Data Documentation

Dataset Information

Dataset Title:

NCCOS Assessment: An Aquaculture Opportunity Atlas for the Southern California Bight

Description:

Shapefiles of the Aquaculture Opportunity Area (AOA) study developed during 2021 for the Southern California Bight. Included in this dataset are:

(1) Study areas in the Southern California Bight developed based on depth and jurisdictional boundaries. Four study areas were identified (North, Central North, Central South, South).

(2) Suitability modeling results for the North, Central North, Central South, and South Southern California Bight study areas are presented as categories (“Unsuitable,” “Low,” “Moderate,” “High”)

(3) High-High clusters (HH) from the Aquaculture Opportunity Atlas for Southern California. Clusters were identified within each of the four study areas (North, Central North, Central South, and South).

(4) Refined High-High clusters (HH) from the Aquaculture Opportunity Atlas for Southern California. Clusters were identified within each of the four study areas (North, Central North, Central South, and South).

(5) Options from the Aquaculture Opportunity Atlas for Southern California. Options were identified within two of the study areas, North and Central North.

Purpose:

Planning and siting for marine aquaculture operations requires thorough synthesis and spatial analyses of critical environmental data and ocean space use conflicts. This dataset is to aid with visualization of aquaculture opportunity areas (AOAs) suitability model in the Southern California Bight.

(1) Study Areas:
Study areas (North, Central North, Central South, South) were needed due to the geographical breaks and so AOA options could be identified. Study areas were developed based on depth and jurisdictional boundaries.
(2) Suitability Models:

This dataset is to aid with visualization of aquaculture opportunity areas (AOAs) suitability model in the Southern California Bight.

(3) High-High Clusters:
This dataset is an intermediate product used to set the bounds for further analysis to identify options of potential aquaculture opportunity areas (AOAs) in the Southern California Bight. A cluster analysis was performed for each of the four study areas (North, Central North, Central South, and South) and only those clusters larger than 500 acres (the minimum size for an AOA) are presented here.

(4) High-High Clusters Refined:
This dataset is an intermediate product used to set the bounds for further analysis to identify options of potential aquaculture opportunity areas (AOAs) in the Southern California Bight. A cluster analysis was performed for each of the four study areas (North, Central North, Central South, and South) and only those clusters larger than 500 acres (the minimum size for an AOA) and can accommodate a square 500 acre option are presented here.

(5) AOA Options:

This dataset is the options of potential aquaculture opportunity areas (AOAs) in the Southern California Bight. Options between 500 and 2,000 acres were identified through the spatial planning process and will be further analyzed in a NEPA process.

Methods:

(1) Study Areas:

Study areas (North, Central North, Central South, South) in the Southern California Bight were needed due to the geographical breaks so Aquaculture Opportunity Area (AOA) options could be identified. Study areas were developed based on depth and jurisdictional boundaries.

Step 1.1: Federal waters off Southern California, south of Point Conception to the U.S. and Mexico border, were selected as one of the first regions for AOA evaluation because of preexisting spatial data availability, previous analyses in the region, and industry interest in developing sustainable offshore aquaculture operations.

Step 1.2: NOAA further narrowed the AOA option selection criteria in Southern California using a combination of spatial mapping approaches, scientific review, and stakeholder input. As described above, the Southern California AOA area of interest includes federal waters between 5.6 km (3.0 nautical miles [nm]) and 46.3 km (25.0 nm) offshore within the EEZ at depths ranging between 10 m (32.8 ft) and 150 m (492.1 ft).

(2) Suitability Models:

Planning and siting for marine aquaculture operations requires thorough synthesis and spatial analyses of critical environmental data and ocean space use conflicts (Kapetsky *et al*. 2013). This dataset is to aid with visualization of aquaculture opportunity areas (AOAs) suitability model in the Southern California Bight. A gridded relative suitability analysis, commonly used in a Multi-Criteria Decision Analysis (MCDA), was performed to identify the grid cells with the highest suitability for aquaculture development in the study areas (Longdill *et al*. 2008; Radiarta *et al*. 2008; Gimpel *et al*. 2015; Bwadi *et al*. 2019). Spatial data layers included in the suitability analysis identify space-use conflicts and environmental constraints such as active national security areas, maritime navigation, ocean industries, and natural resource management. We utilized a submodel structure to capture ocean use and conservation concerns including national security; natural and cultural resources; industry, navigation, and transportation; and aquaculture and fishing. Data layers with no compatibility with aquaculture development (*e.g.*, shipping fairways) were captured in the list of incompatible constraints and removed from further analysis due to known incompatibility with aquaculture. This model structure ensures that each submodel is given equal representation in the overall suitability model regardless of how many data layers are present in each submodel.

The geometric mean of the four submodels (*i.e.*, national security; industry, navigation, and transportation; natural and cultural resources; fishing and aquaculture) was used to calculate an overall suitability score. The geometric mean (***Equation 1***) was chosen because it grants equal importance to each variable (Bovee 1986; Longdill *et al*. 2008; Silva *et al*. 2011; Muñoz-Mas *et al*. 2012). Furthermore, all data layers and submodels had equal weight within the suitability model. The resulting suitability score is for general aquaculture, with scores approaching 0 representing low suitability and 1 representing high suitability relative to the other grid cells. Any grid that contained a data layer with a 0 score (i.e., constraints data layer) was deemed unsuitable for aquaculture. Suitability scores among the different study areas and different models should not be compared, as the score is unique to each study area and model.

$$
\begin{gathered}
geometric\ mean\ AOA\ suitability\ model = \sqrt[n]{x_1 \cdot x_2 \cdot x_3 \cdot x_4} \\
x_1 = \ national\ security\ variables \\
x_2 \ = \ natural\ and\ cultural\ resources\ variables \\
x_3 \ = \ industry, navigation, and\ transportation\ variables \\
x_4 = \ fishing\ and\ aquaculture\ variables
\end{gathered}
$$

Equation 1.

Step 2.1: 1. A suitability polygon with a 4.05 ha (10 ac) hexagonal grid was created using the extent of the created study area polygons (North, Central North, Central South, South; see Step 1.2), which was only in the US Federal waters of the Southern California Bight and at depths between 10 and 150 m.

Step 2.2: Each data layer was scored on a 0 to 1 scale, with scores approaching 0 representing low suitability and 1 representing high suitability relative to the other grid cells for aquaculture. Any grid that contained a data layer with a 0 score (*i.e.*, constraints data layer) was deemed unsuitable for aquaculture, and not considered further in the analysis. Next, an overall suitability score was calculated for each submodel (*i.e.*, national security; industry, navigation, and transportation; natural and cultural resources; fishing and aquaculture) by taking the geometric mean of all scores within each grid cell. Scoring rationale for both categorical and continuous data can be seen in *Appendix C* of Riley *et al*. 2021. The geometric mean of the four submodels was used to calculate an overall suitability score.

Step 2.3: Suitability scores are presented as categories ("Unsuitable," "Low," "Moderate," "High") grouped by quantiles of the calculated scores, with all scores of 0 being in the "Unsuitable" category and represented by the color red. Within the suitability submodel and overall model maps, standardized colors were used to depict categories, with orange representing "Low," yellow "Moderate," and blue "High" suitability and coinciding with each proportion of quantile values. With all suitability maps, relative categories still represent values ranging from 0 to 1, with the "Low" category representing the lowest quantile of the data, "Moderate" the middle quantile, and "High" the upper quantile. Presenting categories rather than actual suitability scores simplified interpretation of results and provided optimal contrast among categories.

Distribution of scores varies among the suitability submodels (*e.g.*, number of data layers, score range of data distribution depicted); for example, in one submodel a score of 0.5 could be classified as "High," while in another submodel or region a score of 0.5 could be "Low" because the scores are relative. Thus, suitability scores among the different study areas and different submodels should not be compared, as the score is unique to each study area and submodel.

(3) High-High Clusters:

Step 3.1: A Local Index of Spatial Association (LISA) analysis, which identifies statistically significant clusters and outliers, was performed on the final relative suitability modeling results (Anselin 1995). All grid cells with a score of 0 were not included in the cluster analysis, as these areas are unsuitable for aquaculture and are not considered further. The ArcGIS Pro Cluster and Outlier Analysis tool was used to implement the LISA analysis (Esri 2021a). The fixed-distance spatial conceptualization was utilized within this analysis as it allows the identification of localized clusters. The function inputs were a 250-m search distance and 9,999 iterations with row standardization and a false discovery rate correction applied to allow for more conservative results by estimating the number of false positives for a given confidence level, adjusting the critical p-value accordingly (Esri 2021b). Statistically significant clusters ($p < 0.05$) of the highest suitable scores (i.e., high-high clusters) were identified, with any clusters smaller than 202 ha (500 ac) excluded, as this was the minimum AOA target size.

(4) Refined High-High Clusters:

Step 4.1: A Local Index of Spatial Association (LISA) analysis, which identifies statistically significant clusters and outliers, was performed on the final relative suitability modeling results (Anselin 1995). All grid cells with a score of 0 were not included in the cluster analysis, as these areas are unsuitable for aquaculture and are not considered further. The ArcGIS Pro Cluster and Outlier Analysis tool was used to implement the LISA analysis (Esri 2021a). The fixed-distance spatial conceptualization was utilized within this analysis as it allows the identification oflocalized clusters. The function inputs were a 250-m search distance and 9,999 iterations with row standardization and a false discovery rate correction applied to allow for more conservative results by estimating the number of false positives for a given confidence level, adjusting the critical p-value accordingly (Esri 2021b). Statistically significant clusters ($p < 0.05$) of the highest suitable scores (i.e., high-high clusters) were identified, with any clusters smaller than 202 ha (500 ac) excluded, as this was the minimum AOA target size.

Step 4.2: Next multiple iterations of a 500 acre square option were fit within this shape and dissolved to create the final shape used for the precision siting model.

(5) AOA Options:

Step 5. 1: The first step in the precision siting model evaluated the high-high cluster output from the LISA cluster analysis and refined each cluster to accommodate at minimum a square option that is 500 ac (i.e., the minimum AOA size requirement). For each of those clusters, an iterative process was developed, where the first iteration was to identify every possible location accommodating a square that is 2,000 ac. Next, all remaining areas within that cluster were examined to determine if additional square options less than 2,000 ac could be placed. Using 500-ac increments, three further iterations were run using 1,500 ac, 1,000 ac, and 500 ac to identify any additional areas within each cluster. Larger size options were prioritized over smaller options, as increased size would support more farms, space to optimally configure farming locations, and maximum flexibility in mooring configurations. However, it is important to note that size was not considered when ranking the options in the next parts of the precision siting model.

All potential options identified within a single high-high cluster were ranked using the within-cluster model, which is structured to identify the highest suitable option according to closest proximity to an inlet, lowest relative fishing effort, and lowest relative vessel traffic. The data within these three submodels of the within-cluster model were rescaled using a 0 to 1 range, with 0 being less suitable for aquaculture and 1 being more suitable for aquaculture. This is the same method used in the suitability model; however, it is important to note that the rescaling is performed for the data in each individual cluster in the within-cluster model.

Cited Publications:

- Morris, J.A. Jr., J.K. MacKay, J.A. Jossart, L.C. Wickliffe, A.L. Randall, G.E. Bath, M.B. Balling, B.M. Jensen, and K.L. Riley. 2021. An Aquaculture Opportunity Area Atlas for the Southern California Bight. NOAA Technical Memorandum NOS NCCOS 298. Beaufort, NC. 485 pp. https://doi.org/10.25923/tmx9-ex26

Suitability Models:

- Bovee, K.D. 1986. Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. Instream Flow Information Paper 21, Report 86(7), U.S. Fish and Wildlife Service. https://pubs.er.usgs.gov/publication/70121265
- Bwadi, B.E., F.B. Mustafa, M.L. Ali, and S. Bhassu. 2019. Spatial analysis of water quality and its suitability in farming giant freshwater prawn (*Macrobrachium rosenbergii*) in Negeri Sembilan region, Peninsula Malaysia. *Singapore Journal of Tropical Geography*, 40:71-91. https://doi.org/10.1111/sjtg.12250

- Gimpel, A., V. Stelzenmüller, S. Töpsch, I. Galparsoro, M. Gubbins, D. Miller, A. Murillas, A.G. Murray, K. Pınarbaşı, G. Roca, *et al*. 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
- Kapetsky, J.M., J. Aguilar-Manjarrez, and J. Jenness. 2013. A global assessment of potential for offshore mariculture development from a spatial perspective. FAO Fisheries and Aquaculture Technical Paper No. 549. Rome: FAO. https://www.fao.org/3/i3100e/i3100e.pdf
- Longdill, P.C., T.R. Healy, and K.P. Black. 2008. An integrated GIS approach for sustainable aquaculture management area site selection. *Ocean & Coastal Management*, 51(8-9): 612-624. https://doi.org/10.1016/j.ocecoaman.2008.06.010
- Muñoz-Mas, R., F. Martínez-Capel, M. Schneider, and A.M. Mouton. 2012. Assessment of brown trout habitat suitability in the Jucar River Basin (Spain): Comparison of data-driven approaches with fuzzy logic models and univariate suitability curves. *Science of the Total Environment*, 440:123-131. https://doi.org/10.1016/j.scitotenv.2012.07.074
- Radiarta, I.N., S.-I. Saitoh, and A. Miyazono. 2008. GIS-based multicriteria evaluation models for identifying suitable sites for Japanese scallop (*Mizuhopecten yessoensis*) aquaculture in Funka Bay, southwestern Hokkaido, Japan. *Aquaculture*, 284(1-4):127-135. https://doi.org/10.1016/j.aquaculture.2008.07.048
- Silva, C., J.G. Ferreira, S.B. Bricker, T.A. DelValls, M.L. Martín-Díaz, and E. Yáñez. 2011. Site selection for shellfish aquaculture by means of GIS and farm-scale models, with an emphasis on data poor environments. *Aquaculture*, 318(3-4):444-457. https://doi.org/10.1016/j.aquaculture.2011.05.033

High-High Clusters and Refined High-High Clusters:

- Anselin, L. 1995. Local Indicators of Spatial Association—LISA. *Geographical Analysis*, 27(2):93-115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x
- Esri. 2021a. ArcGIS Pro: Release 2.8.0. Redlands, CA: Environmental Systems Research Institute.
- Esri. 2021b. What is a z-score? What is a p-value? Esri ArcGIS Pro online. Available from: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/what-is-a-z-score-what-is-a-p-value.htm

Associated Datasets:

- NCCOS Assessment: An Aquaculture Opportunity Atlas for the U.S. Gulf of Mexico. 2023. Riley, Kenneth L., Wickliffe, Lisa C., Jossart, Jonathan A., MacKay, Jonathan K., Randall, Alyssa L., Morris, Jr., James A. NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.25921/q829-4492

People & Projects

Dataset Authors:

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- NOAA NMFS Office of Aquaculture

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- US DOC; NOAA; NOS; National Centers for Coastal Ocean Science (NCCOS)
- US DOC; NOAA; NMFS; Office of Aquaculture
- US DOE; Advanced Research Projects Agency-Energy (ARPA-e), Macroalgae Research Inspiring Novel Energy Resources (MARINER)

Associated Online Resources:

- NCCOS Project, Aquaculture Opportunity Areas for Federal Waters of the United States Exclusive Economic Zone, https://coastalscience.noaa.gov/project/aquaculture-opportunity-areas-for-federal-waters-of-the-united-states-exclusive-economic-zone/
- NCCOS Project, An Aquaculture Opportunity Area Atlas for the Southern California Bight https://coastalscience.noaa.gov/data_reports/an-aquaculture-opportunity-area-atlas-for-the-southern-california-bight/

Extents

Start Date:	2021-10-18
End Date:	2021-10-18
Northern Boundary:	34.422305
Southern Boundary:	32.518165
Western Boundary:	-120.450994
Eastern Boundary:	-117.183297

Suitability:

Central North:	NB 33.988418; SB 33.783710; WB -118.675949; EB -118.457218
Central South:	NB 33.675444; SB 33.556669; WB -118.285864; EB -117.967609
North:	NB 34.422305; SB 33.988837; WB -120.450994; EB -118.984100
South:	NB 33.368336; SB 32.518165; WB -117.658897; EB -117.183297

Keywords

Sea Areas, Water Bodies, Marine Protected Areas:

- Santa Barbara Channel
- Santa Monica Bay
- Southern California Bight
- Southern California

Theme Keywords:

- Aquaculture
- Marine aquaculture
- Spatial planning
- Marine spatial planning
- Offshore aquaculture

NCCOS Keywords:

- NCCOS Research Priority > Marine Spatial Ecology
- NCCOS Research Topic > Coastal Aquaculture Siting and Sustainability
- NCCOS Research Location > Region > Pacific Ocean
- NCCOS Research Data Type > Geospatial

File Information

Total File Size:	10.8 MB total, 79 files in 9 folders (unzipped)
Data File Format(s):	ShapeFile .SHP and ancillary files
Data File Compression:	.zip
Data File Resolution:	none
GIS Projection:	Projected Coordinate System: NAD 1983 (2011) California (Teale) Albers (Meters) WKID 6414 / Albers, False Easting: 0.0, False Northing: -4000000.0, Central Meridian: -120.0, Standard Parallel 1: 34.0, Standard Parallel 2: 40.5, Latitude of Origin: 0.0/ Geographic Coordinate System: NAD 1983 (2011) WKID 6318 and WGS 1984 WKID 4326

Documentation Files:

- BrowseGraphic.PNG
- DataDocumentation.PDF
- 01_AOA_SOCAL_Study_Areas_Thumbnail.PNG
- 02a_AOA_SOCAL_Suitability_Central_North_Thumbnail.PNG
- 02b_AOA_SOCAL_Suitability_Central_South_Thumbnail.PNG
- 02c_AOA_SOCAL_Suitability_North_Thumbnail.PNG
- 02d_AOA_SOCAL_Suitability_South_Thumbnail.PNG
- 03_AOA_SOCAL_HH_Clusters_Thumbnail.JPG
- 04_AOA_SOCAL_HH_Clusters_Refined_Thumbnail.JPG
- 05_AOA_SOCAL_Options_Thumbnail.JPG

Data Files:

(1) Study Areas:

- AOA_SOCAL_Study_Areas.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .LYR, .SHP.XML)

(2) Suitability Models:

- AOA_SOCAL_Suitability_Central_South.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML, .LYRX)
- AOA_SOCAL_Suitability_Central_North.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML, .LYRX)
- AOA_SOCAL_Suitability_North.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML, .LYRX)
- AOA_SOCAL_Suitability_South.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML, .LYRX)

(3) High-High Clusters:

- AOA_SOCAL_HH_Clusters.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML)

(4) Refined High-High Clusters:

- AOA_SOCAL_HH_Clusters_Refined.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML)

(5) Options:

- AOA_SOCAL_Options.SHP (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHP, .SHX, .SHP.XML)

Table 1: Data Dictionary for AOA_SOCAL_Study_Areas.SHP

Column	Label	Definition	Units	Range
1	StudyArea	Name of each study area	n/a	n/a
2	Acres	Areal extent of each study area	acres	42,801 - 172,996

Table 2a-d: Data Dictionary for AOA_SOCAL_Suitability_[Central_North/ Central_South/ North/ South].SHP

Column	Variable	Label	Definition	Units	Range
1	Suit_Score	Suit_Score	Overall Suitability Score	n/a	0 - 1.00

Table 3: Data Dictionary for AOA_SOCAL_HH_Clusters.SHP

Column	Variable	Label	Definition	Units	Range
1	StudyArea	StudyArea	Study area cluster is in	n/a	n/a
2	Acres	Acres	Area of each cluster	acres	682 - 28,851

Table 4: Data Dictionary for AOA_SOCAL_HH_Clusters_Refined.SHP

Column	**Variable**	**Label**	**Definition**	**Units**	**Range**
1	Cluster	Cluster	Name of the cluster	n/a	n/a
1	StudyArea	StudyArea	Study area where cluster is found	n/a	n/a
2	Acres	Acres	Area of each cluster	acres	2645 - 25,280

Table 5: Data Dictionary for AOA_SOCAL_Options.SHP

Column	**Variable**	**Label**	**Definition**	**Units**	**Range**
1	StudyArea	StudyArea	Study area where option are found	n/a	n/a
1	Option	Option	Option name	n/a	n/a
2	Acres	Acres	Area of each option	acres	500 - 2,000

Parameter Information

Parameter Description:

Parameters: Option Location and Areal Extent
Property Type: calculated
Units: acres
Observation Category: model output
Sampling Instrument: Models/Analyses > Data Analyses > Environmental Modeling
Sampling and Analyzing Method:

Federal waters off Southern California, south of Point Conception to the U.S. and Mexico border, were selected as one of the first regions for AOA evaluation because of preexisting spatial data availability, previous analyses in the region, and industry interest in developing sustainable offshore aquaculture operations. NOAA further narrowed the AOA Option selection criteria in Southern California using a combination of spatial mapping approaches, scientific review, and stakeholder input. As described above, the Southern California AOA area of interest includes federal waters between 5.6 km (3.0 nautical miles [nm]) and 46.3 km (25.0 nm) offshore within the EEZ at depths ranging between 10 m (32.8 ft) and 150 m (492.1 ft).

Data Quality Method:

For more details, see Riley *et al*. 2021.

Document Information

Date:	2023-12-03
Resource Provider:	NCCOS Data Manager, nccos.data@noaa.gov, US DOC; NOAA; NOS; National Centers for Coastal Ocean Science (NCCOS)
Comment:	This data documentation describes data files archived as a NOAA NCEI data accession, and is intended to provide dataset-level metadata for the purposes of discovery, use, and understanding.
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