Center for Independent Experts (CIE) Independent Peer Review

Review of Aquaculture Opportunity Areas Atlases for the Gulf of Mexico and Southern California Bight

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EXECUTIVE SUMMARY

This document includes the desk review of the Aquaculture Opportunity Atlases developed by NOAA for the Gulf of Mexico and the Southern California Bight. The purpose of these atlases is to identify locations that might be suitable for the development of Aquaculture Opportunity Areas (AOAs) for offshore aquaculture. Both atlases follow the same structure and match the traditional scientific journal article style with an introduction, methods, results, and discussion. The atlases are very technical and focus on a detailed explanation of the methods, data layers used during the process, and description of the suggested AOAs. The discussion covers most of the limitations of the methodological approach.

The elaboration of the atlases relied on stakeholder consultations to define what would be needed for aquaculturists, to gather data, and to understand potential conflicts, particularly with the military, fishing industry, and protected resources. The technical aspects are well described, and the general methodological approach is state-of-the-art. The AOAs are not focused on any particular type of aquaculture, and this explains why the methodology is divided into two major steps, “suitability model” and “precise siting”. While the first step aims to minimize conflict, the second aims to prioritize siting based on general oceanographic characteristics that are assumed to be ideal for aquaculture development.

Although is difficult to determine if additional data layers could be added to the analysis, as this would require a deep knowledge of existing data for these two areas, the amount of data layers is impressive, and it suggests that the authors carried out an excellent and thorough search. A detailed evaluation of dataset comprehensiveness could be carried out in the next phase, Programmatic Environmental Impact Statement (PEIS), which will require a more detailed spatial analysis. The study also involved an analysis of data quality, which ensures that only information that meets certain standards is included in the decision-making process. Accordingly, the standard methodology and the comprehensive set of data layers suggest that the report includes the best scientific information available.

The major recommendations to improve the documents are related to the potential misleading expectations related to the fact that the atlases are framed in the context of Marine Spatial Planning, but only provide a component of that process. Some methodological aspects should also be clarified for the sake of transparency. This is particularly relevant when dealing with a contentious topic like aquaculture. Finally, some assumptions and limitations could be further discussed. In particular, there is a lack of discussion about the uncertainties in the process. Acknowledging those uncertainties and targeting specific areas with the highest uncertainty will not only increase the transparency of the process, but it will also be useful in order to guide the next steps of the development of offshore aquaculture in both areas of interest (i.e., PEIS).

BACKGROUND

Aquaculture production is increasing as the demand for seafood increases worldwide (FAO 2020). In general, seafood is one of the most commonly traded commodities in the world. The onset of the COVID-19 pandemic also emphasized the role of seafood in food security. In particular, this has raised the relevance of aquaculture products as a means to mitigate the reliance on importing seafood and consequently ensuring food security at the national level. Along these lines, as stated in the Gulf of Mexico Atlas, the "Presidential Executive Order 13921 (E.O.), *Promoting American Seafood Competitiveness and Economic Growth* (May 7, 2020), called for the expansion of sustainable seafood production in the U.S. to ensure food security; provide environmentally safe and sustainable seafood; support American workers; establish coordinated, predictable, and transparent federal actions; and remove unnecessary regulatory burdens."

The current understanding of how aquaculture should be managed relies on the Ecosystem Approach to Aquaculture (EAA), a strategy proposed by the Food and Agriculture Organization (FAO) in 2008 (Soto et al. 2008). The EAA embraces the fact that aquaculture is part of the wider social-ecological system, and consequently, it needs to consider other human activities as well as the natural ecosystem. The implementation of EAA is based on the following principles:

- Aquaculture development and management should take account of the full range of ecosystem functions and services, and should not threaten the sustained delivery of these to society,
- Aquaculture should improve human well-being and equity for all relevant stakeholders, and
- Aquaculture should be developed in the context of other sectors, policies and goals.

Marine Spatial Planning (MSP) focuses on minimizing conflicts of interest among stakeholders, allowing for an efficient zoning of the coastal and marine areas (Douvere 2008). Consequently, MSP could be a tool to guide the expansion of aquaculture while embracing EAA principles. The full implementation of MSP is a complex process that requires a series of stages to ensure a successful outcome, from data gathering, to stakeholder engagement, scenario analysis, conflict resolution, and adaptive management plans, among others. A vital step common to all MSP processes is data gathering and the development of tools that allow the exploration of different scenarios as alternatives.

The two atlases reviewed in this document represent that specific stage of the MSP. The atlases provide compilations of the best information available to guide decisions on where offshore aquaculture could be emplaced. Furthermore, the atlases provided a methodology to suggest Aquaculture Opportunity Areas (AOAs) where conflict with other activities could be minimized. The goal of this review is to provide an independent critical assessment of both atlases (Appendix 1) articulated around four Terms of Reference (Appendix 2).

DESCRIPTION OF THE REVIEWER'S ROLE IN THE REVIEW ACTIVITIES

As a CIE-appointed reviewer, I was asked to conduct an impartial and independent desk review of the Aquaculture Atlases for the Gulf of Mexico and Southern California (Appendix 1 for full references). In preparation for the peer-review process, and as one of the tasks described in the Performance Work Statement (PWS, Appendix 2), I read the background documents to become familiar with the Aquaculture Opportunity Areas initiative and the process that led to the final documents under review.

I had the opportunity to ask questions about the process during an online meeting. We had a general conversation about expectations, structure of the documents, and logistics. During the meeting, Dr. James Morris provided a general informative overview of the Atlases. The structure of the documents to review, which follows a traditional scientific paper, and the nature of a desk review make my role straightforward and familiar, as it matches the traditional peer-review process followed by most scientific publishers. Following those clarifications, I proceeded to independently review the documents following the Terms of References described in the PWS (Appendix 2 – Annex 2). This review document was organized following the structure described in the peer-review report requirements section of the PWS (Appendix 2 – Annex 1).

My general approach to the review was to provide comments that aim to improve clarity and avoid potential ambiguities. Furthermore, based on the structure of the PWS, my review is organized following a tabular structure, which will facilitate any actions that the authors would like to take.

SUMMARY OF FINDINGS FOR EACH ToR

The desk review focused on the four Terms of References (ToR) defined in the PWS (Appendix 2 – Annex 2). For simplicity, each ToR is presented below (in *italics*) before the review assessment, which is framed around strengths and weaknesses as per the work statement.

ToR #1: Methods

> "*Please provide comments on the methodology, assumptions, or other factors described within the draft reports to inform siting of aquaculture. Are the scientific methods sound, the assumptions reasonable, and analyses logical? If you find that justification is lacking or specific information was applied incorrectly in reaching conclusions, please specify in your comments.*"

Based on the description of the ToR, the analysis of strengths and weaknesses required in the PWS will focus on the Material and Methods sections of both documents. Page number indicates the pdf page, not the page numbers of the documents as this could be confusing as numbering re-started after one of the sections in the GOM document.

Strengths

The study areas and the general workflow are clearly described. Furthermore, the general workflow is logical and uses a standard method commonly available in the literature. It is important to state that there are other workflows available in the literature that could differ from the one presented in Figure 2.5; however, the one in Figure 2.5 contains all essential steps to guarantee the successful application.

In general, the method is clear and objective, and addressing the specific question of the ToR, I found that the scientific methods are sound, the assumptions reasonable, and analyses logical. The comments in the "Weaknesses" section aim to improve the clarity of the document as they are not major weaknesses that would require reanalysis of the data.

The precautionary principle is implicitly considered in each step, e.g., setback definitions, which is a crucial component of modern management and a way to embrace ecosystem-based management. Although ToR #4 indicates that aspects related to legal and policy matters should be avoided, it is important to highlight that some of the setbacks that come from regulations seem very narrow, particularly the 500-ft setbacks, as this distance could be within the area of influence of a fish farm (Weitzman et al. 2019). These aspects should be carefully considered in the next step (PEIS).

Weaknesses

The first document that was peer-reviewed was the Atlas for the Gulf of Mexico (GOM hereafter). Accordingly, most of the references target that document. Due to the similarities in the methodological section between GOM and South of California (SOCAL hereafter), the same comments for GOM apply to SOCAL unless otherwise stated. Furthermore, in few cases, specific aspects related to SOCAL are described in detail in the review. This applies to the analysis of the other ToRs.

Page 46 (GOM): "Supplemental information was also collected via listening sessions initiated through NOAA's 11 Request for Information (RFI) in the Federal Register (85 FR 67519; October 23, 2020)." What is this supplemental information? How was it used? It is unclear after reading the methods. I assume that this supplemental information was used to determine what layers were important to consider, but it is not clear. From the offshore aquaculture perspective, it is clear that industry was consulted to determine what is needed for successful aquaculture; however, it is unclear what supplemental information means. As I mentioned, I

assume that the relevant layers were identified by these engagements and the literature review, but for the sake of objectivity, it is important to disclose why the used layers were deemed relevant for the analysis. If this completely relies on the literature review, the outcomes of that review should be more obvious. Also, the description of the literature review as well as the outcomes of that process could be further clarified. For example, what type of review was done? Was it a systematic review? Scoping review?

Figure 2.5 (GOM): I believe that Figure 2.5 could be improved. For example, there are layers from the data inventory that are used for the Precise Siting Analysis, e.g., oceanography data during the among-cluster model. Accordingly, an arrow from 5 to 8 in Figure 2.5 would provide a better description of the information flow.

Building upon the previous example about oceanography data, current velocity is very valuable information for aquaculture siting, and it could be argued that it is needed upfront, at least for some species, but in this case, that information is used in the refining steps. Accordingly, the authors could expand the description of the steps in Figure 2.5. For example, it could be argued that given that critical variables for aquaculture suitability are not included in the "suitability model", the "suitability model" aims to discard areas that are not suitable for aquaculture rather than optimizing the use of space targeting aquaculture. For example, if current velocity is not suitable for aquaculture, aquaculture will not happen, but this area could be easily found in a high-high cluster, which could be misleading if the goal of the "suitability model" is not clarified. Rather than "to identify the grid cells with the highest suitability for aquaculture development in the study areas", it could be "to identify the grid cells with the lowest conflict between new aquaculture and other human activities in the study areas". I assume that given that the AOAs are not focused on any particular type of aquaculture, which increases the complexity of the approach, the authors divided the methods into two major steps, "suitability model" and "precise siting". While the first step aims to minimize conflict, the second aims to prioritize siting based on general oceanographic characteristics that are assumed to be ideal for aquaculture development. Clarifying the goals of each component could improve the reader's interpretation of the general process.

Page 55 (COM): "Small variations to the Lightsom et al. (2015) categorical framework…" The categorical framework could be explained here as it is not clear for the reader.

Page 55 (GOM): "Data were checked for completeness and quality". How was this process done? Any objective criteria? This could be briefly explained in the text or in the appendices. In page 71, a similar comment could be made when the authors state "A final QA/QC on all data layers was performed before data were utilized in the final submodels and model.". Also, a QA/QC analysis should not be done at a final step. It should be done at the beginning, unless this only applies to the layers that were not part of the suitability model, but included in the precise siting analysis.

Page 55 (GOM): The section Data is not comprehensive. The following data are described: NMFS Protected Resources, Bathymetry, Vessel Traffic, Deep-sea Coral Observational Data (1985 – 2021), Fish Havens, Oceanographic Data, Water Quality Data, Commercial and Recreational Fishing Data, Harmful Algae Blooms (HABs) (*Karenia brevis*) (2000 – 2018), but this is not a comprehensive description of all data layers used in the decision-making process. The authors need to justify why these layers warrant further explanation and why other layers are not part of this extended description.

Page 57 (GOM): For clarity, explain what "n" means in the equation of the product method.

Page 64 (GOM): "This submodel structure ensures that each is given equal representation in the final suitability model regardless of how many data layers are present in each submodel" needs to be reconciled with page 70 "No weights were applied to data layers or submodels." Although no weights were used, it is true that each submodel is given an equal representation. Both sentences in the same document can create confusion to the reader regarding the method that has been used.

Page 66 and 67 (GOM): Figures 2.9 and 2.10 are not well explained. The equations presented in the figures should be described in detail. What are a and b? These parameters must be described in the text because they determine what is a 1 and a 0 in terms of suitability. With the current description, the reader could think that the lowest value of the dataset gets the lowest (or highest) suitability, which is not necessarily true as this depends on the parameters a and b. For example, 0 vessels could be a 1, but 200 vessels could be a 1 too as the threshold for suitability could be 205. These thresholds need to be carefully described. As written, it is not clear how this was done. These thresholds are not clear in the Appendix either and the columns Range, Foot and Ceiling seem to suggest that the thresholds a and b were not used. Furthermore, the text should be better explained, particularly '…. the Z-membership function was used to represent this interaction within the suitability model, as this function uses polynomial curves created by using the minimum and maximum values of each dataset (Figure 2.7) (Landuci et al. 2020). One is added to the maximum value of each dataset to ensure that no cells are given a score of '0'. Numerical data were never given a '0' as this would remove the grid cell from the analysis." In addition, although Figure 2.10 presents the case of increasing suitability with the number of observations, this case is not described in the text. This is exemplified by the fact that Figure 2.10 is not mentioned in the text. I realized that this happens at several places in the manuscript. Also, in some situations, the authors cited figures in an unconventional order. For example, Figure 2.12 is mentioned before 2.11. This should be revised throughout the document.

SOCAL: Related to the previous comment, an equivalent of Figure 2.10 from GOM is missing in SOCAL.

Page 70 (GOM): “After the suitability scores were determined for each study area, an analysis was performed to describe the data most influential in removing area for each submodel” What type of analysis? This is the methodological section and these aspects should be clear.

Page 71 (GOM): Regarding “Local Index of Spatial Association”: It seems that this process is to identify statistically significant clusters that are high-high. Do I correctly understand that in the maps, e.g., Figure 2.12, categories will be high (coming from LISA), unsuitable (coming from constraint layers), and moderate, which would be all areas minus high and unsuitable? Also, it is unclear why the maps in the results section are divided into four categories.

Page 72 (GOM): “An attempt was made to minimize bias through the implemented unweighted approach”. This is unclear. What type of bias? Note that an “unweighted” approach is a particular case of a weighted approach in which equal weight is given to all layers. I am not sure if the unweighted approach will be discussed later in the document, but this statement in the methods is a bit out of place as it requires a discussion about the assumptions behind the approach and the inclusion of the broader literature about pros/cons of both approaches.

Page 73 (GOM): “Notably, each of these potential limitations were best addressed within the data obtained and processed for analysis, and the analysis itself.” This is unclear.

Page 73 (GOM): Figure 2.11 has weights; however, as it was stated above, weights were not used. The figure increases uncertainty about the methodology used. Also, Figure 2.11 is cited a couple of times in the document adding uncertainty (see comment below). The “equal weights” is indeed the “unweighted” approach, but this clarification could be added to the legend to avoid ambiguities.

Page 74 (GOM and SOCAL): “Next, all remaining areas within that cluster were examined to determine if additional sites less than 2,000 ac were present.”. This is unclear because in Figure 2.12 there is overlap between small and large areas. Furthermore, Figure 2.9 in SOCAL is different despite using the same methodologies. In SOCAL, it seems that overlap is obvious. I think that this step needs to be clarified. Furthermore, if multiple 2,000 ac areas are selected, how is the best one identified if several ones result in the same scoring in the within-cluster step? This is possible taking into account the resolution of the hexagonal grid and the resolution of the layers. This is not a big deal from the operational perspective, but it is important to be clear in the methodology.

Page 74 (GOM and SOCAL): Would the results be impacted if rectangles were used instead of squares in the precise siting?

Page 67 (SOCAL): I was expecting to see an among-cluster section; however, this is not developed in the same way as in the GOM. Again, this is not a big deal from the methodological perspective; however, the text of SOCAL must be adapted because the following is stated: "The 2019 vessel traffic data were used in the suitability model, with the number of vessels transiting a grid cell being counted for the entire year. For the within- and among-precision siting models, mean vessel traffic from 2015 through 2019 for transits through the site was utilized" despite the fact that there is no "among-precision siting".

Page 74 (GOM): "All potential sites identified within a single high-high cluster were ranked using the within-cluster model, which is structured to identify the highest suitable site according to closest proximity to an inlet, relatively low fishing effort, and relatively low vessel traffic (Figure 2.11, Figure 2.13)." This is unclear, as Figure 2.11 and Figure 2.13 show different models. The same approach, citing two figures happens later with 2.11 and 2.14. Also, the configuration of Precision Siting Model needs to be justified. Why those layers? This is particularly relevant for layers like AIS, which is in the general suitability model, but also in the refinement, and for the Meteocean data, which is in the Precision Siting but not in the general scoring. Actually, this could be problematic as it was stated above. What if the current speed and waves are not good for aquaculture? Areas *a priori* identified as high suitability could be deemed not appropriate based on these layers. Accordingly, a justification for the exclusion of these layers from the suitability model is needed.

Page 75 (GOM): Among cluster: what if there are two potential AOA within the same cluster that meet the dispersion criteria (this could happen in a large cluster)? One of the potential AOA would be directly discarded and perhaps a less suitable AOA from another cluster could be selected.

Page 83 (GOM): the concept "geographically distinct study area" could be misleading. Clarify.

Summary

As stated above, the methods are standard. The authors designed a protocol in which some layers of information were selected and grouped around five areas, one of them being a set of constraint layers. Using a geometric mean, the areas were combined into a single scoring for each of the considered hexagons in the area of interest. Furthermore, additional information was used for a refined analysis to locate ideal AOA within the areas that scored high in the suitability analysis. In addition to the technical aspects highlighted above, the major points for clarification are related to the transparency that is required when siting a contentious activity such as aquaculture in the open ocean. These aspects are:

1) Why these layers? The authors talked about stakeholder engagement, and based on a preliminary conversation, the number of meetings to gather information was outstanding;

however, it is only clear how this information was used in the context of defining areas that would be suitable for aquaculture, not areas that would be non-suitable. If the selection of layers did not come from the engagement but it came from a literature review, they need to be justified.

2) How are these layers used? How are a and b calculated in the re-scaling? It is currently unclear as the equations are not described. These technical aspects are explained with detail in the previous sections (*Weaknesses*). Although the clarity of setbacks was a strength, it is also important to consider them in the PEIS and this could be disclosed in the discussion.

3) What is the uncertainty of the process? See also my general comment below. Although this exercise is not a MSP per se, as MSP implies a stronger collaboration among stakeholders and rightsholders in the decision making process, the atlas provides a valuable tool to inform MSP and more importantly, guidance on AOA. The authors state this in the introduction, and the requirement of additional steps to fully complete a MSP process, but despite the disclaimer, the results aim to inform MSP in regard to AOA and could be used in further steps, e.g., environmental impact assessments. Accordingly, an assessment of uncertainty should be done or at least clearly stated in the discussion, so decision-makers understand that these are the best selected AOA based on the criteria defined in the Atlas. For example, the authors state that no weighting of the different layers was done. Accordingly, within each category of the suitability model (Figure 2.8 in GOM), all layers contribute equally. This assumption could be challenged by different stakeholders and impact the results of the AOA as the authors stated in the methods. For example, a common approach in MSP is to provide weights to each layer of information. An easy example could be related to fishing activities of two species, one that contributes to the economy with $100 and the other with $1. If they are treated as contributing equally, some fishers could challenge the approach and require that the species that contributes the most be weighted the most. The authors clearly stated that weighting was not the goal, but the pros and cons of this approach must be addressed; otherwise, the issue is disclosed but not considered when recommendations are made. This could be added to the discussion.

ToR #2: Data quality and appropriateness

> "*Please consider the accuracy, quality, appropriateness, and application of data considered in the spatial analyses. If any additional relevant data or information exists that was not considered and should have been, please specify in your comments.*"

Based on the description of the ToR, the analysis of strengths and weaknesses required in the PWS will focus on the Results of both documents.

Strengths

The assessment of accuracy and quality of the data are at the core of this ToR. This is very hard to assess due to the number of layers and the multidisciplinary knowledge that would be required to evaluate the information included in the analysis. However, the authors have been very transparent with the sources, and Appendix A is outstanding. Nevertheless, as it was highlighted above, the authors should improve the description of the QA/QC in the methodological section. There are some statements about data accuracy and quality scattered through the document, but this should be more transparent and formal. Finally, additional data could be available but not added to the set of layers. This is hard to evaluate as it needs to be assessed by an expert in the area. Although it seems that the compilation of layers is outstanding, the authors could add a disclaimer for the PEIS step in which the existence of other local data is assessed.

Regarding appropriateness, and from my perspective, I think that this is the major strength of the analysis. The authors have included a plethora of datasets and it seems a very thorough and comprehensive analysis. Data gaps are possible, and local experts' knowledge could provide a more precise assessment; however, from my perspective, the layers that the authors included are appropriate and they support the recommendations that the authors have pushed forward.

Finally, the criteria for using the data are very clear. Although some aspects need to be clarified in the methodology, the tables are very informative, and the reader becomes rapidly familiar with how the information is applied. It is important to highlight a relevant aspect, which is going to be very valuable for potential development: the description of the AOA is outstanding. I have seen descriptions of AOA or equivalent types of figures in the past and the synthesis provided in the Atlas, together with the information and links in the appendices, constitutes a major strength that could be readily used by industry to make a decision regarding the viability of the different AOA. It could be argued that time series of environmental data could be provided, but I think that this is a good start. In addition to the detailed description of the AOA, I found particularly useful the commonalities presented in SOCAL at the end of the Results section. A similar section exists for GOM, but it is shorter than for SOCAL.

Following the same approach for the previous ToR, the weakness section includes a series of recommendations and suggestions that could improve the atlas.

Weaknesses

Page 87, Table 3.1 (GOM): Two layers, SUA and UXO-polygon, which are included in Table 2.5, are not included in this table. I think that they should be included as there is nothing in the text to explain their absence. I did not exhaustively check the other submodels due to the

lack of time, but a thorough review to ensure a perfect match would be good before the final release of the atlas.

Page 89 (GOM): It is unclear how the suitability was categorized. What is high, moderate, and low in terms of values? Is this a relative scale? High in a relative scale could be a 0.05. Considering that there is a clear, predefined range from 0 to 1, and the need for transparency, the values from the suitability model should be disclosed. This is also related to the comment in the previous ToR about the LISA step (LISA categories: high-moderate-unsuitable and final maps categories: high-moderate-low-unsuitable). This comment applies to all maps in the document.

Page 113 (GOM): The same issues with scales apply to the fishing data. The scale is relative and not absolute, which limits the interpretation of the data layer. For example, the absolute scale would provide a better understanding of the validity of the unweighted approach and potential biases.

Page 118 (GOM): In the section about the constraints, the wording could be misleading. The area could be removed for several reasons, but in some instances, it read as “An additional 15.2% of the Central study area …” which suggests an incremental or stepwise approach in the percentage of removed area. The text should be adjusted for clarification.

Page 120 (GOM): “The top three ranking AOA options per study area were identified using the Among-Cluster precision siting model with each study area producing two 2,000-ac AOA options and one 500-ac AOA option for a total of 4,500 ac per study area.” Why one 500-ac? The priority was large areas. For example, it seems that W-8 could accommodate a 2,000-ac AOA. Based on this uncertainty and after re-reading the introduction, I consider that the objective of the general process should be clarified in the section “AOA Identification Process”. There is a general objective that tackles the identification of areas, but the specific aspect of dividing the total area into four sub-regions, and equally distributing 3 AOA per sub-region could be clarified as part of the goal/strategy rather than a posteriori during the Results section. This is also relevant to standardized methods and applies to SOCAL. In SOCAL, as it was stated above, the among-cluster approach is not part of the methods. Similarly, the dispersion of 30nm is not included in the decision to identify AOAs. For a reader of both documents, it would be better to have a common methodology and include the decisions as part of the general objectives or guiding criteria. For example, if the objective of the Atlas is to identify, for example, 10 AOAs, in the methods, the authors could add a sentence “if possible, these 10 AOAs will be separated by at least 30nm to increase the diversity of areas…”. In that way, the reader would be able to see the same method in both atlases and the decision-making process would be fully transparent. Otherwise, the question is obvious, why are 30nm needed in GOM and not in SOCAL?

Page 126 onwards - Tables 3.8, 3.9, and 3.10 (GOM): Re-scaling models during the "among-cluster" step could be misleading. Let's say that clusters A, B, and C score 0.99, 0.98, and 0.97, respectively, in one submodel, and 0, 0.5, and 0.99 in another submodel. After the re-scaling, clusters A and C would score the same, but the suitability of cluster C is higher. Perhaps I misinterpreted the methods regarding how the rescaling works. I understand that the rescaling is done to maximize differences, and this could be done in the within-cluster without major biases because all potential AOA are very close and the differences in scores among them is expected to be small. However, when comparing potentially distant clusters during the among-cluster rescaling, the potential artefact highlighted above could play a role. Again, I want to re-emphasize that this could be a matter of my understanding of the methods.

As it could be derived from these comments, the suggestions/clarification are related to the use of the data and not the data itself. The same comments apply to SOCAL, and consequently, no additional detailed comments are added in relation to that document.

Summary

Following the previous ToR, and the general quality of the document, the authors have accomplished this ToR; however, for the sake of transparency and clarity in the communications process, the following considerations could help to improve the Atlas:

1) As it could be derived from strengths and weaknesses, and building upon the assessment of the previous ToR, the comprehensive collection of data layers is impressive. The number of selected layers covers the different models with rigor. The division of the layers into four submodels, "National Security", "Industry, Navigation, and Transportation", "Natural and Cultural Resources", and "Fisheries and Aquaculture" covers the major potential conflicts of offshore aquaculture. However, just to embrace uncertainty, the authors could recognize that additional layers could be available and the PEIS step could be a good moment to refine this information at the local scale. As it was mentioned above, the use of biophysical criteria that are relevant for aquaculture is restricted to the precise siting step, which could lead to potentially conflicting AOA that are suitable from the perspective of avoiding conflict, but are simply not ideal for aquaculture. This is not a strong criticism, but I think that the objective of the "suitability model" (step 6 in the step-by-step process) must be clarified. From my perspective, it is a model that does not inform about suitability for aquaculture, but about potential spatial conflicts. The "precision modelling" is the only one that brings some oceanographic data that could be relevant for optimizing aquaculture. The goals of both steps in the modelling procedure should be clarified.

2) One of the key components of the ToR is about accuracy and quality, which are difficult to evaluate for the reviewer as it would require access to the raw data and description of the layers, which in multiple cases is only available upon request and could require security clearance. Based on the links disclosed in the appendices, the process for data selection is very

transparent, and relied on contrasted sources. Therefore, a preliminary analysis suggests that the data are probably state-of-the-art, and the quality is the best that can be accessed. The authors also highlighted in some examples the limitations of the datasets, e.g., regarding resolution, which suggests that data quality was a crucial consideration during the construction of the atlas. Nevertheless, there are some loose ends in the description of the methodology (see detailed comments in the *Weaknesses* section) that should be clarified to ensure how data quality was determined. I recognize the complexity of describing this for such a large number of data layers; however, the general principles to guide these decisions could be articulated and described in a general table. I do not think that this should be described for each layer, but for example a guiding principle like "Layers with a spatial resolution under X km were discarded due to the limited power to discriminate AOA" or "Layers with a percentage of missing data over X% were discarded due to the potential bias on AOA selection", etc.

3) The ToR also focuses on the application of the data, and several aspects have been highlighted in the previous ToR regarding methodological aspects. However, when discussing how the data are used, it is important to touch on two aspects. The first one is the use of relative scales. I understand that the general goal of this exercise is to prioritize areas and it is not that relevant if an area gets a 0.4 or a 0.99, and LISA provides the potential of grouping them (despite the issues regarding clarity highlighted above). However, given that all layers were standardized to a range between 0 and 1, it would be nice to see the final score of the suitability model. I am very aware that prioritizing an area with a score of 0.4 could be seen by citizens or organizations opposed to aquaculture as a very low score; however, I think that not showing the score of the suitability model provides opponents with a direct argument to challenge the prioritization. I think that the absolute values should be shown and the explanation of how the model works should be further explained. This would be aligned with my general comment that this exercise is a tool, a process that informs MSP, but it is not MSP itself (see general recommendations).

4) Building up on the previous point, the authors disclosed the scores for the precise siting, which were rescaled to 0-1. That rescaling presents some advantages, but it also presents some potential issues, if I properly understood the rescaling procedure. In any case, beside the specific issue highlighted in the *Weaknesses* section regarding the potential bias of the rescaling process with the selection of the AOA, disclosing these values can also bias the perception of the reader. The rescaling brings the scores of the optimal AOAs to values close to 1, which could be misleading, as the reader could think that given that they are close to 1, they must be very suitable. I think that the use of rescaling should be further justified to eliminate these potential biases.

5) Finally, another minor comment is the need to align, or at least clarify, the objectives regarding where the areas should be identified. The selection of 3 AOA per area in GOM could be seen as subjective. What if most of the suitable footprint is on a single area? I understand the approach of identifying three (3) areas per sub-region, and the fact that this is a tool to

inform MSP; however, these aspects that could exert a bias on the outcome, e.g., the selection of poor (or poorer) areas because they are in a different subregion. Accordingly, the general objectives should be clarified to indicate upfront and not through the methods and results, that the goal is to distribute the AOA as much as possible along the study area.

ToR #3: State-of-the-art

> "*In general, does the draft report include and cite the best scientific and commercial information available? Are assumptions and uncertainties addressed fairly and clearly, where appropriate? If not, please explain.*"

Based on the description of the ToR, the analysis of strengths and weaknesses required in the PWS will focus on the Discussion of both documents.

Strengths

The discussion is brief but with a strong focus on assumptions and uncertainties, addressing the limitations of the study. In fact, some of the comments highlighted above are mostly addressed in the discussion. For example, while the introduction of the Atlas is a bit ambiguous regarding the objective, the following statement is outstanding and clearly describe the purpose of the study: Page 284 (GOM): "This Atlas was developed for the specific purpose of identifying locations that might be suitable for locating AOAs and includes limitations specific to that purpose."

Some of the limitations or approaches that are discussed could be introduced above to avoid uncertainty until the end. For example, the consultation with stakeholders is unclear in the methods and it is much clearer in the discussion; accordingly, clarification in the early parts of the document would help the reader.

The lack of inclusion of potential climate change effects is disclosed in the discussion, which is very relevant. At the same time, this could be considered a weakness as layers such as storminess could be relevant for planning in the long-term. In any case, it is clarified, which is probably enough, taking into account the scope of the work.

Weaknesses

As stated above, it seems that the stakeholder consultations were useful to determine aquaculture criteria, mostly in terms of bathymetry, and data availability. Data gathering was particularly relevant in the case of national security, fishing community and protected resources. This is not bad, but could be misleading in the context of marine spatial planning (MSP). In the context of MSP, consulting stakeholders has a broader connotation, which is not

part of the process carried out in the elaboration of the atlases, and consequently, the current wording could be misleading. For example, during the preparation for the review process I could access the negative opinion of citizens about the process and aquaculture in general as part of Docket ID: NOAA-NMFS-2020-0118. Request for Public Input. Accordingly, when I read in the methods "Based on all the information collected through engagement and outreach, study areas were identified and delineated from the AOI for spatial modeling for potential AOAs in federal waters of the Gulf of Mexico", together with the emphasis on MSP in the introduction, it generated expectations regarding an inclusive process. Indeed, this is not observed in the methods/results and it is clearly disclosed in the discussion by stating "This stakeholder process was not a consensus building or task force-driven process that included prescribed representation. The goal of this study was to produce descriptive analyses that provided in-depth understanding of constraints and opportunities for identification of AOAs." As I mentioned before, the introduction and methods could create false expectations and be misleading.

The methods are not compared with other proposed methods from the literature. The methods are quite standard, but it would be good to have a critical analysis of the approach. As I mentioned in the analysis of previous ToRs, there are some limitations and perhaps this could be compiled in a Table with a qualitative analysis of the impact of that limitation. For example, a reader could say that the Precise Siting relies on squares but could question "what would happen if rectangles were used instead of squares?". Could this impact the chosen AOA?

The authors were challenged by the fact that they needed to build a general model without having a target aquaculture type, as it is very different to identify a good location for finfish, shellfish, or seaweeds aquaculture. The discussion recognizes this, but it also reinforces my point that the goal of this study is to find areas with lower conflict rather than the most suitable areas for aquaculture.

Summary

The discussion is excellent, and it addresses several of the issues highlighted in ToRs #1 and #2. The method is standard, and it is definitely state-of-the-art. The two major points are related to the same points:

1) Minimizing misleading interpretation of the process, particularly taking into account that some of the comments in the consultations were simply not considered but the methods could lead the reader to think the opposite. A definition of stakeholder, a stakeholder analysis and a clear definition in the methods of the goal of the interactions with stakeholders is needed. Although this is highlighted when analyzing the discussion, it should be address in the introduction/methods.

2) A summary of the critical analysis of the methods and a further comparison of the methods with the broader literature, e.g., Meaden et al. (2016), could be very useful for transparency. While I provided some criticism about the methods, I would like to reiterate that the methods are valid, and no further analyses are required, but these limitations should be clearly defined, and potentially compiled in a table. This would be critical material to be considered in the PEIS step.

ToR #4: Guidance

> "*To the extent possible, you are asked to limit your review to the topics and questions listed above regarding the use and interpretation of the best available data, rather than address any legal or policy matters.*"

As discussed during the online meeting to clarify questions and doubts, this ToR is not addressed in the review as it reads as guidance for the other ToR.

CONCLUSIONS AND RECOMMENDATIONS

The specific purpose of these atlases is the identification of locations that might be suitable for locating AOAs. The background is outstanding, and it provides a clear position on US aquaculture with particular emphasis on the two areas of interest. While some methodological aspects need to be clarified, the general approach is state-of-the-art. Furthermore, it seems that the authors performed a thorough approach to ensure that all available data that met the quality threshold was included in the analysis. Finally, the authors have discussed assumptions and limitations of the approach. Accordingly, both atlases meet the quality standards expected in these types of documents. Although the specific comments to each section and the major summary points are described in detail above, the most salient recommendations are:

1) Introduction: Clarify the objective of the atlases in the introduction to avoid generating false expectations. The atlases are a component of the MSP process, but not MSP itself. Particular emphasis could be put on the role of the stakeholder consultations, and some of the rationale used to define AOAs (e.g., in GOM 3 per area using a dispersion method, in SOCAL all of them are in the same area). Most of these aspects are in the discussion, but they should be mentioned earlier in the documents.

2) Methods: Some details of the methods should be clarified. This does not mean that the methods are incorrect, but the methodological approach is crucial to select AOAs and given the contentious nature of aquaculture, these technical aspects need to be very clear. This

involves technical aspects such as a and b in the fuzzy logic model, a clear definition of the QA/QC and rationale to include/exclude data layers, the impact of rescaling during precise siting, and the specific role of the suitability model (minimize spatial conflict) and the precise model (optimize for general aquaculture).

3) Results: The results are clearly presented, and each AOA is well defined. The absolute values of the suitability model are not shown and the visualization relies on the LISA method (although there is a mismatch in categories). For the sake of transparency, the authors should explain why.

4) Discussion: Although the methods are state-of-the-art, a general discussion comparing the approach with other works would enrich the document. This is particularly relevant for the discussion about the weighting process, which could diminish the impact of relevant societal layers in the decision-making progress, and consequently could impact the outcome of the eventual MSP process. The “uncertainty” of the process is not acknowledged. This uncertainty covers different stages of the process, from the risk to leave behind valuable data layers that exist but the authors are not aware of, to the setbacks, which can be adequate for some types of aquaculture but not for others. Similarly, the lack of focus on a particular type of aquaculture could play a role in the precise siting step, which brings uncertainty to the real suitability of the AOAs; although it is important to highlight that this uncertainty is inherent to the task of creating AOAs for all types of aquaculture.

In conclusion, these recommendations would increase the clarity and transparency of the process, but they would also provide more direction to the PEIS process.

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Weitzman, J., Steeves, L., Bradford, J., & Filgueira, R. (2019). Far-field and near-field effects of marine aquaculture. World seas: An environmental evaluation, 197-220.

Appendix 1: Bibliography of materials provided for review

Morris JA Jr., MacKay JK, Jossart JA, Wickliffe LC, Randall AL, Jensen BM, Bath GE, Balling MB, Riley KL. 2021. An Aquaculture Opportunity Atlas for the Southern California Bight. NOAA Technical Memorandum NOS NCCOS #XXX. XXX p.

Riley KA, Wickliffe LC, Jossart JA, MacKay JK, Randall AL, Jensen BM, Bath GE, Balling MB, Morris JA Jr. 2021. An Aquaculture Opportunity Atlas for the U.S. Gulf of Mexico. NOAA Technical Memorandum NOS NCCOS #XXX. XXX p.

Appendix 2: CIE Performance Work Statement

Performance Work Statement

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

Review of Aquaculture Opportunity Areas Atlases for the Gulf of Mexico and Southern California

Background

NOAA is mandated by the Information Quality Act, as well as the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NOAA science products, including scientific advice, can be 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

NOAA has directives to preserve ocean sustainability and facilitate domestic aquaculture in the United States. Amid the COVID-19 global pandemic, the U.S. developed several policies and plans to bolster the domestic supply of seafood and address concerns about food security. Among the most notable of these policies was the issuance of an Executive Order (EO) on Promoting American Seafood Competitiveness and Economic Growth, which offers a particular focus on spatial planning for Aquaculture Opportunity Areas (AOA) to support aquaculture development. An AOA is a small defined geographic area that has been evaluated to determine its potential suitability for commercial aquaculture. Two spatial analyses were developed for the Gulf of Mexico and Southern California for use by the National Marine Fisheries Service (NMFS) and other coastal managers to inform development of AOAs in federal waters. The results of the spatial analyses are provided in the form of "atlases" that comprise modeling methods, results, maps, and other descriptive information to inform the AOA development process. These analyses were developed by the NOAA National Centers for Coastal Ocean Science (NCCOS) in partnership with the NMFS, and in coordination with cooperating federal and state agencies, Regional Fishery Management Councils, and State and tribal governments.

The spatial analyses utilize the largest and most comprehensive datasets available for spatial planning for aquaculture in coastal ocean waters of the U.S. EEZ. These data were compiled through mining of existing data

[1] http://www.cio.noaa.gov/servicesprograms/pdfs/OMBPeerReviewBulletinm05-03.pdf

within NOAA and various partners' geodatabases including the regional ocean portals, marinecadastre.gov, and acquisition through individual requests to various government, industry, and environmental entities. With over 200 datasets per region, the spatial analyses identify multiple study areas that were informed directly by the aquaculture industry. A 10-acre spatial resolution grid was used for each study area to model aquaculture suitability, ultimately providing a relative suitability score for each grid cell. Standard approaches in Geographic Information Systems (GIS) analyses were used to develop scoring and modeling methods including Multi-criteria Decision-making Analysis (MCDA), Fuzzy Logic Membership Functions, and Logic Index of Spatial Association (LISA) and cluster analyses.

The outcome of this analysis, along with other information including public input will be used to inform an Programmatic Environmental Impact Statement (PEIS) under the National Environmental Policy Act (NEPA) to determine the probable level of impact associated with development of Aquaculture Opportunity Areas.

Given the importance and magnitude of the AOAs effort, it is important that science used to inform identification represent the best available science. Therefore, the CIE reviewers will conduct a peer review of the scientific information contained within the AOA Atlases based on the Terms of Reference (TORs) referenced below. Given the public interest, it will be important for NOAA to have a transparent and independent review process of the spatial analysis and approach 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
NOAA requires three reviewers to conduct an impartial and independent peer review in accordance with this Performance Work Statement (PWS), OMB Guidelines, and the ToRs below. The reviewers shall have working knowledge and recent experience in **marine spatial analysis (e.g., multicriteria analysis, suitability modeling, spatial statistics) with applications to general ocean industry planning, preferably with experience applying analyses towards government or industry applications and with specific expertise in aquaculture**. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

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

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

Four weeks before the peer review, the Project Contacts will send by electronic mail or make available at an FTP site to the CIE reviewer all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NOAA 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:

Exec. Order No. 13921, 85 Fed. Reg. 28471 (May 7, 2020). Available at: https://www.federalregister.gov/documents/2020/05/12/2020-10315/promoting-american-seafood-competitiveness-and-economic-growth

Aquaculture Opportunity Areas, NOAA Fisheries. Available at: https://www.fisheries.noaa.gov/aquaculture-opportunity-areas

Aquaculture Opportunity Areas 2020. Docket ID: NOAA-NMFS-2020-0118. Request for Public Input. Available at: https://www.regulations.gov/docket?D=NOAA-NMFS-2020-0118

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

3. Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the PWS and ToRs, and shall not serve in any other role unless specified herein. Modifications to the PWS and ToRs can not 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.

5. Deliver their reports to the Government according to the specified milestone 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 July 2021. Each reviewer's duties shall not exceed 10 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Schedule	Milestones and Deliverables
Within two weeks of award	Contractor selects and confirms reviewers
Two weeks prior to the review	Contractor provides the pre-review documents to the reviewers. Reviewers participate in Webinar.
August 2021	Each reviewer conducts an independent peer review as a desk review
Within two weeks after review	Contractor receives draft reports
Within two weeks of receiving draft reports	Contractor submits final reports to the Government

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards:

(1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each ToR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel
Since this is a desk review travel is neither required nor authorized for this contract.

Restricted or Limited Use of Data
The contractors may be required to sign and adhere to a non-disclosure agreement.

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Annex 1: Peer Review Report Requirements

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

2. The main body of the reviewer report shall consist of a Background, Description of the 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 documents:

An Aquaculture Opportunity Atlas for Southern California. *Full reference to be provided.*
An Aquaculture Opportunity Atlas for the Gulf of Mexico. *Full reference to be provided.*

We request comments for all areas described below to be provided in tabular format, including: line number(s), comment type (i.e., data source/references, methods, assumptions/interpretation, results/conclusions, other).

1. Please provide comments on the methodology, assumptions, or other factors described within the draft reports to inform siting of aquaculture. Are the scientific methods sound, the assumptions reasonable, and analyses logical? If you find that justification is lacking or specific information was applied incorrectly in reaching conclusions, please specify in your comments.
2. Please consider the accuracy, quality, appropriateness, and application of data considered in the spatial analyses. If any additional relevant data or information exists that was not considered and should have been, please specify in your comments.
3. In general, does the draft report include and cite the best scientific and commercial information available? Are assumptions and uncertainties addressed fairly and clearly, where appropriate? If not, please explain.
4. To the extent possible, you are asked to limit your review to the topics and questions listed above regarding the use and interpretation of the best available data, rather than address any legal or policy matters.