Independent Peer Review Report of

Garrison, LP, Litz, J, and Sinclair, C. 2020 Predicting the effects of low salinity associated with the MBSD project on resident common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, LA. NOAA Technical Memorandum SEFSC-XXX

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EXECUTIVE SUMMARY

The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations and specify whether the science reviewed is the best scientific information available.

The purpose of the work to be reviewed (Garrison *et al.*, 2020) is to provide advice on how potential changes in salinity in Barataria Bay caused by flow diversion may affect the survival rates of the resident common bottlenose dolphin population. Garrison *et al.* describes a simulation and the analyses that jointly contribute to it. The simulation relies on inputs from a separate hydrodynamics model and at section II, Garrison *et al.* describe a method for translating the hydrodynamic model forecasts of salinity by observation station to a simulation grid, with bias correction and a derived error distribution to be used in simulation. In order to evaluate how salinity changes caused by flow diversions might impact individual dolphins, Garrison *et al.* superimpose on the grid a distribution of individual bottlenose dolphins based on analysis of sightings data described in section I. Simulations described at section III allow the individual dolphins to move daily in a constrained random walk. The movement is assumed rather than modeled but appears consistent with external information. As individual dolphins move through a daily field of salinity in the simulation, they acquire a dose of salinity which is then converted via a dose:response curve under continuous exposure to estimate dolphin population survival. The dose:response under continuous exposure curve was developed by an expert elicitation process. To estimate population survival, Garrison *et al.* have modeled continuous exposure as the longest single streak, a conservative interpretation.

The report is clear and provides good explanations and arguments for all modeling and analytical decisions. It does not go beyond estimating possible survival rates under varying diversion scenarios superimposed on a range of underlying hydrographs and the authors are careful not to over-interpret results, limiting their final comment only to say that the estimated survival rates under the diversion scenarios would not be sustainable by the population over the near term. Given the estimated rates, which are likely conservative given the longest streak definition, this is a reasonable conclusion.

The project includes a range of analyses and leads to a complex simulation. There is always more that might be done, and a few areas of possible further explanation or analysis are noted. However, none are likely to make a material difference to the final estimates and no recommendations are made to undertake the work. The two most important inputs to the simulation are salinity forecasts from an external model and the dose:response relationship (both the curve and the definition of continuous exposure) developed in an expert elicitation process. Both are beyond the scope of work possible by Garrison *et al*.

The simulation developed by Garrison *et al.* provides a way of moving from data on stations and individuals to wider areas and the population and allows probabilistic estimates of population survival. It adds support and credibility to overall conclusions on how flow diversions might affect dolphin population survival and is fit for purpose.

BACKGROUND

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*

The purpose of the work to be reviewed (Garrison *et al.*, 2020) is to provide advice on how potential changes in salinity in Barataria Bay may affect the survival rates of the resident common bottlenose dolphin population. While not the subject of the paper or of this review, it is clear that results from the reported work will form input to a much wider discussion and decision-making process about the potential cause of the specified salinity changes being considered – the Mid-Barataria Sediment Diversion (MBSD). The Terms of Reference (ToR) for this review are expressed as a set of five questions which relate to technical decisions, analyses, and presentation of conclusions.

Garrison *et al.* (2020) brings together a wide range of complex information from multiple sources and attempts to provide simple, tractable advice based on a complex simulation model, effectively a numerical convolution of salinity fields, dolphin distribution and movement, and a salinity exposure to dolphin survival function. The source of information on potential salinity changes in Barataria Bay is the integrated hydrodynamics, morphodynamics, nutrient dynamics, and vegetation dynamics Delft3D model reported by Sadid *et al.* (2018). Garrison *et al.* use salinity change forecasts from the Sadid *et al.* model but develop a novel bias correction procedure at Section II of their report to make the forecasts useful for the purpose in hand. The Sadid *et al.* model was developed for uses beyond the scope of the Garrison *et al.* work and has not been optimized for predicting salinity fields; it is not the subject of this review but some delving into its limitations is necessary, as is consideration of how Garrison *et al.* generate salinity fields for use in simulations. These issues are covered at Question 2 of the ToR.

Garrison *et al.* bring together information on potential salinity variations across Barataria Bay with information on dolphin distribution and movement to determine exposure of simulated individuals to lowered salinity under varying flow diversion scenarios. The ToR do not pose specific questions on the analyses of dolphin distribution which are reported in section I of Garrison *et al*. However, as part of the exposure simulation exercise, it is considered under Question 3 of the ToR. Question 3 (and Section III of Garrison *et al.*) brings together the exposure simulation with an individual salinity dose-response curve developed using expert elicitation (EE) to estimate how dolphin population survival is potentially affected by diversion options. The EE process and results are considered at Question 3, as is the synthesis of all information and analyses to provide estimates of how diversion scenarios might impact dolphin population survival rates.

Questions 1,4, and 5 of the ToR are general and relate to statistical methods, descriptions of bias and uncertainties, and appropriateness of conclusions, respectively. Questions 1 and 4 especially overlap with Questions 2 and 3. Specific comments are made at Questions 2 and 3 while responses at questions 1 and 4 provide summaries.

REVIEWER'S ROLE IN THE REVIEW ACTIVITIES

*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*

The role of the reviewer is set out in the CIE Statement of Work, Attachment A, attached here in Appendix 2.

There was no review workshop but all materials (see Appendix 1) were provided in advance and a briefing meeting was held by video conference on 26th August. No panel report is required, and all CIE reviewers are tasked with producing independent reviews of the paper by Garrison *et al.* (2020). To that end, I have read all supplied papers as well as a range of other materials necessary to complete the review and prepare this report by the agreed deadline.

Review workshops, presentations, and active questioning are usual for CIE reviews. Amongst other things they help expose reviewer's misunderstandings. The workshop on 26th August was a briefing meeting but not an active workshop with opportunity to delve into the work. The work reported in Garrison *et al.* is complex and detailed and it would be easy to misunderstand aspects of it even though the paper is well-written and clear. I trust I have not misinterpreted or misunderstood any aspects.

SUMMARY OF FINDINGS BY ToR

*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*

The ToR are expressed as five questions, ordered here as Questions 2,3,1,4,5 to keep a logical flow. The questions are highlighted in *purple italics* to distinguish them from the CIE Tor highlighted in *blue italics*.

Question 2 *Is the approach to incorporating uncertainty in Delft3D model predicted salinity values (described in Section II) appropriate, and does the analysis accurately describe and quantify uncertainty where possible?*

Sadid *et al.* describes an advanced mechanistic model integrating hydrodynamics, morphodynamics, nutrient dynamics, and vegetation dynamics. Unlike models familiar in fisheries and population dynamics, it is not fit to data by balancing process and observation errors but is calibrated to external observations from 2014 and then validated using specific observations in a non-calibration year, 2016. Details of the calibration and validation are provided in Sadid *et al*. In essence, standard calibration statistics related to model skill (bias, bias%, correlation, RMSE, RMSE%) for each of water-level, flow, and salinity, are calculated as an annual statistic for each observation station across the spatial domain. For water-level and flow, overall target requirements are set for the station statistics and these are mostly, though not entirely, met (Tables 3.2 and 3.4 of Sadid *et al.*). No overall targets are set for salinity calibration which appears to be subjective following appraisal of all annual calibration statistics (Table 0.3 of Sadid *et al.*) and daily forecasts (e.g., Figure 3.20 of Sadid *et al.*) by station for salinity (as well as for water-level and flow by station). Calibration is best for water-level, less so for flow and least so for salinity.

The hydrodynamics model is jointly calibrated for multiple outputs across a wide area, not just Barataria Bay, but from the perspective of this review, the issue is whether the calibrated model and forecasts of salinity in Barataria Bay are reliable and can be used in the simulation study to advise on how diversion rates might impact on dolphin population survival. Looking in detail at salinity calibration, on a station-to-station basis some of the Barataria Bay stations (e.g., CRMS0178; see Figure 3.20 of Sadid *et al.*) appear to have poor skill. Sadid *et al.*, at their Table 0.3, categorise the forecast at this station to be "fair" even though the absolute forecast minus observed bias is negative 5ppt, or 28%. Biases of this magnitude are potentially critical in forecasting the impacts of salinity change on bottlenose dolphins given the approach taken of defining exposure fields and assessing survivorship effectively based on integrated dosage.

Garrison *et al.* recognise the issue of bias in salinity forecasts and explain in some detail at section II.1 what they refer to as retrospective bias and forecast bias. Garrison *et al.* tackle retrospective bias (i.e., the bias in how well the model fits past and known data, as alluded to above *re* model calibration). They also, however, clearly recognise that salinity forecasts under different diversion scenarios are unquantifiable as it is unknown how well the model can be used to forecast outside the range of previous observations and calibration. Forecast salinity by station in absolute terms but also in how bias may vary depending on diversion scenario are major prediction uncertainties that cannot be addressed within the dolphin survivorship estimation work but might be addressed externally by consideration of the Sadid *et al.* model given these uncertainties potentially affect all subjects of interest in decision-making.

To evaluate potential dolphin population survival under different diversion, and hence salinity, scenarios, Garrison *et al.* develop a grid simulation with salinity values assigned by cell daily in representative years. Individual dolphins are distributed across grid cells and moved according to analyses reported at section I of Garrison *et al.* (see Question 3, below) and an integrated exposure history is developed and used with an individual dose-response function (see Question 3, below) to estimate population survival rates under different diversions.

Given the known retrospective biases in salinity by station in the validation year (2016), Garrison *et al.* have developed a method to bias correct salinity forecasts daily by station to be used in the simulation grid. Garrison *et al.* are clear that the method only attempts to address retrospective bias and not forecast bias. The method relies on the detailed salinity forecasts by hour and station and recalculates the calibration statistics from Sadid *et al.*, plus the standard deviation of the mean bias in daily salinity, and uses a standard partitioning clustering, agglomerative approach (k-means) to allocate stations to clusters to which a distribution of bias corrections to daily forecasts can be applied in the simulations, thus capturing model bias and uncertainty about that bias. The method relies on i) recalculation of calibrations statistics, ii) k-means clustering, and iii) application of a generalized additive mixed model (GAMM) with autoregressive (AR) structure to defined clusters.

The recalculated calibration statistics cover the entire validation year. Garrison *et al.* argue that the RMSE as used for calibration and validation is a measure of prediction accuracy but the standard deviation of the bias is the more appropriate measure of variability in the bias estimate required for simulation purposes. This is reasonable. Ultimately, Garrison *et al.* develop a by-cluster distribution of bias by clustering on the mean daily bias (MBE), RMSE, sd(MBE), as well as salinity, and east and north dimensions.

The k-means analysis uses standard approaches and packages in R. All are well explained and tabulated/graphed. The cluster number is fully explored and the choice of two clusters is reasonable and supported by the analyses (se Figure II.6). Looking at Figure II.5 and Table II.1, it appears the main cluster separation is by the north variable with a division near 3260000 as well as distinctly by negative *vs* positive mean bias. Cluster 1 stations all display salinity positive bias. Cluster 1 is more northerly and includes stations with lower salinity and little or no dolphin distribution; if clustering is stretched to four clusters then stations with no dolphins (USGS1 and USGS3) are split off entirely from cluster 1. Cluster 2 has more stations including those associated with greater dolphin density and with negative salinity bias (e.g., CRMS0178). The cluster optimization statistics (Figure II.6) do not support the use of 3 clusters but it is interesting that the split off, third cluster in Figure II.5 is of stations slightly but not distinctly westward within Cluster 2 but with higher sd(MBE). If followed through with an additional GAMM, this would lead to a flatter parametric bootstrap distribution for the new cluster, but the bias would be less than for the currently defined Cluster 2 and it is unclear that it would have any material impact on final results. Overall, the clustering approach is appropriate, has been carefully implemented and reasoned, and the outputs are intuitively reasonable.

Bias is not expected to be constant through time as salinity is autocorrelated at each station. Garrison *et al.* account for this by applying GAMMs with AR structure, again applying a known package within R. The GAMMs allow the daily mean bias across stations within a cluster to be modelled while the AR structure allows for autocorrelation in the daily series. Within clusters, random effects are assumed for stations. Fits to the GAMMs with a three-day autocorrelation term reduce the residual correlation and appear to be supported for both clusters 1 and 2 (Figures II.9 and II.12 respectively). The patterns of daily bias are perhaps surprisingly well fit by such a simple model (Figures II.10 and II.13) given the complexity of the data but there is a remaining high degree of variance on a daily basis, especially at cluster 2. This is reflected in the resulting parametric bootstrap distributions for the two clusters (Figures II.12B and II.14B).

However, the resulting distributions are applied in the simulation at a cluster level and scrutiny of Figure II.13 for cluster 2 (arguably the most influential on final dolphin survival rate results) is interesting. On a station by station basis, many of the 2016 observations lie outside the 95% CIs of the GAMM predictions, suggesting the bias correction distribution may be too narrow, though there is no indication it is itself biased. In simulations, the cluster 2 bias correction of predicted salinities will generally be in the region of -2.15 to -2.5ppt. From visual inspection of relevant stations in Figure II.2, this seems reasonable.

Overall, the approach to incorporating uncertainty in Delft3D model predicted salinity values is appropriate. The analysis accurately describes and quantifies uncertainty about Delft3D salinity predictions and forecasts and develops a credible method for bias correcting Delft3D daily salinity predictions for each cluster of stations used in the simulation model. Uncertainty in the bias correction, especially at cluster 2, may be underestimated but the bias correction itself appears to be reliable. Some exploration of 3 clusters (splitting cluster 2) would be interesting but predicting its impact is difficult as GAMMs would need to be refit to develop new mean bias distributions and all simulations would then need to be redone. Garrison *et al.* clearly distinguish between retrospective bias and forecast bias. The methods developed deal with the former only.

Question 3 *Does the low salinity exposure model (Section III) adequately and accurately describe and account for the various sources of uncertainty? Are the key model inputs described and do they represent the best available data?*

The low salinity exposure simulation model incorporates four components: i) the daily projected salinity field (see question 2) run for representative years in multiple “cycles” (decades) under different diversion scenarios, ii) bias corrections to the salinity fields based on Garrison *et al.* section II (see Question 2), iii) a distribution and movement model of dolphins applied to the daily salinity field forecasts to develop an exposure history (Garrison *et al.* section I), and iv) application of a dose-response curve developed using expert elicitation (EE) to the exposure history to estimate how different diversions affect dolphin survival (Garrison *et al.* section III). All four components are used in the simulations to develop advice on how alternative diversion scenarios might impact bottlenose dolphin survival rates. Here, at Question 3, the need is to examine (iii) and the use of all components in the simulation

<u>The Distribution model and Movement</u>

Section I.2 of Garrison *et al.* is a brief but clear summary of extensive design and field work. It builds on referenced previous studies and is taken at face value. My only comment is that at speeds of up to 30km/h, conducting surveys in up to Beaufort Sea State 4 may not be ideal from a sightings perspective as opposed to a mark-recapture one. However, as the Barataria Bay and Estuarine system (BBES) is enclosed, perhaps this is not as problematic as in open seas. I am confident in the experience and expertise of the researchers.

I am confident the abundance estimation based on capture-mark-recapture models and photo-identification is reliable, but for this review it is not actually pertinent except as background and for providing insight that assists interpretation. The work is impressive and adds considerably to knowledge, but the key focus here needs to be on estimation of the spatial distribution as used in the simulation grid. Together with the forecast daily salinities and assumptions about movement, it defines the exposure history of dolphins to which the dose:response curve is applied.

Sightings, not photo-id, data are used to define spatial distribution. They come both from during the photo-identification survey itself but also from “off survey” periods within the survey timeframe. The coverage of the BBES is extensive and the metric used for defining density is sightings per unit effort (SPUE) where sightings are numbers of dolphins per 100m of trackline, estimated for 500mx500m cells within a grid. Using SPUE to estimate relative density by cell relies on consistent probability of detection from the trackline and transect width but no data or analyses are presented by Garrison *et al.* to support that this is the case. Given the survey occurred over a 19-day window and potentially in sea states up to BSS 4, in areas spanning Barataria Pass to small embayments, it is not obvious that the probability of detection from the trackline would have been constant. Nor is it clear that while in survey mode, were the tracklines for sightings as used for SPUE the same as those for the mark-recapture efforts including diversions to photograph dolphins? If so, this could severely impact SPUE consistency. Sightings work was not conducted as part of a dedicated sightings/distance survey to estimate abundance and it is unclear from the description if sighting protocols were designed or *ad hoc* and if detection functions can in fact be estimated to support the assumption of consistency. It would be helpful in the report to have less on abundance estimation but more on sightings protocols, including in relation to the mark-recapture work, information (e.g.) on variations in effort, and relevant statistics to support the use of the spatial distribution results.

To develop a spatial distribution across the entire simulation grid, Garrison *et al.* fit the SPUE data using a simple Generalized additive Model (GAM) following standard approaches and using a known R package and assumed error structure (Tweedie to account for overdispersion and zero counts). The GAM fitting makes well-justified assumptions and fits to the mid points of the SPUE cells (as x and y coordinates) and distance from the Barataria Pass, and uses an offset term to account for variable effort by cell. The model is deemed to fit well and the summary statistics at Table I.7 support this except that the deviance explained is very low. Residuals are skewed negative for all variables (Figure I.7) and the residual plot for "North" especially seems somewhat visually inconsistent with the approximate significance reported at Table I.7. As noted by Garrison *et al.*, however, the predicted *vs* observed SPUE suggests an overall good fit (Figure I.8). It is unclear if the GAM was fit directly or if it was chosen following wider exploration.

Overall, the approach taken to estimating the spatial distribution for use in the simulation model uses available data to good effect, notwithstanding some concerns about the quality of those SPUE data and low explanatory power of the surface fitting. Uncertainties associated with the SPUE are not explored in detail but are acknowledged. It is unclear if the sightings work was designed or *ad hoc* and whether distance statistics by cell (or groups of cells) are available. The GAM as fit is straightforward and is a reasonable approach to using the gridded SPUE to develop a spatial density distribution. However, as Garrison *et al.* state in the final sentence of section I, *the simulated dolphin spatial distribution is an important factor in the model outcomes*; it would be helpful in the report to provide more support for the choice of the GAM and, if data are available, to explore covariates.

At section III.4, Garrison *et al.* recognize the assumption that the spatial density distribution from the GAM is based only on data for late March 2019 and is assumed to be representative for all years and at all times of the year. This is a major potential uncertainty with the simulation and hence overall results. If spatial distribution varies seasonally and annually depending on flow, salinity, prey availability, and other factors, then the sole starting distribution may be unrepresentative and final results misleading. Garrison *et al.* note at section I.4 that the distribution is consistent with the observed limited exchange of dolphins between regions observed in 2019 and previously and that dolphins in BBES have limited home ranges. Wells *et al.* (2017) reports on ranging patterns of bottlenose dolphins in BBES based on satellite telemetry and tag deployments in 2011, 2013, and 2014. The Wells *et al.* study suggests high multi-year site fidelity and constrained utilization distance, with few, limited excursions outside of the Bay area, providing strong support for the use of the single spatial density. However, though the study spans a period of stress following the Deepwater Horizon oil spill, there remains uncertainty as to how the spatial density distribution might be affected by persistent changes in the environment caused by any diversion scenarios. The individual dolphin tracks suggest core areas of activity but do show wider movements into other BBES areas and the tagging appears to have been concentrated near the Barrier islands rather than further north into the central bay.

In the simulations, dolphins are assigned randomly onto the grid using the relative densities from the GAM. Dolphins are then moved daily using a constrained random walk favoring nearby grid cells and with a daily maximum movement of 5km, argued by Garrison *et al.* to be consistent with telemetry studies of Wells *et al*. The Wells *et al.* study uses daily telemetry data, but it is not clear in the paper what daily maximum movements were observed; perhaps the Garrison *et al.* argument is based on personal communication or familiarity with the data. Garrison *et al.* describe the movement algorithm used in the simulation and illustrate some simulated individual dolphin movement simulations in Figure III.5, noting these are consistent with movements seen by Wells *et al*. This is a limited, subjective validation of the movement algorithm but it would be interesting to see how simulated movement distributions for individuals starting from cells in which dolphins were tagged in the Wells *et al.* study. These could then be compared to dolphin movement histories and estimated kernels in the Wells *et al.* study.

Expert Elicitation of the dose-response curve

Modelling the salinity field and dolphin distribution and movement is complex but supported by extensive data. In contrast, there is no data available to estimate the relationship between the salinity exposure (dose) and its effect on individual dolphin survival (response). Defining this dose:response relationship is a key step to allow simulation of how alternative diversion scenarios might affect population level survival. Expert elicitation (EE) is a process used to represent expert knowledge and understanding as a probability distribution. Even absent data, information still exists and can be harnessed in a structured process. EE is a now well-used process in multiple fields, including conservation (e.g. McBride *et al*, 2012). The purpose of EE is well summarized by Garthwaite *et al.* (2005): *Much of the literature on elicitation has been concerned with formulating a probability distribution for uncertain quantities when there is no data with which to augment the knowledge expressed in that distribution. This situation arises in decision making, where uncertainty about the 'state of nature' needs to be expressed as a probability distribution in order to derive (and then maximise) expected utility. Similarly, it arises in the use of mechanistic models. Such models are built in almost all areas of science and technology, to describe, understand and predict the behaviour of complex physical processes. The user is required to specify the values of appropriate model inputs, in order to run the model and obtain outputs, but there is generally uncertainty about the 'true' values of the inputs. It is then important to formulate that uncertainty and to propagate it through the model so as to quantify the uncertainty in model outputs.*

Understanding sub-lethal effects on populations is a major problem and defining the bottlenose dolphin dose:response, with no directly-relevant data available, is an issue well suited to use of EE where a wealth of understanding and knowledge can still be drawn on, both on bottlenose dolphins in Barataria Bay, including related to the Deepwater Horizon oil-spill, and marine mammal responses elsewhere. The decision-making process requires input and recourse to EE is reasonable. Critical to the use of EE in decision-making processes is that the expert(s) involved is (are) judged to be impartial, and that the process is well facilitated and ordered, asking the right questions. The EE process and debrief are available as presentation files for this review (Booth *et al.*). The facilitation team from the UK Sea Mammal Research Unit (SMRU) is well-qualified and has facilitated EE on a range of marine mammal sub-lethal impacts problems, including elsewhere in the USA. The SHELF (Sheffield Elicitation Framework) tools used for the EE are freely available, well-documented, and much used (https://rdrr.io/cran/SHELF/). It is not entirely clear which experts were involved in the EE process but from the presentations by the facilitators (Booth *et al.*), consideration of the EE workshop non-SMRU presenters list and shape outputs suggests a number of at least 4 and perhaps 7. In passing, it would be interesting to compare the experts and process used for the EE with those used to advise on post DWH oil-spill disease as reported by Schwacke *et al.* (2017). The structured questioning and considerations evident in the Booth *et al.* presentations indicate a high level of engagement and the resulting dose:response curve is shown in Garrison *et al.*, Figure III.3. It is important to recognize that EE is an expert as opposed to stakeholder process, with the purpose of representing trusted expert knowledge in a form suitable for use in the decision-making process. The resulting dose:response curve and its associated uncertainty become given inputs to the simulation model. The EE process uses a Delphi approach to develop a single expert-based distribution and alternatives are not provided.

Two things require brief comment. First, it is unclear in the EE questions or in Garrison *et al.*, why a salinity of less than 5ppt is chosen as a fixed component of the dose:response curve. This could be further explained but in fact seems well-founded (see, e.g., Hornsby *et al.*, 2017). Second, the definition of *continuous exposure* is not clear from the EE process. This is considered by Garrison *et al.* who adopt a definition of "longest streak" as "the longest stretch of continuous days below 5ppt with breaks of 2 days or fewer". This is recognized as conservative but is a reasonable interpretation.

<u>Simulating how survival may be impacted by different diversion scenarios</u>

The final simulations bring together all the preceding model components as outlined in Garrison *et al.* at section III.1. In total, for each diversion scenario applied to representative years of specific decades with varying hydrographs (i.e. water flow daily profiles), 1,000 simulations incorporating Sadid *et al.* model daily salinity forecasts for standardized grid cells (not observation stations) of 500mx500m, uncertainty as modelled for the bias corrections by cluster, randomly (weighted) drawn initial dolphin locations by grid cell, constrained daily random walks to other cells, and random selection from the individual dose:response curve.

The description in Garrison *et al.* is generally good but would benefit from simplification at the third paragraph of section III.1 and a table showing the cycles (i.e., decades) and representative years, together with a summary statement about flow rates and patterns of hydrographs, as well as a clearer explanation of the "alternate hydrographs". Are cycles required at all, or would it be simpler just to report by a set of representative years? It is unclear how alternate hydrographs in 1994, 2006, 2010, and 2011 can apply to "each" cycle and why 1994 is an alternate when it is already the representative year for the 1990s cycle. The purpose of simulating with the range of cycles and representative years needs to be clarified but is not directly referenced in the discussion at section III.4. Presumably, and given all analyses are for a single year, it is to cover a wide range of flow rate baselines against which the diversion alternatives will have greater or lesser impact? This is hinted at in the results under "survival rates". Note that at section III.1 paragraph 3, the representative year for cycle5 is stated as 2008; presumably, this should be 2018? Also, as diversion scenarios are referred to as "alternatives", it is a bit confusing *cf "*alternate".

Results are presented on the initial distribution and movement histories which is useful, if not for validation (see above), then at least to build credibility. Results for annual population survival at No Action and three diversion alternatives are shown for cycle0, representative year (i.e., the 1970 hydrograph) overall and by regions of BBES. In addition, results are shown for the alternate hydrographs (1994, 2006, 2010, 2011) and for the different representative hydrographs (1975, 1985, 1994, 2008, and 2018 (stated as 2008)). Results are tabulated but also shown as box and whisker plots with probabilities of differences between No Action and specified diversion alternatives. The text presentation of results at section III.3 is comprehensive and careful, providing a simple interpretation. It is good that the overall No Action survival rate for cycle0 of 0.890 (0.753-0.982) is consistent with those from Schwacke *et al.* (2017), providing, alongside the movement histories, confidence in this No Action effective baseline against which comparisons are made.

The results clearly show how population survival might be impacted by the alternative diversion scenarios, given the models and assumptions, with no obvious surprises. Increasing diversion flows reduce salinity, causing longest streak estimates to increase and survival estimates to decline. As predicted, in low flow years annual population survival is higher (0.950 [0.861-0.997] in 2006 *vs* 0.890 [0.753-0.982] in 1970) and the impact of increased diversions is also smaller (Table III.3) and not significant (Figure III.11). For all simulation years other than 2006, all three diversion scenarios result in reduced annual population survival.

Question 1 *Are the statistical approaches applied in each section of the document appropriate to the problems addressed and are the results properly supported considering the available input data and statistical assumptions?*

Statistical approaches applied are considered section by section (of Garrison *et al.*)

Section I (*Photo-identification Capture-Mark-Recapture Study and Abundance Estimation*)

The title of section I does not refer to the data collection and analyses of interest to this review – estimating the spatial distribution of bottlenose dolphins in Barataria Bay. This perhaps reveals an underlying problem in that the estimation of the distribution is apparently secondary and relies on data (SPUE) which were not the primary focus for field work aimed at abundance estimation. Potential issues with the sightings and effort data are not discussed in detail and there is no obvious consideration of their reliability for use in the one statistical approach applied (GAM). Some exploration of the sightings against the tracklines would be useful. Assuming the SPUE data are reliable and the probability of detection from the trackline is constant across cells, then the application of the GAM is straightforward, using a known, transparent, and freely available R package. Variables are limited and an offset is used to allow for variable effort. Implementation appears to be appropriate given the data available and consideration of model diagnostics is sound. The model does not have great explanatory power, but the fit appears sufficient to allow use of the estimated spatial distribution to be used in the simulation exercise.

Section II (*Prediction Bias and Uncertainty in Delft3D Outputs*)

Two statistical approaches are applied at section II: i) a cluster analysis to determine regional clusters of station annual salinity bias patterns (from modeled forecasts of daily salinities by station by Sadid *et al.*), to which ii) GAMMs are applied to develop regional (i.e., cluster) specific bootstrap distributions of mean annual bias to be applied in the simulation to grid cells within regions. This is the crux of the simulation, forming the link with salinity forecasts by the hydrodynamics model to dolphin distributions and low salinity exposure.

The cluster analysis uses a standard partitioning and agglomerative approach implemented in known, transparent and freely available R packages. The clustering approach used is appropriate given the data, recalculated validation statistics from Sadid *et al.* including the addition of sd(MBE) and geographic variables. The analyses are clear and well-described, and the definition of the two regional clusters is well-supported.

GAMMs with autoregressive components are used to estimate the mean and variance by region of annual estimation bias of salinity estimates from the Sadid *et al.* model. GAMMs are used to model how the day of the year affects mean bias using autoregressive terms to allow for serial autocorrelation by station. GAMMs also allow stations to be treated as random effects, a reasonable assumption given the prior clustering. The approach is appropriate, and the analyses use a known, transparent and freely available R package. The implementation appears sound, with clear reasoning for the models used, and choice of autoregressive terms. Fits to daily salinity biases are good.

Section III (*Low Salinity Exposure Model and Predicted Impacts of the MBSD on Survival Rates*)

Section III does not have any statistical analyses but brings together all other model components into the simulation. The expert EE process uses tools (SHELF) to represent expert judgment as probability distributions but Garrison *et al.* does not, and need not, consider that.

Overall, Garrison *et al.* apply appropriate statistical approaches in each section. The statistical approaches are all implemented using well-known and freely available R packages, and all analyses are well-argued and the results supported. Statistical assumptions are sound. The analyses rely on external data and model outputs and represent a considered and valid approach to ensuring those data and outputs are appropriately used in the simulations of dolphin population survival under alternative diversion scenarios. The only concern is with the sightings and effort data analyzed to determine an initial dolphin distribution to be used in simulations. More explanation of those data and exploration of their consistency with assumptions would be helpful.

Question 4 *Have the sources of uncertainty and caveats in the analysis been adequately described? Is the treatment of the bias and uncertainty in the analysis adequate given the scope and scale of the project? Are there additional potential sources of uncertainty that can be quantified and should be incorporated into the model?*

Garrison *et al.* are very careful and precise in discussing major uncertainties and unknowns. For example, it is made clear that: i) while the bias correction approach using clustering and GAMMs attempts to deal with retrospective bias in salinity estimation, it is not possible to deal with forecast bias, which is beyond the scope of the project; and ii) the "longest streak" definition is conservative due a range of uncertainties and unknowns. In general, Garrison *et al.* clearly explain assumptions and uncertainties. The only place in the report where an uncertainty is acknowledged but arguably not explored sufficiently is at section I where further exploration of uncertainties associated with sightings and effort data would be helpful. Arguably, more supporting information might also have been added at section III to explain the choice of the 5ppt salinity cut-off and the longest streak definition. Garrison *et al.* do reflect on the longest-streak and conclude it is likely conservative while the 5ppt was a given to the Garrison *et al.* project from the EE process.

Whether other sources of uncertainty should be incorporated into the model depends on how the model outputs will be used in a decision-making context. It is unclear if detailed estimates are required of probabilities, which are likely to be precisely wrong, or whether the focus might be on developing roughly right but robust conclusions. It is an interesting conundrum for advisors using complex models, which create expectations of highly detailed and precise results. Given the uncertainties in all aspects of the simulation model, striving for robust advice would seem preferable. This creates a focus on bias and robustness testing.

Garrison *et al.* have attempted to bias correct salinity forecasts and have developed a credible approach. Whether final advice on dolphin population survival would be impacted by alternative analyses is moot. Further clustering and refitting of GAMMs to develop finer bootstrap bias distributions is possible and could be used for sensitivity testing, but it is a large job and would probably not affect the overall mean survival estimates which are fundamentally driven by the salinity forecasts from the Delft3D model. Revisiting the spatial distribution analysis might also be considered to allow some sensitivity testing, but it is unlikely to lead to any major differences. Consideration of the estimates of longest streak vs survival at section III, and the very wide distribution of the dose:response curve (Figure III.3), suggests it is likely that any amount of re-analysis at sections I and II will be swamped by the dose:response curve under the longest-streak definition.

The wide dose:response distribution is a reflection of uncertainty expressed by experts, but the key aspect of the curve that matters to advice on how population survival might be impacted by diversion scenarios is the main relationship, also a reflection of expert knowledge and judgment. Bypassing the complex simulation, the Delft3D model forecasts large changes in salinity across Barataria Bay under diversion scenarios in all but low flow years. Given individual bottlenose dolphin survival is affected by salinity, the dose:response curve, applied under a longest-streak definition, is the main driver of advice.

Results on population survival are provided under a range of past hydrographs with salinity forecasts or a range of alternative flow diversions. The range of hydrographs is used to reflect possible variation in future hydrographs.

Question 5 *Are the conclusions presented appropriate and supported by the available models and data?*

Garrison *et al.* at section III.4 restrict commentary to a clear description of results, external observations that support the results, and uncertainties. Three major uncertainties are highlighted: i) forecast error, iii) future climate impacts on water flow, and iii) the longest-streak definition. The concluding paragraph is to the point and does not overelaborate. Overall, the conclusions are appropriate and are supported by the available models and data.

CONCLUSIONS AND RECOMMENDATIONS

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***

Garrison *et al.* describes a simulation and the analyses that jointly contribute to it. The simulation relies on inputs from a separate hydrodynamics models and at section II, Garrison *et al.* describe a method for translating the hydrodynamics model forecasts of salinity by observation station to a simulation grid, with bias correction and a derived error distribution to be used in simulation. In order to evaluate how salinity changes caused by flow diversions might impact individual dolphins, and dolphin population survival, Garrison *et al.* superimpose on the grid a distribution of individual bottlenose dolphins based on analysis of sightings data described in section I. Simulations then allow the dolphins to move daily in a constrained random walk. The movement is assumed rather than modeled, but appears consistent with external information. As individual dolphins move through a daily field of salinity in the simulation, they acquire a dose of salinity which is then converted via a dose:response curve under continuous exposure developed by expert elicitation to estimate dolphin population survival. In order to estimate population survival, Garrison *et al.* have modeled continuous exposure as the longest single streak, a conservative interpretation.

The report is clear and provides good explanations and arguments for all modeling and analytical decisions. It does not go beyond estimating possible survival rates under varying diversion scenarios superimposed on a range of underlying hydrographs and the authors are careful not to over-interpret results, limiting their final comment only to say that the estimated survival rates under the diversion scenarios would not be sustainable by the population over the near term. Given the estimated rates, which are likely conservative given the longest streak definition, this is a reasonable conclusion.

There is always more that might be done. In this case, more explanation of sightings and effort data as used to develop the distribution of dolphins would be helpful. However, it is not likely to make any material difference to overall conclusions and it is not therefore suggested that there should be a full re-analysis. Similarly, while an extension of clustering and GAMM exploration for bias correction and distribution definition would be interesting, it again is not likely to make a material difference to conclusions and is not suggested as being necessary. Outputs from EE processes are in a sense immutable. They are based on condensation and translation of expert judgment. One aspect of the EE output had to be interpreted by Garrison *et al.* and their use of the longest streak is reasoned but acknowledged as conservative. Likely alternatives would lead to lower estimates of population survival. It does not seem necessary, therefore, to explore alternative definitions though it would be relatively simple, presumably requiring outputs from existing simulations. I do not recommend any further analyses.

Ultimately, the estimates of population survival under alternative diversion scenarios depend most critically on corresponding salinity forecasts and the individual dose-response relationship (both the curve and the definition of continuous exposure). The simulation provides a way of moving from stations and individuals to wider areas and the population and allows probabilistic estimates of population survival. It adds support and credibility to overall conclusions and is fit for purpose; it is important not to get distracted by details related to specific statistical analyses that may have no bearing on final advice.

APPENDIX 1

The reviewer report shall include the following appendices:

a. Appendix 1: Bibliography of materials provided for review

Bibliography of materials provided for review

Prior to the Workshop, all materials were provided *via* Google Drive:

- Booth, C. Summary of an Expert Elicitation on the Effects of Exposure to Low Salinity in Estuarine Bottlenose Dolphins. Presentation.3
- McDonald, T. L., F. E. Hornsby, T. R. Speakman, E. S. Zolman and others. 2017. Survival, density, and abundance of common bottlenose dolphins in Barataria Bay (USA) following the Deepwater Horizon oil spill. Endang Species Res 33:193-209. https://doi.org/10.3354/esr00806
- Sadid, K., Messina, F., Hoonshin, J., Yuill, B, Meselehe, E. 2018. Basinwide Model Version 3: Basinwide model for mid-Breton Sediment Diversion Modeling. The Water Institute of the Gulf. Prepared for and funded by the Coastal Protection and Restoration Authority under TO51. Baton Rouge, LA.
- Schwacke LH, Thomas L, Wells RS, McFee WE and others (2017) Quantifying injury to common bottlenose dolphins from the Deepwater Horizon oil spill using an age-, sex- and class-structured population model. Endang Species Res 33:265- 279. https://doi.org/10.3354/esr00777
- Wells, R. S., L. H. Schwacke, T. K. Rowles, and others. 2017. Ranging patterns of common bottlenose dolphins Tursiops truncatus in Barataria Bay, Louisiana, following the Deepwater Horizon oil spill. Endang Species Res 33:159-180. https://doi.org/10.3354/esr00732

Following the workshop, an additional paper was provided:

- Booth, C. Debrief of an Expert Elicitation on the Effects of Exposure to Low Salinity in Estuarine Bottlenose Dolphins.

Additional references are:

- Garthwaite, P.H., J.B. Kadane, A. O'Hagan (2005) Statistical Methods for Eliciting Probability Distributions. Journal of the American Statistical Association 100:470, 680-701
- Hornsby, F.E, T.L. McDonald, B.C. Balmer, T.R. Speakman, K.D. Mullin, P.E. Rosel, R.S. Wells, A.C. Telander, P.W. Marcy, K.C. Klaphake, L.H. Schwacke (2017) Using salinity to identify common bottlenose dolphin habitat in Barataria Bay, Louisiana, USA. Endangered Species Research 33:181-192
- M.F. McBride, S.T. Garnett, J.K. Szabo, A.H. Burbidge, S.H.M. Butchart, L. Christidis, G. Dutson, H.A. Ford, R.H. Loyn, D.M. Watson, M.A. Burgman (2012) Structured elicitation of expert judgments for threatened species assessment: a case study on a continental scale using email. Methods in Ecology and Evolution 3:906–920

APPENDIX 2

The reviewer report shall include the following appendices:

b. Appendix 2: A copy of the 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

Predicting the effects of low salinity exposure associated with the Mid-Barataria Sediment Diversion project on resident common bottlenose dolphins (Tursiops truncatus) in Barataria Bay, LA.

Background

The National Marine Fisheries Service (NMFS) is mandated by multiple statutes 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 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 and 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

The Mid-Barataria Sediment Diversion (MBSD) project is part of the State of Louisiana's Coastal Master Plan to mitigate the long-term effects of land and marsh loss. The MBSD project is a multi-decade project that is designed to reconnect the flows of freshwater, sediment, and nutrients from the Mississippi River into the northern portion of the Barataria Basin on an annual basis. In the current planning phase, several possible maximum outflow volumes are being considered, with the preferred alternative (Applicant's Preferred Alternative) capping the maximum instantaneous inflow from the project at 75,000 cubic feet per second. The actual amount of freshwater outflow into the Basin would vary depending upon Mississippi River flow volumes.

While the MBSD project is projected to create new wetlands and reduce the net land loss over the 50-year project life, the annual influx of large volumes of freshwater is expected to result in significant changes in this estuarine system. In particular, there is a resident population of common bottlenose dolphins (Tursiops truncatus) which is expected to experience increased exposure to low salinity water on an annual basis during the MBSD operations compared to projected conditions without the diversion. Prior studies have demonstrated that exposure to low salinity water can have negative effects on bottlenose dolphin health and survivorship. Previous studies have also demonstrated that resident populations in estuarine systems maintain strong site-fidelity even in the presence of negative environmental changes or depletions in prey availability.

In this analysis, NMFS developed a simulation approach to evaluate the probable effects of changes in salinity in Barataria Bay, LA associated with the Mid-Barataria Sediment Diversion (MBSD) project on the resident common bottlenose dolphin stock. Daily salinity surfaces from the Delft3D hydrodynamic model were used to assess the changes in the distribution of low salinity (<5 ppt) in the Bay and subsequent projected impacts on the bottlenose dolphin population. We used information on the initial spatial distribution of dolphins, simulated dolphin movements, modelled exposure to low salinity, and an expert elicitation-based dose-response curve relating exposure to low salinity to survival to estimate expected annual survival rates for the bottlenose dolphin population. This analysis focusses exclusively on the survival impacts of low salinity exposure in a given year and does not consider other ecological or environmental effects or cumulative effects over time.

The outcome of this analysis, along with information on other potential impacts of the projects on bottlenose dolphins, will be used to inform an Environmental Impact Statement under the National Environmental Policy Act (NEPA) and the Natural Resource Damage Assessment (NRDA) Restoration Plan under the Oil Pollution Act (OPA) to determine the probable level of impact to bottlenose dolphins from the MBSD project under a range of possible diversion scenarios.

Given the importance and magnitude of the MBSD project, it is important that the science used to predict potential impacts on survival rates in this marine mammal population represents the best available science. Therefore, the CIE reviewers will conduct a peer review of the scientific information in the low salinity exposure model based on the Terms of Reference (TORs) referenced below. Given the public interest, it will be important for NMFS to have a transparent and independent review process of the model used in this assessment.

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

Requirements
NMFS requires three (3) reviewers to conduct an impartial and independent peer-review following 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, (2) quantitative ecology, and/or (3) ecology, physiology, or population dynamics of bottlenose dolphins.

Tasks for Reviewers
1) Review the following background materials and reports before the review:

Booth, C. Summary of an Expert Elicitation on the Effects of Exposure to Low Salinity in Estuarine Bottlenose Dolphins. Presentation.

McDonald, T. L., F. E. Hornsby, T. R. Speakman, E. S. Zolman and others. 2017. Survival, density, and abundance of common bottlenose dolphins in Barataria Bay (USA) following the Deepwater Horizon oil spill. Endang Species Res 33:193-209. https://doi.org/10.3354/esr00806

Sadid, K., Messina, F., Hoonshin, J., Yuill, B, Meselehe, E. 2018. Basinwide Model Version 3: Basinwide model for mid-Breton Sediment Diversion Modeling. The Water Institute of the Gulf. Prepared for and funded by the Coastal Protection and Restoration Authority under TO51. Baton Rouge, LA.

Schwacke LH, Thomas L, Wells RS, McFee WE and others (2017) Quantifying injury to common bottlenose dolphins from the Deepwater Horizon oil spill using an age-, sex- and class-structured population model. Endang Species Res 33:265-279. https://doi.org/10.3354/esr00777

Wells, R. S., L. H. Schwacke, T. K. Rowles, and others. 2017. Ranging patterns of common bottlenose dolphins Tursiops truncatus in Barataria Bay, Louisiana, following the Deepwater Horizon oil spill. Endang Species Res 33:159-180. https://doi.org/10.3354/esr00732

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 report consistent with the PWS. Each CIE reviewer shall complete the independent peer review in the 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 September 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	Milestones and Deliverables
Within two weeks of award	Contractor selects and confirms reviewers
No later than two weeks before the review	Contractor provides the pre-review documents to the reviewers
August 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
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NMFS, Southeast Fisheries Science Center
75 Virginia Beach Dr.
Miami, FL 33149
305-322-0768

Annex 1: Peer Review Report Requirements

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

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the TORs.

3. The reviewer report shall include the following appendices:

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

Annex 2: Terms of Reference for the Peer Review

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

Garrison, LP, Litz, J, and Sinclair, C. 2020. Predicting the effects of low salinity associated with the MBSD project on resident common bottlenose dolphins (Tursiops truncatus) in Barataria Bay, LA. NOAA Technical Memorandum SEFSC-XXX, 85 pgs.

The reviewers will provide input on the following questions:

1. Are the statistical approaches applied in each section of the document appropriate to the problems addressed and are the results properly supported considering the available input data and statistical assumptions?
2. Is the approach to incorporating uncertainty in Delft3D model predicted salinity values (described in Section II) appropriate, and does the analysis accurately describe and quantify uncertainty where possible?
3. Does the low salinity exposure model (Section III) adequately and accurately describe and account for the various sources of uncertainty (e.g., uncertainty in the Expert Elicitation dose-response model, abundance estimation, and dolphin movement model)? Are the key model inputs described and do they represent the best available data?
4. Have the sources of uncertainty and caveats in the analysis been adequately described? Is the treatment of the bias and uncertainty in the analysis adequate given the scope and scale of the project? Are there additional potential sources of uncertainty that can be quantified and should be incorporated into the model?
5. Are the conclusions presented appropriate and supported by the available models and data?