results should be removed.

p. 24 Model Implementation. A brief description should be added here to describe which computer language the model is implemented in, how long the runs take, and how many iterations of the model are run to estimate uncertainty in the baseline case.

p. 35 Equation 29. The subscript t is used for years throughout, but here changed to the Greek letter tau τ. Instead, minimum biomass should be t between 0 and τ with N_t subscript. The same issue is true in many equations in sections 4.5.1-4.5.4.

p. 36 The definition of the probability of decline (4.5.4) is ambiguous. For the model runs, there are i = 1000 replicates in each of t = 100 years, but the definition is missing for subscript i. It would be better defined along these lines: "For each model replicate i, the minimum abundance $N_{\mathrm{min},i}$ within the 100 years is found, and the highest decline calculated as $(N_0–N_{\mathrm{min}})/N_0$. Then the proportion of these iterations that are greater than 0.3, 0.5, and 0.8 is calculated."

p. 36-37 The Recovery Potential Assessment (RPA) criteria (median time to reach 1000 mature individuals) need some clarification to explain what happens in scenarios when the median trajectory never reaches 1000 mature individuals. Perhaps "…when the median simulation did not exceed 1000 mature individuals within 100 years, we instead report the proportion of replicates that did exceed this threshold."

p. 36-37 For median time to reach 1000 mature individuals, please clarify how this is calculated: (a) for each model replicate calculate the year it exceeds 1000, then find the median (what to do when it never exceeds 1000?); or (b) for each year calculate whether median abundance is above 1000, and report the first such year.

Figure 4: caption should include the units and mention that this is in log-scale: "(log prey availability in mg dry weight.m^{-2})".

p. 39 "We found strong correlations between calving rate and the *Calanus* indices from eGOM and swGSL". The strength of the correlation (r^2) should be reported and Figure 7-8 should show the data and the model fit, since this has crucial bearing on predicted calving rates during 2010-19 and for the alternative run basing this on *Calanus* indices for 1990-2010.

p. 40 Section 5.2.2. Mortality rate estimates and confidence intervals are reported as hazard rate model parameter values, which are difficult to interpret. For example, 1.474 for vessel strike mortality appears to translate to <10% mortality (Figure 5). I recommend converting all the values in this paragraph to survival rates per year.

p. 43 Figures 7 & 8 need to include 0 on the y-axis. Additionally, both figures should include the actual data, not just the model predictions based on prey indices, so that the reader can judge how accurate the model predictions are.

p. 46 Section 6.3.1 "The risk reduction under full implementation was estimated at 90% for adults and 60% for juveniles. The weak-rope scenario was implemented at 50%..." This statement is unclear. Is the weak-rope scenario 50% risk reduction for adults and juveniles, or 45% and 30% respectively (50% of the risk reduction)?

p. 46 Section 6.3.2 No explanation is given for the choice of -0.3% and +0.7% per year for changes in future vessel strike mortality, or for why the declines are smaller than the increases.

p. 47 Section 6.3.3 Prey availability scenarios are assumed to be drawn randomly from either 1990-2019 ("steady") or 2010-2019 ("decline"). However, it is more likely that conditions come in regimes of good and bad conditions.

p. 47 Section 6.3.3 It is not clear to me whether the model includes the full uncertainty associated with the prey index values, and the full uncertainty associated with the relationship between the prey index and calving success. Values should include this uncertainty and not be taken from the median estimates in Figures 7 and 9.

p. 48 Section 6.3.4 Given the absence of any evidence that noise currently impacts right whale feeding or survival, I would suggest paring down the noise scenarios from six to three, and reducing the range of impacts to -10%, 0%, +10%.

p. 48 Section 6.4. The sensitivity analysis is worth doing, but it is not statistically valid to look for significant regressions when fitting to model outputs. The analysis can be retained but references to "statistically significant" outcomes should be removed throughout.

p. 50 Figure 10. Remove the gap on the y-axis between zero and the plotted values, especially important since this gap obscures population sizes close to extinction.

p. 52 Figure 11. Background colors should go from blue to white to red, with white showing steady state. It also took time to understand that the background color is simple math (birth rate minus death rate), which would be clearer with a dashed 1:1 line representing zero population growth.

p. 53 Figure 12. The y-axis label should be changed to "Probability of quasi-extinction", and "Threshold" renamed to "Proven female threshold".

p. 55 Figure 13. Include zero on the y-axis to accurately represent the decline in population size over time.

p. 56 Table 2. One of the threats is listed as "Prey", but should be named "Low prey" or "Lack of prey".

p. 57 Figures 14 and 15 should have the same y-axis so that the magnitude of threats are directly comparable.

p. 60 Section 7.3.4 Prey accessibility is modeled as ranging from -30% to +30% of the baseline scenario, which does not represent a reasonable range of outcomes. The baseline scenario (2010-19) is the worst observed, while 1990-2010 is the best observed, therefore the models should range from 30% below the worst (2010-19) to 30% above the best (1990-2010) conditions.

p. 60 Section 7.4 sensitivity analyses. More explanation is needed here. Only symbols are referred to in the text and figures (referencing Table S1 for definitions). Instead, for parameters deemed sensitive, the results should include the definition in plain English, how they impact population growth rates, and why they are important in the model (or submodels).

p. 63 “probability of which is approximately 0” -> replace with “probability of which is <0.0001” or similar.

Summary of findings related to terms of reference

The terms of reference for the CIE review specifically asks for discussion around the three topics below. Here I briefly respond.

Based on the scientific information and analyses presented, does this report consider all of the best available data and represent an appropriate approach? If not, please indicate what information or analysis 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.

Yes, the report does consider all of the best available data and represents an appropriate approach. It focuses on projecting current conditions (roughly 2010-2019 for most assumptions) into the future, which is reasonable, especially when trying to predict the risk to North Atlantic right whales from anthropogenic causes.

Are the baseline scenarios and use of demographic rates during 2010–2019 as the reference for most of the demographic processes appropriate for the analysis? If not, please indicate what considerations are missing and whether/why other periods should be used.

Yes, these scenarios are appropriate to forecast the risk of continuing the status quo in the 2010s in terms of the extinction risk to North Atlantic right whales. As I argue above, I would also include at least one scenario that models the system as being driven by different regimes during which prey availability, entanglement risk, ship strike risk, and calving rates are “good” for a period of years, followed by a period of “bad” years. This scenario would be better at reproducing the conditions that allowed the population to increase at around 3% per year in the past.

In general, are the scientific conclusions in the reports sound and interpreted appropriately from the information? Have the sources of uncertainty and caveats in the analyses been adequately described? If not, please indicate why not and if possible, provide sources of information on which to rely.

Yes, the scientific conclusions are valid: a reduction in the entanglement risk would greatly reduce the quasi-extinction risk to the population, suggesting an immediate management response to turn around the population decline. Sources of uncertainty are well described and included in the model.

Conclusions and recommendations

Major recommendations arising from the review points above are as follows:

1. Conduct retrospective diagnostics to validate the model, to demonstrate that model fits are not biased at the end of the time series.
2. Include a regime shifts scenario that models good periods (like those in the early 1990s and 2000s) and bad periods (like the late 1990s and 2010s), and has some probability of the population returning to the population growth rates seen over 1990-2010.

3. Use a consistent period of time (2010-19) to model recent prey-influenced calving rates and injury and mortality rates, rather than using 2010-19 for the former and 2014-19 for the latter.
4. Include a scenario where calving rates are resampled from observed data in past periods of time, rather than being based on an uncertain relationship between prey availability and calving rates. Also provide diagnostics that compare predictions of calving rates from prey availability to past calving rates, to check how well this relationship matches the data.
5. Adjust the method used to initialize individuals in the first year of the simulations to better reflect the individual level at which uncertainty occurs (point 7 of the major points above).

Cited references

Caswell H, Fujiwara M, Brault S (1999) Declining survival probability threatens the North Atlantic right whale. Proceedings of the National Academy of Sciences 96:3308-3313

Fujiwara M, Caswell H (2001) Demography of the endangered North Atlantic right whale. Nature 414:537-541

Myers RA (1998) When do environment-recruitment correlations work? Reviews in Fish Biology and Fisheries 8:285-305

NOAA (2022) North Atlantic right whale (*Eubalaena glacialis*): Western Atlantic stock. Draft U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021, pp 22-48. Available from https://media.fisheries.noaa.gov/2021-10/Draft%202021%20NE%26SE%20SARs.pdf

Pace III RM, Corkeron PJ, Kraus SD (2017) State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution 7:8730-8741

Pace III RM, Williams R, Kraus SD, Knowlton AR, Pettis HM (2021) Cryptic mortality of North Atlantic right whales. Conservation Science and Practice 2021:e346

Runge MC, Linden DW, Hostetler JA, Borggaard DL, Garrison LP, Knowlton AR, Lesage V, Williams R, Pace III RM (2022) A management-focused population viability analysis for North Atlantic right whales, draft 08-2022.

Appendix 1: Bibliography of materials provided for review

Linden DW, Hostetler JA, Pace III RM, Garrison LP, Knowlton AR, Lesage V, Runge MC, Williams R (2022) Multistate capture-recapture models to estimate mortality and reproduction in North Atlantic right whales (1990-2019)

NOAA (2021) North Atlantic right whale (*Eubalaena glacialis*): Western Atlantic stock. Draft U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021, pp 22-48. Available from https://media.fisheries.noaa.gov/2021-10/Draft%202021%20NE%26SE%20SARs.pdf

Pace III RM, Corkeron PJ, Kraus SD (2017) State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution 7:8730-8741

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Appendix 2: CIE performance work statement

Performance Work Statement (PWS)

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Center for Independent Experts (CIE) Program

External Independent Peer Review

North Atlantic Right Whale Population Viability Analysis

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act (ESA), and Marine Mammal Protection Act (MMPA) 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

NMFS Greater Atlantic Region established the Population Evaluation Tool Subgroup under the North Atlantic Right Whale (NARW) Recovery Plan U.S. Implementation Team to assist NMFS in the implementation of the North Atlantic Right Whale Recovery Plan. The intention was to bring together the diversity of expertise most appropriate to develop a population viability analysis (PVA) for NARW. The Population Evaluation Tool Subgroup[2] consists of appropriate

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[1] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

[2] PET Subgroup Members: Dr. Richard Pace, Chair, NOAA Fisheries, Northeast Fisheries Science Center; Dr. Michael Runge, U.S. Geological Survey; Dr. Lance Garrison, NOAA Fisheries, Southeast Fisheries Science Center;

experts in integrated population models and/or population viability analyses. The need for a PVA was highlighted most recently in NOAA Fisheries' 5-year reviews for NARW (August 2012 and October 2017), required under the ESA to ensure that the listing classification of the species is accurate. The objective of the Population Evaluation Tool Subgroup is to develop a population viability analysis that will allow the agency to characterize the North Atlantic right whale extinction risk, taking into account current and future threats. This modeling effort is underway and a final report is expected in 2022 which will help identify demographic benchmarks useful to inform management and gaps in research.

NMFS is required to use the best available scientific and commercial data in making determinations and decisions under the ESA and MMPA. Given the importance of this effort and likely use in management discussions under the ESA and/or MMPA, it is critical that the PVA be based on the best available science and be statistically sound. Therefore, the CIE reviewers will conduct a peer review of the scientific information and approach in the North Atlantic right whale PVA 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 future considerations to further the recovery of right whales.

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 (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 working knowledge and recent experience in one or more of the following: (1) wildlife population modeling; (2) population viability analyses; and/or (3) quantitative ecology. In addition, experience with large whale science is helpful, though not required. 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 reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

1) Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact 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 Contact will consult with the CIE on where to send documents. The CIE reviewer shall read all documents in preparation for the peer review, for example:

Dr. Jeffrey Hostetler, U.S. Fish and Wildlife Service; Amy Knowlton, New England Aquarium; Dr. Veronique Lesage, Fisheries and Oceans Canada; Dr. Daniel Linden, NOAA Fisheries, Greater Atlantic Regional Fisheries Office; Dr. Rob Williams, ORCA

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

Pace, RM, III, R. Williams, S.D. Kraus, A.R. Knowlton, H.M. Pettis. 2021. Cryptic mortality of North Atlantic right whales. Conservation Science and Practice. https://doi.org/10.1111/csp2.346

NMFS, 2021. North Atlantic right whale *(Eubalaena glacialis*). Draft U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2021. Pages 22-48. https://media.fisheries.noaa.gov/2021-10/Draft%202021%20NE%26SE%20SARs.pdf

2) Webinar: Additionally, approximately two weeks prior to the peer review, the CIE reviewers will participate in a webinar with the NMFS Project Contact and Population Evaluation Tool Subgroup members to address any clarifications that the reviewers may have regarding the ToRs or the review process. The NMFS Project Contact 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 31, 2022. 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.

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
August 2022	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:

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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:

    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

The reviewers will provide input on the following questions:

1. Based on the scientific information and analyses presented, does this report consider all of the best available data and represent an appropriate approach? If not, please indicate what information or analysis 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. Are the baseline scenarios and use of demographic rates during 2010–2019 as the reference for most of the demographic processes appropriate for the analysis? If not, please indicate what considerations are missing and whether/why other periods should be used.

3. In general, are the scientific conclusions in the reports sound and interpreted appropriately from the information? Have the sources of uncertainty and caveats in the analyses been adequately described? If not, please indicate why not and if possible, provide sources of information on which to rely.

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