Center for Independent Experts (CIE)

Independent Peer Review Report

An Aquaculture Opportunity Atlas for the Southern California Bight

An Aquaculture Opportunity Atlas for the Gulf of Mexico

Prepared by

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Glossary

AOA – Aquaculture Opportunity Areas

CEA – Cumulative Effects Assessment

CIE – Centre for Independent Experts

GIS – Geographic Information System

GoM – Gulf of Mexico

OMU – Ocean Multi-Use

SoC – Southern California Bight

UA – Uncertainty Analysis

1. Executive Summary

An independent review was performed on two provided reports "*An Aquaculture Opportunity Atlas for Southern California Bight*" (SoC) and "*An Aquaculture Opportunity Atlas for the Gulf of Mexico*" (GoM). The document presented here was developed under contract with Center for Independent Experts (CIE) in the period 08/18/2021 to 09/06/2021 and addresses the Terms of Reference (ToR) outlined on Section 4 of this document. A clarification webinar was held on 08/18/2021 with the scientific panel to illustrate to the three reviewers the methodological rationale and the main results of the AOA analysis.

This review report evaluates both reports as their methodological procedure for AOA in Southern California Bight and the Gulf of Mexico are based on the same suitability analysis method. Reviewer comments were structured to provide comments on both reports or specifically addressing issues emerging in one of the study areas. Comments with bookmarks AOA-SoC or AOA-GoM should be interpreted as specific for Southern California Bight or Gulf of Mexico report). Comments with no bookmarks are relevant for both reports.

Results of the AOA in Southern California Bight and the Gulf of Mexico illustrated different areas of opportunity for aquaculture development based on data collected through stakeholder engagement and modelled using GIS software. The analysis was performed on a large geographic scale and its geographic extent is the first of its kind in USA waters and provides a practical example on how marine spatial planning (MSP) coupled with geographic information technology can be used to strategically organize emerging human activities at sea such as aquaculture by considering ecological, oceanographic and socio-economic features of the geographic area of study.

The methodological workflow is robust, and the application of geospatial instruments is well advanced, based on a consolidated technique, such as multi-criteria decision analyses. The multi-criteria decision analysis is based on different data categories including Blue Economy sectors (national security, navigation, fishery & aquaculture) and ecological features (natural & cultural resources) and physical component of the sea that are aggregated into submodels. Considerable amount of geospatial data was collected for this purpose (over 200 data layers used for SoC and for the GoM).

The review concludes with a set of recommendations for the consolidation of the AOA suitability analysis and the Atlases, in terms of methodological workflow, data integration to better understand logistical characteristics of coastal territories that are relevant for the aquaculture sector, geospatial metadata structure and compliances, integration of MSP planning principles into the analysis and recommendations for further research.

2. 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.

This document is a review for both reports provided: "*An Aquaculture Opportunity Atlas for Southern California Bight*" (SoC) and "*An Aquaculture Opportunity Atlas for the Gulf of Mexico*" (GoM). The review was conducted from 08/18/2021 to the 09/06/2021. On 08/18/2021 (9:30am - 11am EDT) a clarification webinar was organized by M.Chandler (NOAA) and M.Shivlani (NTVI) to introduce the rationale, data, methods and results of the analysis to the reviewers.

3. Reviewer's role

My role was to act as independent CIE reviewer for the following two reports:

- *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.*

- *K. L. Riley, Wickliffe, L.C., Jossart, J.A, MacKay, J.K., Randall, A.L., Jensen, B.M., Bath, G.E., Balling, M.B. and Morris, Jr., J.A. 2021. An Aquaculture Opportunity Atlas for the U.S. Gulf of Mexico. NOAA Technical Memorandum NOS NCCOS #XXX. XXX p.*

On 08/06/2021 I received the two draft reports.

As required by the CIE Performance Work Statement available in Appendix 2, I pre-reviewed the reports handed to me by CIE prior to the clarification webinar held on 08/18/2021 with two other CIE reviewers. I was actively involved in the Webinar meeting to better understand the review process to be done and asked for further information on the required structure of the review and its content. I took notes of some key aspects presented by the panel regarding methods, data and results of the analysis that I used to perform the review in a later stage. I performed my independent review of the reports from the 08/18/2021 to the 09/06/2021.

My review is presented in Section 5 entitled *Summary of Findings*. The review is structured according to the Terms of Reference (ToR) described in Section 4. Where considered appropriate, I conducted an additional review of complementary literature on aquaculture suitability models and geo-platforms for MSP purposes relevant for the presented analysis. In line with the ToR, the purpose was to deliver a review with the best available knowledge, further support the development of the AOA suitability model and improve the knowledgebase of the data layers composing the SoC and GoM Atlases.

4. Terms of Reference

I was asked to provide a scientific peer-review of the following documents:

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

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

- ***ToR1****: 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.*
- ***ToR2****: 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.*
- ***ToR3****: 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.*

To the extent possible, I was asked to limit my 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.

5. Summary of findings

5.1 ToR 1: Methods, assumptions and analysis

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.

- **Theoretical workflow**. The stepwise approach presented in the workflow Figure 2.5 (page 7 of the AOA-GoM report) provides a clear and systematic procedure that can be adapted and used also by other researchers and planners seeking similar approaches for aquaculture suitability analysis across the globe.

- **Modelling approach**. The aquaculture suitability analysis is robust, and uses most relevant geospatial software and programming languages, namely ArcGIS, for its implementation. Spatial instruments applied in the suitability analysis were merged into a logic workflow that can be replicated and scaled in other sea areas. The suitability model was designed by taking into consideration different submodels. This approach is in line with most recent multi-criteria decision analysis techniques applied in MSP and in the siting of aquaculture areas.

- **Categorization of data**. Data categorization into Maritime Economy sectors was defined reasonably, using Lightsom's ("*Data categories for marine planning: U.S.*") categorization for US marine planning conditions.

- **Uncertainty analysis (UA)**. An uncertainty score of 0.5 was applied to take into consideration uncertainty of potential conflict of aquaculture with certain uses. This approach seems in particular important in the AOA-GoM report, where a multitude of military areas exist with unknown types of military training activities. The approach selected to handle the lack of knowledge is reasonable and suggestion to further communicate in future with stakeholder (AOA-GoM report, page 20) can further reduce the uncertainty under this aspect. Overall, an uncertainty analysis (UA) to address how the equal weighting and scoring strategy used in the study affects the results of suitability analysis should be considered. The use of an UA as integrative part of the workflow can 1) increase the robustness of the theoretical workflow and 2) provide opportunity for reflection on the use of alternative means of scoring attribution, for example through the future integration of stakeholder knowledge for scoring.

5.2 ToR 2: Spatial analysis

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.

- **Datasets & submodels.** On balance the dataset used to construct the AOA Suitability Analysis is extensive and comprehensive of the main ecological features, oceanographic conditions and Maritime Economy activities in the study sites. The dataset is structured into submodels, each submodel groups the data into different Maritime Economy categories, natural/cultural

features and constrains. The data tables provided in the reports (Appendix A) listing the data layers engaged for each submodel are clear and well described.

- **Logistic submodel**. One of the submodels, the logistics submodel used in the within-cluster analysis (page 29 AOA-GoM report) uses a *distance to inlet* variable to account for cost/benefits of site selections for the maintenance and servicing of the offshore aquaculture site. The distance is measured from navigable inlets on the GoM. In the AOA-SoC report (page 38 Table 2.11) the *nearest distance to port* is taken into consideration as a logistic variable. Although both logistic variables were reasonably embedded into the AOA suitability analysis, considerable advancements in the integration of logistic and infrastructural data for aquaculture suitability analysis exist that can contribute to the further development of the logistic submodel in the SoC and the GoM. The rationale for the integration of the logistic submodel with additional variables is the opportunity to characterize the socio-economic conditions on land that are particularly favourable for aquaculture development at sea. I performed a complementary review of suitability analysis[1,2] with particular focus on the use of coastal/terrestrial data in marine aquaculture suitability analysis either as single layers or as submodels. The review illustrates a set of data layers that can be implemented to further enhance the existing logistic submodel. The following data layers were identified:

    a. Near port fish processing facilities
    b. Accessibility to ports:
        1) Port distance from highway
        2) Roads viability/density
    c. Port characteristics:
        1) Port size
        2) Port growth potential
    d. Availability and proximity of storage sites for breeding fry and selling fish

  The suggested data layers can be partially extrapolated from land use data (vector or raster layers) and/or from national or state/county level geo statistics.

- **Complementary Maritime Economy data layers**. I found the presence of data layers on the socio-economic conditions of the state's/county's Maritime Economy currently under-represented. The information on jobs, wages and GDP presented in both reports can be spatialized and incorporated as data layers into the data inventory of the Atlas:

    a. For the GoM, the data on state level presented as graphs/pie chart for Texas (Page 89-100 Figure 3.30, 3.31), Louisiana (page 136-137 Figure 3.65,3.66) and Florida (page 187-188, Figure 3.102, 3.103), should be spatialized and made available as spatial data layers in the data inventory.

[1] Brigolin, D., Porporato, E., Prioli, G., Pastres, R., 2017. Making space for shellfish farming along the Adriatic coast. ICES Journal of Marine Science 74. https://doi.org/10.1093/icesjms/fsx018.
[2] Dapueto, G., Massa, F., Costa, S., Cimoli, L., Olivari, E., Chiantore, M., Federici, B., Povero, P., 2015. A spatial multi-criteria evaluation for site selection of offshore marine fish farm in the Ligurian Sea, Italy. Ocean & Coastal Management 116, 64–77. https://doi.org/10.1016/j.ocecoaman.2015.06.030.

b. For the SoC, the data on state level presented as graphs/pie chart for California (page 196-198 Figure 3.87), should be spatialized and made available as spatial data layers in the in the data inventory.

These Maritime economy datasets for the study area could be relevant to address the readiness of the study area for further development of Maritime Economy activities and characterize the dependency of coastal communities from the sector.

- **Metadata inventory**. Appendix A (page 1 A-1 for the AOA-SoC and AOA-GoM report) provides an extended description of the sources of data layers engaged in the analysis in form of a tabular inventory. The presented Atlas, that is based on multiple sources of data, data providers and formats, could further benefit from a standard compliant metadata description procedure. For instance, ArcGIS uses the Federal Geographic Data Committee's (FGDC) Content Standard for Digital Spatial Metadata (CSDGM)[3] but also other ISO content standards for describing geospatial data, such as the ISO 19115:2014[4], can be adapted.

- **Metadata inventory attributes.** It was noticed that the metadata inventory (Appendix A) from Table A-1 to A-7 follows a specific metadata description structure (*submodel datasets->source->source/link-metdata link*), while from Table A-8 onwards the metadata structure follows a different rationale (*submodel datasets->source-source link->metadata link->spatial resolution->temporal range/time-step/z levels*). It should be considered to further harmonize metadata structure and compilation (e.g., through the CSDGM or ISO 19115). This allows one to have better versioning and control of future data updates that may be relevant as input data in a future AOA suitability analysis. Among the already defined metadata attributes, it is suggested to consider the following metadata attributes: *abstract, ownership, license, data format, resolution (for raster formats) and time stamp (either as time range, or as date of data production)*.

- **Modelled multi criteria factors**. In aquaculture suitability analysis there are emerging trends of integrating data layers resulting from complex model-based analytical procedures. In particular, the following two modelling procedure can have further impact on the development of the AOA suitability analysis:

  a. *Cumulative effects assessment (CEA) procedure*. MSP as an instrument to plan sea space allocation for different sectors and users of the sea has the aim to reduce negative effects to marine ecosystems, but also to minimize negative effects among interacting sectors at sea. CEA[5] is a systematic procedure to identify and evaluate the effect of multiple activities on single or multiple receptors. CEA is a widely applied geospatial instrument to analyse additive or synergic effects of multiple pressures (e.g., marine litter, oil slicks, eutrophication, invasive species, heavy metals, diseases, etc.) exerted by human activities on marine ecosystems or on other activities depending on ecological conditions of the marine environment. There are emerging

[3] https://desktop.arcgis.com/en/arcmap/latest/manage-data/metadata/support-for-iso-metadata-standards.htm
[4] https://www.iso.org/obp/ui/#iso:std:iso:19115:-1:ed-1:v1:en
[5]Judd, A., Backhaus, T., Goodsir, F., 2015. An effective set of principles for practical implementation of marine cumulative effects assessment. Environ. Sci. Policy 54, 254–262.

segments of research[6] incorporating CEA as criteria/submodel for aquaculture suitability analysis. The rationale of CEA integration into aquaculture suitability analysis can be argued as follows:

1) *Effects of other uses on AOA*. CEA can be used as a proxy indicator for the ecological status of already heavily impacted sea areas (areas scoring high CEA).

2) *Effects of aquaculture development on ecological components*. CEA can be used for further considering whether the installation of aquaculture sites may cause additional unsustainable ecological effects in the area.

b. *Viewshed analysis (AOA-SoC page 207)*. Falconer et al. (2013)[7] uses a GIS-based modelling procedure that combines visual, seascape and landscape analysis to produce spatial models that indicate where there is the potential for new aquaculture development with minimal visual impact. A visual impact assessment may not be a necessary analysis occurring after AOA suitability model run, but according to Falconer it can constitute an integral part of the suitability analysis by identifying AOA that have lowest visual effects on socio-cultural and natural assets of the coastal landscape. A complementary literature review[8,9] of some key datasets that can be engaged for viewshed analysis for aquaculture suitability analysis resulted into the following data layers:

- Coastal viewpoints of particular natural, cultural and heritage value
- Panoramic roads along the coast
- Buildings (residential buildings, hotels)
- Ferry routes
- Cadastral value of coastal properties
- Coastal tourism data

5.3 ToR 3: Scientific knowledge applied and uncertainties

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.

[6] Porporato, E.M.D., Pastres, R., Brigolin, D., 2020. Site Suitability for Finfish Marine Aquaculture in the Central Mediterranean Sea. Frontiers in Marine Science 6. https://doi.org/10.3389/fmars.2019.00772. Gimpel, A., Stelzenmüller, V., Töpsch, S., Galparsoro, I., Gubbins, M., Miller, D., Murillas, A., Murray, A.G., Pınarbaşı, K., Roca, G., Watret, R., 2018. A GIS-based tool for an integrated assessment of spatial planning trade-offs with aquaculture. Science of The Total Environment 627, 1644–1655. https://doi.org/10.1016/j.scitotenv.2018.01.133.

[7] Falconer, L., Hunter, D.-C., Telfer, T.C., Ross, L.G., 2013. Visual, seascape and landscape analysis to support coastal aquaculture site selection. Land Use Policy 34, 1–10. https://doi.org/10.1016/j.landusepol.2013.02.002.

[8] Depellegrin, D., 2016. Assessing cumulative visual impacts in coastal areas of the Baltic Sea. Ocean & Coastal Management 119, 184–198. https://doi.org/10.1016/j.ocecoaman.2015.10.012

[9] Griffin, R., Chaumont, N., Denu, D., Guerry, A., Kim, C.-K., Ruckelshaus, M., 2015. Incorporating the visibility of coastal energy infrastructure into multi-criteria siting decisions. Marine Policy 62, 218–223. https://doi.org/10.1016/j.marpol.2015.09.024

- **Context of application of hexagonal grids**. I made a complementary review on SCOPUS to investigate the application range of hexagonal grids for spatial planning in marine environments. By using the key terms ("*Marine Spatial Planning" AND "Hexagon"/ "Maritime Spatial Planning" AND "Hexagonal"*) resulted into two manuscripts applying hexagonal grids in the context of species prediction modelling[10] and in the domain of maritime navigation planning[11]. A further google search of the terms identified the *Marine Spatial Plan for Washington's Pacific Coast*[12]. While the cited reference of Birch et al. 2017 justifies well the methodological benefits of using hexagonal grids in geospatial modelling, the citation from Elsner et al. 2012, that applies hexagon grids to map hurricane tracks with spatial climate data, seems a bit different from the MSP context and the research challenge of aquaculture suitability analysis addressed in the report. I may suggest to further consolidate the methodological choice of using hexagons grids by highlighting its application also in marine conservation planning, navigation security and MSP.

- **Uncertainty analysis** (AOA-GoM). Main uncertainties stated in the GoM report refer to the scoring provided in the national security dataset applied in the suitability analysis. Based on Table 3.1 I counted about 18 layers being "*down-scored to 0.5 due to uncertainty of military training activities in the area*." My understanding is that this involves a substantial amount of data in a single submodel. In the section "*further discussion*" (page 243), considerations on the application of an uncertainty analysis should be made including overall consideration on the robustness of the results under consideration of the current scoring strategy and in the light of the scores applied in the National Security Database.

6. **Reducing uncertainty in the national security submodel** (AOA-GoM). It is stated that national security considerations were assigned a score of 0.5 within the analysis to account for uncertainty within that area and unknown types of military training activities occurring. This seems a reasonable approach to tackle the absence of knowledge and given the confidentiality of the information used. The selected approach performs well also when considering that there is an overall lack of best practices in MSP research that handles military data layers as an integral part of a geospatial analysis. Other studies investigating use-use interactions including compatibility/conflict analysis with military sites for MSP purposes were applied within Menegon et al. (2018)[13] using COEXIST methodology[14]. This methodology enables one to investigate the pairwise spatial compatibility of two uses within a defined grid system. The methodology is based on five criteria (see table below) that may give results useful for the further improvement of the National security submodel as it allows one to

[10] Domisch, S., Friedrichs, M., Hein, T., Borgwardt, F., Wetzig, A., Jähnig, S.C., Langhans, S.D., 2019. Spatially explicit species distribution models: A missed opportunity in conservation planning? Diversity and Distributions 25, 758–769. https://doi.org/10.1111/ddi.12891.
[11] Tsatcha, D., Saux, E., Claramunt, C., 2014. A bidirectional path-finding algorithm and data structure for maritime routing. International Journal of Geographical Information Science, Taylor & Francis, 2014, 28 (7), pp.1355-1377. ff10.1080/13658816.2014.887087ff. ffhal-01073178f.
[12] Ecology.wa.pa, 2017. Marine Spatial Plan for Washington's Pacific Coast. Publication no. 17-06-027 Revised June 2018. https://apps.ecology.wa.gov/publications/documents/1706027.pdf
[13] Menegon, S., Depellegrin, D., Farella, G., Sarretta, A., Venier, C., Barbanti, A., 2018. Addressing cumulative effects, maritime conflicts and ecosystem services threats through MSP-oriented geospatial webtools. Ocean & Coastal Management 163, 417–436. https://doi.org/10.1016/j.ocecoaman.2018.07.009
[14] Gramolini, R., Grati, F., Fabi, G., & Schule, T. (2010). GRID GeoReference interactions database. Deliverable D39 COEXIST Project. Interaction in coastal waters: a roadmap to sustainable integration of aquaculture and fisheries.

distinguish among spatio-temporal characteristics, water column use of the activity, level of mobility and location. This could help to systematically reduce the uncertainty on the scoring for the data layers on military operating areas, military training routes and special use airspace available in the AOA-GoM report.

Criteria	Spatio-temporal Use characterization	Scoring
Vertical	Pelagic Benthic Whole water column	1 2 3
spatial (horizontal)	Small Medium Large	1 2 3
temporal scale	Short Medium Long/permanent	1 2 3
mobility	Mobile Fixed	1 2
location	Land Sea	1 2

6. Conclusions & recommendations

The following conclusions and recommendations were drawn from both reports and refer to planning concepts, data needs, methodological aspects and model development.

The general conclusion of this report is that the developed methodological workflow, data layers of the Atlas and modelling procedure can be considered as a best practice in geospatial decision making for offshore aquaculture development. The presented reports provide a solid base for the analysis and future development of aquaculture sector in the Gulf of Mexico and Southern California Bight and in other areas of the USA's sea space.

It is recommended that future development of the AOA suitability analysis takes into consideration coastal/terrestrial assets that can further improve the logistical submodel.

The approach to tackle uncertainty in the use of national security data layers due to their unknown spatio-temporal dynamics is reasonable, taken also in consideration the restrictions of the data and the overall absence of best practices in the use and handling of military data in MSP contexts across the globe. It is recommended to further investigate how the scoring of military areas may affected the final outcome of the suitability analysis and if further stakeholder engagement may provide opportunities for improvement of the outcome. It is recommended to test military datasets with use-use compatibility criteria, such as proposed within the COEXIST methodology.

It is recommended to test model-based variables in the suitability analysis, in particular, Cumulative Effects Assessment as a proxy/submodel of ecological status of suitable aquaculture sites.

Where applicable, it is recommended to apply a viewshed analysis (especially in the SoC) as a suitability criterion for precision citing of aquaculture areas, with lowest visual impact.

Given the multi-source nature of the data layers, it is recommended to develop a metadata inventory of the dataset engaged using built-in ArcGIS data standards compliances or an alternative one, such as ISO. This will provide a better control of data layer versioning and control of future data and model updates.

Consolidate the workflow through the application of an uncertainty analysis, to better understand how chosen weighting/scoring strategy affects final suitability outcome. This provides benefits also in terms of future communication of results to stakeholders.

It is recommended to increase replicability and the scientific impact of the approach by releasing an ArcGIS Toolbox for AOA that facilitates the application of the tool by a wider audience. Make the ArcGIS Toolbox/script available to the ArcGIS and more broadly to the geographic information technology community through a release of the tool, for instance on GitHub[15], a software development platform and community.

It is recommended to better address in what terms in the methodology and outcomes relates/supports ecosystem-based management. Both reports provide an extensive data collection and analysis of natural resources in the study. I missed in the discussion a contextualization to what extent the applied suitability analysis is based on an ecosystem-based approach. Based on the provided information the study very well includes ecosystem-based management practices, such as for instance inclusiveness (as data collection is based on a large stakeholder engagement) or place-based approach (as the analysis is divided in regions according to ecological criteria and ecological resources).

It is recommended to test suitability analysis with novel concepts of "*smart*" sea space allocation that can create win-win conditions at sea and or reduce trade-offs in terms of environmental conditions, sea space consumption and cost-benefit ratio. One of these concepts is Ocean Multi-Use (OMU). OMU is defined as: "*Ocean multi-use is the joint use of resources in close geographic proximity by either a single user or multiple users. It can cover a multitude of use combinations in the marine realm and represents a radical change from the concept of exclusive resource rights to the inclusive sharing of resources and space by one or more users" [16]*. From a spatial modelling point of view, a OMU rationale to aquaculture suitability analysis has the key advantage to look at use-use interaction as opportunity to reduce constraints and identify opportunity of transforming a spatial constraint into a spatial opportunity[17,18]. In particular, the presented AOA suitability analysis can be tested for colocation of

[15] https://github.com/

[16] Depellegrin, D., Venier, C., Kyriazi, Z., Vassilopoulou, V., Castellani, C., Ramieri, E., Bocci, M., Fernandez, J., Barbanti, A., 2019. Exploring Multi-Use potentials in the Euro-Mediterranean sea space. Science of The Total Environment 653, 612–629. https://doi.org/10.1016/j.scitotenv.2018.10.308

[17] Weiss, C.V.C., Ondiviela, B., Guinda, X., del Jesus, F., González, J., Guanche, R., Juanes, J.A., 2018. Co-location opportunities for renewable energies and aquaculture facilities in the Canary Archipelago. Ocean & Coastal Management, Maritime Spatial Planning, Ecosystem Approach and Supporting Information Systems (MapSIS 2017) 166, 62–71. https://doi.org/10.1016/j.ocecoaman.2018.05.006

[18] Benassai, G., Stenberg, C., Christoffersen, M., Mariani, P., 2011. A sustainability index for offshore wind farms and open water aquaculture. Presented at the Coastal Processes 2011, Naples, Italy, pp. 3–14. https://doi.org/10.2495/CP110011

future offshore wind energy sites and aquaculture[19] or in the colocation of a recreational fishery in proximity of aquaculture development sites.

Acknowledgements

I would like to thank the staff from NOAA for organizing the clarification webinar and Manoj Shivlani and Roberto Koeneke from CIE for contacting me for this review.

[19] van den Burg, S.W.K., Aguilar-Manjarrez, J., Jenness, J., Torrie, M., 2019. Assessment of the geographical potential for co-use of marine space, based on operational boundaries for Blue Growth sectors. Marine Policy 100, 43–57. https://doi.org/10.1016/j.marpol.2018.10.050.

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.

K. L. Riley, Wickliffe, L.C., Jossart, J.A, MacKay, J.K., Randall, A.L., Jensen, B.M., Bath, G.E., Balling, M.B. and Morris, Jr., J.A. 2021. An Aquaculture Opportunity Atlas for the U.S. Gulf of Mexico. NOAA Technical Memorandum NOS NCCOS #XXX. XXX p.

Appendix 2: A copy of the 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[20]. 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

[20] http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf

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 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.

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

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.

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.

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.

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.

Project Contacts

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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.