Independent Peer Review of the Population Viability Analysis for North Atlantic Right Whales

Center for Independent Experts (CIE)
External Independent Peer Review

by

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1. Executive Summary

The North Atlantic Right Whale (NARW) is one of the world's most endangered marine mammals. Despite protection under relevant legislation in both the United States and Canada, and intensive conservation efforts in both countries, the population has been declining since 2010. In 2018 the National Marine Fisheries Service (NMFS) established the Population Evaluation Tool Subgroup to develop a population viability analysis (PVA) for the NARW. The goal of the Subgroup was to develop a predictive tool that would allow NMFS and its partners to characterize the future population trajectory and extinction risk for NARWs under a variety of scenarios. Development of the PVA is described in "*A Management-focused Population Viability Analysis for North Atlantic Right Whales*."

The present report represents my independent review of the PVA developed by the Population Evaluation Tool Subgroup. It is my overall assessment that the PVA will, indeed, meet the demand for a predictive demographic tool for NMFS and its partners. And, as intended, the PVA will allow: prediction of the future status of NARWs under a variety of conditions; evaluation of the effects of individual anthropogenic threats on the demography of this population; and exploration of the consequences of various management interventions on their recovery. I believe the PVA will prove to be an extremely valuable addition to the conservation toolkit for this species.

It is also my assessment that the draft report considers the best available scientific information for NARWs, including the estimation of cryptic mortality by Pace et al. (2021). The report considers four major issues facing this population, including entanglement, vessel strikes, changes in prey resources, and anthropogenic noise. The two primary anthropogenic threats are entanglement in fixed fishing gear and vessel strikes, including both direct mortality and sub-lethal effects on mortality and reproduction. The PVA deals well with both of these anthropogenic threats and with the effects of a decrease in prey availability. The PVA deals less effectively with the potential effects of noise because we do not yet have direct linkages between exposure to noise and any demographic parameter for NARWs.

The goals laid out in the draft report are appropriate and reflect the clear need for a quantitative assessment tool for NARWs. The five specific objectives reflect typical goals for any Population Viability Analysis (PVA) of an endangered species.

Overall, the general structure of the core age and stage-structured model in PVA is reasonable and reflects the objectives of the approach, the desired model outputs needed to inform management, the current state of knowledge of NARWs, and the anthropogenic threats they face. Certain aspects of right whale demography are simplified in the model, including the assumption that there is no age-based variation in fecundity for mature females. In addition, the model incorporates an unrealistically simple form of density dependence. These simplifications are appropriate, given the current state of the NARW population (well below carrying capacity) and our knowledge of right whale reproduction, but more realistic

simulations could be employed in future iterations. Likewise, the structure of the sub-models used to deal with the effects of mortality, reproduction, entanglement, vessel strike, and prey availability, is generally appropriate. As noted below, I have concerns regarding the sub-model used to estimate the effects of anthropogenic noise.

Parameter estimates for the PVA were developed using historical data from individual right whale sighting histories, mortality records, and an index of prey abundance. We are fortunate to have rich sighting histories of individual NARWs that span decades, derived from photo-identification records of whales contributed by members of the North Atlantic Right Whale Consortium, and curated by the New England Aquarium. In addition, we have extensive, but incomplete, records of right whale mortalities documented by stranding networks in eastern Canada and the U.S. NARWs are stenophagous predators, and primarily consume copepods of the genus *Calanus*, so it is possible to construct an index of prey abundance for the Gulf of Maine, Georges Bank, and Gulf of St. Lawrence. Of course, an index of prey abundance may not accurately reflect the true *availability* of prey to a predator; this may be particularly true for right whales, which are ram filter feeders and require dense aggregations of prey to feed profitably (van der Hoop et al. 2019).

The PVA employs sightings data and information on NARW carcass recoveries from 1990 – 2019 and employs a baseline abundance estimate from 2019. Importantly, the baseline scenario in the model employs a subset of data from the more recent past to parameterize reproductive rates (2010-2019) and injury and mortality rates (2014-2019). I believe this is an appropriate decision, given the changes in these parameters we have observed over the past decade, all of which have worsened the status of the population. Nevertheless, it is important to note that this choice assumes that the current negative conditions, especially with respect to lower prey availability, will persist into the future.

In general, I find the scientific conclusions of the draft report to be sound and interpreted appropriately from the model outputs. The scenarios considered in the report are reasonable, although not exhaustive. The authors have considered the major sources of uncertainty and have included appropriate caveats, where warranted. The *status quo* baseline scenario indicates that the NARW population is likely to continue to decline over the next century, leading to a median reduction of just over half of current abundance and a relatively high (0.684) likelihood of quasi-extinction (fewer than 50 reproductive females) at the end of that period. This rather dire conclusion is, sadly, consistent with our current knowledge of the demography of NARWs.

I have a few suggestions for improvement of the model and recommendations for future work, which are laid out below. However, I believe that the science described in the report is of a very high standard and that the PVA will be extremely useful to managers, scientists, and other stakeholders interested in the future of the NARW. It is clear from even a cursory reading of the report that development of the PVA required an enormous amount of work.

As noted in the draft report, we do not have any clear evidence of a demographic effect of anthropogenic noise on the vital rates of right whales. Instead, therefore, the authors chose to simulate the potential effects of noise through a control parameter in the prey submodel. On Page 32 they recognize that "…*this is a coarse way to represent a reduction in prey accessibility caused by environmental noise limiting the ability of whales to locate and acquire food*…" I agree, but do not believe that this is the most likely potential pathway for the effects of noise on the demography of NARWs. Instead, it is more likely that noise could mask the acoustic signals used by mothers and calves, causing a disruption of the bond between females and their dependent young. However, we have no way to parameterize such an effect. In addition, the approach taken in the draft report assumes that there are no effects of anthropogenic noise other than those experienced on the feeding grounds. Given these limitations in our present knowledge, therefore, I **recommend** that the Noise Submodel be removed from the PVA.

The management regime for NARWs is extremely fluid, reflecting the extremely complex and dynamic policy environments in both the U.S. and Canada. This management landscape is continually changing as new initiatives are developed to address the threats of entanglement and vessel strike, together with the added complications of litigation, at least in the U.S. The authors of the draft report were faced with a complicated decision, therefore, regarding what exactly constitutes a baseline, especially as a series of major mitigation measures are, or soon may be, launched in U.S waters, including the proposed ship strike rule and new measures to reduce the entanglement risk as part of the Atlantic Large Whale Take Reduction Rule. To address this uncertainty in exactly what constitutes 'current conditions,' the authors propose three different baseline scenarios, including the *status quo* (Baseline 1), and scenarios in which injury rates due to entanglement will be reduced by 25% (Baseline 2) or 50% (Baseline 3). Given the enormous uncertainty in what exactly will happen with these initiatives, at least in the very near future, I **recommend** that the PVA include only the *status quo* scenario as a Baseline.

One of the objectives of the work of the PET Subgroup was to *Facilitate communication, outreach, and education with stakeholders and the public.* As the results of the PVA will be of considerable interest to a very broad audience, including fishermen, managers, and other stakeholders, I **recommend** that NMS develop an extended, non-technical summary of the work described in the report, including an explanation of how PVAs are typically used in conservation planning.

I concur with the authors that the PVA should be viewed as a "living tool," which can be adapted, updated, and improved as more information becomes available. The draft report includes several sensible recommendations regarding future model development. I **recommend** that the highest priority of such future work should be to incorporate knowledge of the health status of individual right whales into the model. As the authors note, the core individual-based model is well-suited to the addition of such information, which would likely improve our ability to predict the probabilities of reproduction and mortality at the level of the individual whale.

As a second priority, I support the authors' suggestion that the PVA should be linked to the Decision Support Tool (DST) developed by NMFS as part of the 2021 Atlantic Large Whale Take

Reduction Rule. In the draft report the authors take care to note that "the purposes of the model do *not* include direct links between specific management actions and long-term population dynamics" (Section 2.3.3) and that links between such interventions and changes in demographic rates are the purview of other tools. But, perhaps unsurprisingly, they stray into exploring these linkages in the report, for example in Section 8.3. Therefore, I **recommend** that NMFS support future work to link the DST and PVA in a way that allows managers and other stakeholders to explore the potential demographic consequences of specific management interventions.

I also **recommend** that the authors explore the incorporation of explicit spatial structure into the model. Many PVAs account for spatial structure, especially when there are clear linkages between habitat quality and demographic processes, or in cases where the magnitude of anthropogenic threats varies significantly across the landscape (or seascape). The latter is certainly true for NARWs although, as the authors note, including such spatial structure would require more detailed information on the distribution of whales and the risk of entanglement and vessel strike than currently exists. In addition, the location of a large proportion of the population is unknown for much of the year. Nevertheless, this is an area that might be explored in future iterations of this 'living tool.' As noted in Section 9.3 of the draft report, with additional data it might be possible to separate the risk of ship strike and entanglement in the U.S. and Canada, which would have obvious benefits to the management process.

Finally, given the increasing amount of anthropogenic noise being introduced into the environment of the NARW, together with our uncertainty about the effects of this stressor, I **recommend** that future research address the potential linkages between the exposure to anthropogenic noise and the survival and reproduction of NARWs, so that this factor can be included in future iterations of the PVA.

2. Background

North Atlantic Right Whales (NARWs) are one of the most endangered species of marine mammals. Despite decades of protection under the U.S. Marine Mammal Protection Act, U.S. Endangered Species Act and the Canadian Species at Risk Act, the population remains very small and is declining. The population was estimated to consist of 483 individuals in 2010 (Pace et al. 2017) but declined to about 336 individuals in 2020 (Pettis et al. 2022).

The two primary anthropogenic threats to NARWs are entanglement in fixed fishing gear (primarily pot, trap, and gillnet fisheries) and vessel strikes. Most observed mortality in this population is attributable to these two factors and, apart from neonatal mortality, death from natural causes is rare. In addition, there have been recent changes in the availability of prey (*Calanus* spp.) in the feeding range of this species. The effects of entanglement and ship strike include both direct mortality and sub-lethal effects; this is particularly true for entanglement. Most of the population has been entangled in gear at some point in their lives and a quarter of the population becomes entangled each year (Knowlton et al. 2012). The sub-lethal effects of

entanglement include adverse effects on health, a reduction in overall body size, and decreased reproductive output.

As described in the draft report, there have been several previous demographic analyses of NARWs for the purposes of projecting future population trends and for retrospective analyses of pre-exploitation abundance. In 2018 the National Marine Fisheries Service established the Population Evaluation Tool Subgroup to develop a population viability analysis (PVA) for NARWs. The goal of the Population Evaluation Tool Subgroup was to develop a quantitative, predictive tool that would allow NMFS and its partners to characterize the extinction risk for NARWs under a variety of scenarios. The need for such a PVA was specifically identified by NMFS in its most recent five-year review of the status of NARWs. Subsequent development of the PVA is described in the draft report entitled "*A Management-focused Population Viability Analysis for North Atlantic Right Whales*."

The terms of reference for my review of the PVA and the associated report are as follows:

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.*

3. Description of My Role in the Review Activities

I am a conservation scientist with expertise on the ecology and demography of marine mammal species and my review should be viewed through this lens. The other two reviewers have considerably more expertise in population modeling and population viability analysis; I view my role here to ensure that the PVA is grounded in the best available science on NARWs and that the approach taken is of the greatest possible value to the many stakeholders with an interest in the conservation and recovery of this population.

I was first approached by the CIE to determine my interest in participating in this review in June 2022. I responded in the affirmative and, on August 1st, I was informed that I had been selected as one of the reviewers. I participated in a webinar on August 26th with the other two reviewers

and some of the authors of the report. The webinar was extremely helpful and clarified several questions that we had regarding the report. We had one subsequent e-mail exchange to clarify an additional question; since that time, I have had no contact with the other reviewers, so the present report represents my independent desk review of the PVA.

4. Summary of Findings for Each TOR

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.

As noted by the authors of the draft report, PVAs can be extremely useful in evaluating extinction risk and comparing the potential efficacies of various management interventions. They note many prior instances in which PVAs have been used as an effective conservation tool, including several examples with other marine mammals (Regehr et al. 2015; Runge et al. 2017). It is my assessment that the PVA described in the draft report will meet the objectives of the PET Subgroup and allow NMFS and its partners to predict the future status of NARWs under a variety of conditions; evaluate the effects of individual anthropogenic threats on the demography of this population; and explore the consequences of various management interventions on their recovery. Overall, I believe the PVA will prove to be an extremely valuable addition to the conservation toolkit for this species. The goals of the work laid out in the draft report are appropriate and reflect the clear need for a quantitative assessment tool for NARWs. The five specific objectives reflect typical goals for a PVA of any endangered species.

The desired outputs of the model are reasonable and consistent with the recovery criteria laid out in the U.S. Recovery Plan of 2005 and the Canadian Species at Risk Act (SARA) Recovery Strategy of 2014. The desired demographic metrics for these two management strategies include future abundance, population growth rate, and the likelihood of quasi-extinction. As noted in the draft report, these metrics are all straightforward outputs from the PVA.

Overall, the structure of the model is reasonable and reflects the objectives of the approach, the desired model outputs required to inform management, and the current state of knowledge of NARWs and of the anthropogenic threats they face. The four threats incorporated into the model, entanglement, vessel strikes, changes in prey resources, and anthropogenic noise, are the major known issues facing this population. The two primary anthropogenic threats are entanglement in fixed fishing gear and vessel strikes, which include both effects on direct mortality and indirect effects on mortality and reproduction.

The 'baseline and scenarios' approach described in the draft report is appropriate and will allow managers and other stakeholders to predict the population trajectory of NARWs under baseline conditions and explore the potential effects of various management interventions.

The entanglement and vessel strike scenarios are relatively straightforward and involve varying the incidence and severity of such interactions. However, the approach taken with anthropogenic noise (the *Noise Submodel*) scenario strikes me as slightly odd. As noted in Section 3.5.5 of the draft report, modeling the effects of anthropogenic noise requires evidence that this stressor affects vital rates (survival and/or reproduction). Such an effect could be mediated, for example, if shipping noise interfered with feeding or increased the likelihood of separation of mothers and calves, especially given the very quiet calls made by these pairs (Parks et al. 2019). But, as noted in the report, we do not yet have clear evidence of any demographic effect of anthropogenic noise on right whale demography. Instead, therefore, the authors chose to simulate the potential effects of noise through a control parameter in the prey submodel. I do not see the advantage in retaining this submodel in the PVA given how little we understand about the effects of anthropogenic noise on the vital rates of NARWs and recommend that it be eliminated.

The combined age- and stage-structured approach of the base model makes sense. A fully age-structured model would be preferable, especially if there was evidence of age-related variation in reproductive rates in NARWs, such as a decline in fecundity with advancing age. As far as I am aware, there is no clear published evidence for such age-specific variation in reproductive output in female NARWs (although see Hamilton et al. 1998). We do not know the expected longevity of NARWs but based on the extensive sighting histories of a few animals, including a female that was observed in 1935 with a calf and later resighted in 1995, these are clearly very long-lived animals (Hamilton et al. 1998). Populations with such extended longevity are likely to experience some diminution in fecundity with age, so it would be useful to incorporate age-specific variation in the probability of a female weaning a calf when such information becomes available. Such variation could also influence the reproductive output of younger females. Are first-time mothers, for example, less likely to successfully wean an offspring than older, more experienced females?

The model structure must deal with an awkward mismatch between the reproductive seasonality of NARWs, in which most calves are born during winter, and a census date of July 1st. For example, neonatal mortality (one of the few apparent sources of natural mortality in this population) is incorporated into the early calf-loss rate (κ), and the first survival rate applied to calves is the survival from age 0.5 to age 1.5 ($s1$). It seems that "…calf survival does not depend on survival of its mother…" (P. 25), but what happens to a calf that loses its mother within the first six months of its life?

Given the very low current abundance of NARWs, relative to reasonable assumptions of original population size or carrying capacity, it seems very unlikely that density dependent factors will influence either reproduction or survival within the time frame explored by the PVA. The model considers the future trajectory of the NARW population over the period of a century, which

spans only three or four generations for NARWs. Thus, although biologically implausible, the 'ceiling approach' to density dependence taken by the authors is appropriate in this instance.

It is my assessment that parameterization of the PVA employs the best available science for NARWs, including the important estimation of cryptic mortality by Pace et al. (2021). Good PVAs are data hungry models and this one is no exception. Fortunately, in comparison to most populations of marine mammals, NARWs are relatively well-studied, so we have a rich dataset on the histories of individual whales that serve as the foundation of the core model. Nevertheless, there are still limitations to our understanding of the survival and reproduction of NARWs and, particularly, to the sub-lethal effects of entanglement and vessel collisions. And, of course, there are still many important gaps in our knowledge of the distribution of fishing effort and vessel traffic that limit our ability to fully describe the effects of these threats. This limitation is more acute for the effects of prey limitation and even more so for anthropogenic noise, the effects of which are not captured effectively in the PVA.

It is important to note that the effects of prey availability are linked to an index of the abundance of *Calanus* copepods in the known feeding range of the species in the Gulf of Maine, Georges Bank, and Gulf of St. Lawrence. The feeding range of a significant proportion of the population is unknown, so it is unclear whether this index also reflects the abundance of Calanus populations in these unknown feeding areas. And, of course, an *index* of prey abundance may not accurately reflect the *availability* of prey to a predator; this may be particularly true for right whales, which are ram filter feeders and require dense aggregations of prey to feed profitably (van der Hoop et al. 2019). Nevertheless, the authors of the draft report have done a good job of capturing current knowledge of the prey base of NARWs for the purposes of the PVA.

Many PVAs account for explicit spatial structure, especially when there are clear linkages between habitat quality and demographic processes, or in cases where the magnitude of anthropogenic threats varies significantly across the landscape (or seascape). The latter is certainly true for NARWs although, as the authors note, including such spatial structure would require more detailed information on the distribution of whales and the risk of entanglement and vessel strike than currently exists. This is an area that might be explored in future iterations of this 'living tool.' As noted in Section 9.3, for example, with additional data it might be possible to separate the risk of ship strike and entanglement in the U.S. and Canada, which would have obvious benefits to the overall management process.

The authors take care to note that "the purposes of the model do *not* include direct links between specific management actions and long-term population dynamics" (Section 2.3.3) and that links between such interventions and changes in demographic rates are the purview of other tools. Nevertheless, I agree with their later conclusion (Section 9.2) that an integration of the PVA and these other approaches, such as the Decision Support Tool, is desirable and should be explored in the future. Such integration would allow managers and other stakeholders to explore the population-level effects of various management actions in a way that would allow direct evaluation of the potential benefits in terms of recovery criteria.

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.

The core model employs sightings data and information on NARW carcass recoveries obtained over a three-decade period from 1990 – 2019 and employs a baseline abundance estimate from 2019. Importantly, the baseline scenario in the model employs a subset of data from the recent past to parameterize reproductive rates (2010-2019) and injury and mortality rates (2014-2019). This is an important distinction, and one that deserves greater emphasis in the report. I believe the use of more recent data to estimation reproduction, injury, and mortality, is reasonable, given the changes in these parameters we have observed over the past decade, all of which have worsened the status of the population. If data from the entire period (1990-2019) were used, the baseline scenario would be overly optimistic. Nevertheless, it is important to note that this choice of baseline conditions assumes that the current rather negative conditions experienced by NARWs will persist into the future. It seems to me that this is likely to be true for prey availability and for injury and mortality rates from entanglement and vessel strikes.

I support use of the estimate of abundance for 2019 as a starting value for model projections, even though an estimate was available for 2020. As noted by Pace et al. (2017) the most recent estimate of abundance is likely to be negatively biased because some observations of living whales have not yet been reported.

It is important to note that our knowledge of the causes of mortality of NARWs, even during the 2010-2019 period, are limited. Our knowledge regarding cause of death in NARWs is based on painstaking examination of right whale carcasses by skilled veterinarians, pathologists, and anatomists. Remarkably, in 33 cases for which cause of death could be ascertained in adult or juvenile NARWs from 2003 to 2018, not a single case of natural mortality was identified (Sharp et al. 2019). Five cases of natural mortality were documented in perinatal animals, but it seems that, once a calf survives the rather perilous period around its birth, it is likely to experience very low subsequent rates of natural mortality. A similar pattern was documented in post-mortem examinations conducted between 1970 and 2002 (Moore et al. 2004), although necropsy procedures were not as fully developed during this period. However, as the authors of the draft report note, most (64%) deaths believed to have occurred between 1990 and 2017 were not documented, and cause of death could not be determined even for some recovered carcasses (Pace et al. 2021). Thus, our estimates of the relative importance of entanglement and vessel strike could be biased. Without further direct information on the cause of mortality on a larger proportion of deaths, we cannot assess the possibility of such bias.

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.

In general, I find the scientific conclusions of the draft report to be sound and interpreted appropriately from the model outputs. The scenarios considered in the report are reasonable, although not exhaustive. The authors have considered the major sources of uncertainty and, in general, have included appropriate caveats, where warranted. The primary baseline scenario indicates that the NARW population is likely to continue to decline steadily over the next century, leading to a median reduction of just over half of current abundance and a relatively high (0.684) likelihood of quasi-extinction (fewer than 50 reproductive females) at the end of that period. This rather dire conclusion is, sadly, consistent with our current knowledge of the demography of NARWs.

I do not support the inclusion of three baseline scenarios in the draft report. I recognize that the management regime for NARWs is extremely fluid, particularly at the present time, reflecting the extremely complex policy environment in both the U.S. and Canada. Thus, the authors were faced with a complicated decision regarding what constitutes a baseline, especially as a series of major mitigation measures may (or may not) be launched soon in U.S waters. To address this uncertainty, the authors proposed three different baseline scenarios, including the *status quo* (Baseline 1), and scenarios in which injury rates due to entanglement will be reduced by 25% (Baseline 2) or 50% (Baseline 3). I find this approach to be confusing and unnecessary.

I would also like to see more discussion of the assumptions regarding future conditions, particularly as it relates to patterns of fishing effort. For example, the authors take pains to acknowledge the difficulty of predicting future patterns of future vessel traffic in NARW habitat. On Page 45 they note "*The baseline scenario assumes that current vessel speed regulations will remain constant, as will the overall vessel traffic, thus, the vessel strike injury rate will remain constant over the period of projection.*" The same must certainly be true of future patterns of *effort* in fixed gear fisheries in the U.S. and Canada, especially under different scenarios of climate change. We know that patterns of fishing effort will change, but the PVA assumes that fishing effort will remain constant. And, as noted by the authors, further uncertainty exists regarding future industrial development in offshore waters, such as that associated with renewable marine energy installations. We do not yet understand what effects, if any, such development will have on this endangered population.

Finally, I would like to see a stronger explanation of the limitations of the PVA approach, including an expansion on some of the caveats laid out in Section 8.4. A clear exposition of these limitations would be especially important in any non-technical summary of this work produced for stakeholders outside the scientific community.

5. Conclusions

It is my assessment that the PVA described in "*A Management-focused Population Viability Analysis for North Atlantic Right Whales*" is an appropriate approach that meets the needs of NMFS and its partners responsible for recovery of the North Atlantic Right Whale. Furthermore,

I believe that the report considers the best available scientific information, including data on the demography of right whales and the four major issues facing this population: entanglement; vessel strikes; changes in prey resources; and anthropogenic noise. The use of a subset of recent data to parameterize reproductive rates, injury and mortality rates is appropriate, given the changes in these parameters observed over the past decade, all of which have worsened the status of the population. Finally, the scientific conclusions contained in the report are sound and interpreted appropriately. The major sources of uncertainty have been considered and, in general, appropriate caveats have been described. The primary baseline scenario indicates that the NARW population is likely to continue to decline steadily over the next century, a conclusion that is consistent with our current knowledge of NARWs. Overall, I believe that the science described in the report is of a high standard and that the PVA will be extremely very useful to managers, scientists, and other stakeholders interested in the future of the NARW.

6. Recommendations

As noted in the draft report, we do not have any clear evidence of a demographic effect of anthropogenic noise on the vital rates of right whales. Instead, therefore, the authors chose to simulate the potential effects of noise through a control parameter in the prey submodel. On Page 32 they recognize that "…*this is a coarse way to represent a reduction in prey accessibility caused by environmental noise limiting the ability of whales to locate and acquire food*…" I agree, but do not believe that this is the most likely potential pathway for the effects of noise on the demography of NARWs. Instead, it is more likely that noise could mask the acoustic signals used by mothers and calves, causing a disruption of the bond between females and their dependent young. However, we have no way to parameterize such an effect. In addition, the approach taken in the draft report assumes that there are no effects of anthropogenic noise other than those experienced on the feeding grounds. Given these limitations in our present knowledge, therefore, I **recommend** that the Noise Submodel be removed from the PVA.

The management regime for NARWs is extremely fluid, reflecting the extremely complex policy environment in both the U.S. and Canada. This management landscape is continually changing as new initiatives are developed to address the threats of entanglement and vessel strike, together with the added complications of litigation, at least in the U.S. The authors of the draft report were faced with a complicated decision, therefore, regarding what exactly constitutes a baseline scenario, especially as a series of major mitigation measures are, or soon may be, launched in U.S waters, including the proposed ship strike rule and new measures to reduce the entanglement risk as part of the Atlantic Large Whale Take Reduction Rule. To address this uncertainty in exactly what constitutes 'current conditions,' the authors quite reasonably propose three different baseline scenarios, including the *status quo* (Baseline 1), and scenarios in which injury rates due to entanglement will be reduced by 25% (Baseline 2) or 50% (Baseline 3). Given the enormous uncertainty in what exactly will happen with these initiatives, at least in the very near future, I **recommend** that the PVA include only the status quo scenario as a Baseline.

One of the objectives of the work of the PET Subgroup was to *Facilitate communication, outreach, and education with stakeholders and the public.* As the results of the PVA will be of considerable interest to a very broad audience, including fishermen, managers, and other stakeholders, I **recommend** that NMFS develop an extended, non-technical summary of the work described in the report, including an explanation of how PVAs are used in conservation planning.

I concur with the authors that the PVA should be viewed as a "living tool," which can be adapted, updated, and improved as more information becomes available. The draft report includes several good recommendations regarding future model development. I **recommend** that the highest priority of future work should be to incorporate knowledge of the health status of individual right whales into the model. As the authors note, the core individual-based model is well-suited to the addition of such information, which would likely improve our ability to predict the probabilities of reproduction and mortality and the level of the individual.

As a second priority, I support the authors suggestion that the PVA should be linked to the Decision Support Tool (DST) developed by NMFS as part of the 2021 Atlantic Large Whale Take Reduction Rule. In the draft report the authors take care to note that "the purposes of the model do *not* include direct links between specific management actions and long-term population dynamics" (Section 2.3.3) and that links between such interventions and changes in demographic rates are the purview of other tools. But it seems to me that they stray into exploring these linkages in Section 8.3, for example. Therefore, I **recommend** that NMFS explore the potential to link the DST and PVA in a way that allows managers and other stakeholders to explore the potential demographic consequences of specific management interventions.

I also **recommend** that the authors explore the incorporation of explicit spatial structure into the model. Many PVAs account for spatial structure, especially when there are clear linkages between habitat quality and demographic processes, or in cases where the magnitude of anthropogenic threats varies significantly across the landscape (or seascape). The latter is certainly true for NARWs although, as the authors note, including such spatial structure would require more detailed information on the distribution of whales and the risk of entanglement and vessel strike than currently exists. In addition, the location of a large proportion of the population is unknown for much of the year. Nevertheless, this is an area that might be explored in future iterations of this 'living tool.' As noted in Section 9.3 of the draft report, with additional data it might be possible to separate the risk of ship strike and entanglement in the U.S. and Canada, which would have obvious benefits to the management process.

Finally, given the increasing amount of anthropogenic noise being introduced into the environment of the NARW, together with our uncertainty about the effects of this stressor, I **recommend** that future research address the potential linkages between the exposure to anthropogenic noise and the survival and reproduction of NARWs, so that this factor can be included in future iterations of the PVA.

7. References

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Regehr *et al*. 2015. Resilience and risk: a demographic model to inform conservation planning for polar bears. *U.S. Geological Survey Open-File Report* 2015-1029.

Runge *et al*. 2017. Status and threats analysis for the Florida manatee (*Trichechus manatus latirostri*s), 2016. *Scientific Investigations Report* 2017-5030.

Sharp *et al.* 2019. Gross and histopathologic diagnoses from North Atlantic right whale *Eubalaena glacialis* mortalities between 2003 and 2018. *Diseases of Aquatic Organisms* 135: 1-31.

van der Hoop *et al*. 2018. Foraging rates of ram-filtering North Atlantic right whales. Functional Ecology 33: 1290-1306.

Appendix 1

Bibliography of Materials Provide for Review

Moore *et al*. 2004. Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalaena glacialis*) mortalities (1970-2002). *Journal of Cetacean Research and Management* 6: 199-214.

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Runge *et al*. 2022. A Management-focused Population Viability Analysis for North Atlantic Right Whales. Unpublished document.

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Appendix 2

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

[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; Dr. Jeffrey Hostetler, U.S. Fish and Wildlife Service; Amy Knowlton, New England Aquarium; Dr. Veronique

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:

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:

Diane Borggaard
diane.borggaard@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

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.