Data Documentation

Dataset Information

Dataset Title:

NCCOS Assessment: An Aquaculture Opportunity Atlas for the U.S. Gulf of Mexico

Description:

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

(1) Study Areas: Gulf of Mexico study areas identified for development of Aquaculture Opportunity Area (AOA) in the Gulf of Mexico study. Three options per study area (West, Central, and East) were chosen. Study areas in the Gulf of Mexico developed based on depth, jurisdictional boundaries, and Level III biogeographical breaks.

(2) Harmful Algae Bloom: Compiled observations of Harmful Algal Blooms (*Karina brevis*) from 2000 to 2018 in the Gulf of Mexico and eastern Florida. This includes observation frequency data for finfish toxicity (lethal 100,000 cells/L) in the Gulf of Mexico.

(3) Suitability models: Results for the West, Central, East, and Southeast Gulf of Mexico study areas are presented as categories (“Unsuitable,” “Low,” “Moderate,” “High”) based on ocean use and conservation concerns, including: national security, natural and cultural resources, industry, navigation, transportation, aquaculture, and fishing.

(4) Suitability Analysis High-High clusters (HH): Identified as the most suitable areas from LISA (Local Index of Spatial Association) analysis. HH clusters were developed in 2021 to further refine potential suitable space for AOAs in the Gulf of Mexico.

(5) Suitability Analysis- Refined HH clusters: Refined HH clusters that could accommodate at least one 500-acre AOA option.

(6) Suitability Analysis -Options for Refined High-High Clusters: Highest ranking options for each of the refined HH clusters representing a 500- to 2000-acre area between 50 to 150 meters depth that has relatively high suitability for generalized marine aquaculture based on a within cluster model evaluating logistics, vessel traffic, commercial fishing, and oceanography data.

(7) Suitability Analysis - AOA Options: Location and areal extent of options identified for each study region meeting a dispersion rule (greater than 30 nautical miles distance between locations). Three options per study area (West, Central, and East) were chosen. These nine AOA option areas were developed during 2021.

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 potential aquaculture opportunity areas (AOAs) options in the Gulf of Mexico.

The options represent the results of the AOA suitability model, the within-cluster precision siting analysis, the subsequent among cluster analysis, and the dispersion rule to identify the three highest scoring options among all clusters for each AOA study area. The nine AOA options identified during the AOA Gulf of Mexico planning phase will move on to the next phase of AOA planning in the Gulf of Mexico. Intermediate data can provide ocean intelligence for marine aquaculture for operations requiring less than 500 acres; thus, all High-High clusters and refined clusters used in the precision-siting models are shared here to further public information about the "most suitable HH clusters" from the AOA planning exercise.

Frequency of lethal fish harmful algal blooms are visualized to indicate areas of potential concern for current and future impacts to fish species occupying these areas, and to support coastal and ocean planning and other activities pursuant to the *Energy Policy Act*, *Coastal Zone Management Act*, *Magnuson-Stevens Fishery Conservation and Management Act*, *National Environmental Policy Act*, *Rivers and Harbors Act*, and the *Submerged Lands Act*.

Methods:

(1) Study Areas:

Study areas (<u>West</u>, <u>Central</u>, <u>East</u>, and <u>Southeast</u>) were needed due to the geographical scope of the Gulf of Mexico U.S. Federal waters, and differences in biogeography across those areas, so Aquaculture Opportunity Area (AOA) options could be identified. Study areas were developed based on depth, jurisdictional boundaries, and Level III biogeographical breaks.

Step 1.1: Information to determine initial requirements for AOAs was collected from a series of meetings with experts and stakeholders to identify project requirements for offshore aquaculture (finfish, macroalgae, shellfish, or a combination of species). Supplemental information was also collected via listening sessions initiated through NOAA's Request for Information (RFI) in the *Federal Register* (85 FR 67519; October 23, 2020).

Step 1.2: Based on gathered information, study areas were identified and delineated from the area of interest (*i.e.*, Gulf of Mexico region) for further spatial modeling for potential AOAs. Data needs were identified to formulate study areas and included bathymetric data; political boundaries associated with offshore policies and regulation of submerged lands; Outer Continental Shelf (OCS) boundary, state and federal water demarcations; and marine protected areas. Within the Gulf of Mexico and under certain U.S. fisheries laws such as the *Magnuson-Stevens Fishery Conservation and Management Act*, U.S. federal waters (*i.e.,* U.S. EEZ) are defined as having an inner boundary coterminous with the seaward (or outer) boundary of each of the coastal states. This is coterminous with the boundary of coastal states at 5.6 km (3.0 nm), except for Texas and western Florida, which claim 16.7 km (9.0 nm). The outer boundary extends out to the 370-km (200-nm) limit (Reed 2000). A polygon was clipped to only include federal waters inside the jurisdictional boundaries of the Gulf of Mexico Fisheries Management Council.

Step 1.3: Using the polygon from Step 1.2, water depths from 50 to 150 m (164 ft to 492 ft) were extracted using the NOAA U.S. Coastal Relief Model, which provides comprehensive bathymetric data at 3 arc-second horizontal resolution (~90 x 90 m pixels) for the Gulf of Mexico.

Step 1.4: After the suitable depths were extracted, the area of interest (AOI) was further delineated into study areas using boundaries for the Level III ecoregions, due to the large geographical extent of the preliminary study area (Spalding *et al*. 2007; Wilkinson *et al*. 2009; Ward 2017). Level III ecoregions are limited to the OCS and based on differences within the neritic zone as determined by local water mass characteristics, regional landforms, and biological community type (Yáñez-Arancibia and Day 2004; Spalding *et al*. 2007; Wilkinson *et al*. 2009; Yáñez-Arancibia *et al*. 2009; Mendelssohn *et al*. 2017; Galparsoro *et al*. 2020). Once the biogeographical breaks were applied, four distinct study areas were identified.

The study areas for spatial analysis included the <u>West</u> (W) study area estimated at 27,421 km^2 (10,587 mi^2); <u>Central</u> (C) study area estimated at 17,671 km^2 (6,823 mi^2); <u>East</u> (E) study area estimated at 35,888 km^2 (13,857 mi^2); and the <u>Southeast</u> (SE) study area estimated at 13,766 km^2 (5,315 mi^2).

(2) HAB Observations:

Frequency of blooms (number of years with lethal fish blooms) are visualized to indicate areas of potential concern for current and future impacts to fish species occupying these areas. Multiple Harmful Algae Bloom (HAB) (*Karenia brevis*) data sets were obtained for this data layer, including Harmful Algae BloomS Observing System data (HABSOS) from the NOAA National Centers for Environmental Information (NCEI) (1953-2018) and the HAB Operational Forecast System (HAB-OFS) dataset from the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) (2007-2018). Data includes samples from Texas Parks and Wildlife Department (TPWD), the Louisiana Department of Health and Hospitals (LDHH), Florida Fish and Wildlife Conservation Commission, Florida Fish and Wildlife Research Institute (FWRI), and the NOAA National Ocean Service (NOS) HAB Monitoring Database.

Data were combined and reviewed for erroneous entries. Duplicate data from the resulting database were deleted, leaving a total of 155,307 observations. For the purpose of this K. brevis layer, only data from 2000-2018 were used due to sampling biases. An 8 square kilometer hexagonal grid was created covering the Gulf of Mexico and eastern Florida. Each year between 2000-2018 was evaluated separately. If a grid cell contained an observation that registered a value of over 100,000 cells/L (the lethal toxicity level for finfish), the grid cell received a value of '1'. All other grid cells received a value of '0' to represent observations below the lethal level of concern to fish. After all years were evaluated, the values for each year were totaled to obtain a resulting frequency value for that grid cell, representing the number of years that grid cell had values greater than or equal to 100,000 cells/L for the years 2000-2018.

Methods Overview:
The resulting database was queried for duplicate data, and duplicates were deleted, leaving 151,121 observations. For the purpose of this K. brevis layer, only data from 2000 to 2018 were used because of sampling biases. An 8-square-kilometer hexagonal grid was created covering the Gulf of Mexico and eastern Florida.
Each year between 2000 and 2018 was evaluated separately, and if a grid cell contained an observation that registered a value of over 100,000 cells per liter (the lethal toxicity level for finfish), then that grid cell obtained a value of “1.” All other grid cells received a value of “0” to represent observations below the lethal level of concern to fish. After all years were evaluated, the values for each year were totaled to obtain a resulting frequency value for

that grid cell, representing the number of years that grid cell had values greater than or equal to 100,000 cells per liter for the years 2000-2018.

Process steps:

Step 2.1: Downloaded HABSOS data from National Centers for Environmental Information (NCEI) and imported the CSV to a shapefile in ArcGIS.

Step 2.2: Merged these data with data provided by Karen Kavanaugh (Karen.Kavanaugh@noaa.gov) of NOAA CO-OPS (including Louisiana Dept of Health and Hospitals and Texas Parks & Wildlife Department) and data provided by the Florida Fish and Wildlife Commission (FWRI). Data were requested from FWRI by emailing HABdata@MyFWC.com.

Step 2.3: Data were QA/QC'ed and attributes were re-worked to fit with all of the data provided. For example, the data were re-categorized so the HABs categories ('Category' attribute) all matched the HABSOS categorization scheme. Additionally, all absent or not present data observations were categorized as 'NotPresent'.

Step 2.4: Some errors were found in provided data sets, and follow-up conversations were conducted with data contacts through all data sources. For the HABSOS dataset, we contacted NCEI and were put in touch with the data point-of-contact for the dataset (NCEI Accession 0120767). The errors found in the HABSOS dataset were fixed and the corrected and updated data are now archived with NCEI.

Step 2.5: Additional attributes were added for ease of data analysis. For example, the 'Presence' binary attribute was added in order to easily indicate presence or absence of K. brevis.

Step 2.6: Data duplicates were removed by using ArcGIS tools to identify and delete duplicates based on the following attributes: Sample Date, Sample Depth, Cell Count, Latitude, and Longitude.

Step 2.7: The data were clipped to 1/4 mile inland due to confidence of the data and the lack of relevance to freshwater systems.

Step 2.8: Clipped out only years 2000-2018 for data analysis ("HABS_2000_2018" data layer) after looking at sampling distribution from 1954 to 2018. Sampling was irregularly conducted until about 2000, so for the sake of analysis we used the 2000 to 2018 temporal period as more regular sampling was occurring. The final point data set was complete.

Step 2.9: Lastly, an 8 square kilometer hexagonal grid was created covering the Gulf of Mexico and eastern Florida. Each year between 2000-2018 was evaluated separately, and if a grid cell contained an observation that registered a value of over 100,000 cells/L (the lethal toxicity level for finfish) then that grid cell obtained a value of '1'. All other grid cells received a value of '0' to represent observations below the lethal level of concern to fish. After all years were evaluated, the values for each year were totaled to obtain a resulting frequency value for that grid cell, representing the number of years that grid cell had values ≥100,000 cells/L for the years 2000-2018. This layer indicates the frequency of K. brevis blooms in each 8 square kilometer area over time.

(3) 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). 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; natural and cultural resources; industry, navigation, and transportation; 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.

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

Equation 1.

Step 3.1: Study area polygons with a 4.05 hectare (10 acre) hexagonal grid was created using the extent of the created east study area polygon, which was only in the U.S. Federal waters of the Gulf of Mexico and at depths between 50 and 150 m. In addition, Level III Marine Ecoregions were used to separate the grid into 4 distinct study areas (West, Central, East, and Southeast).

Step 3.2: 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; natural and cultural resources; industry, navigation, and transportation; 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 3.3: 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.

(4) Suitability Analysis - High-High Clusters:

This dataset is an intermediate product to aid with visualization of high-high (HH) clusters identified using the LISA method in an equally-weighted suitability model to determine potential analysis of aquaculture opportunity areas (AOAs) in the Gulf of Mexico. The HH clusters represent the geospatial extent of the most suitable areas from the suitability analysis, which were then used as the foundation for the precision-siting analysis steps. Precision analysis steps were used to define the AOA options for the Gulf of Mexico region. Not all of the HH clusters presented here were used in the precision-siting model, as they could not all accommodate at least one 500-ac AOA option. However, these clusters areas can still provide ocean intelligence for marine aquaculture, for operations requiring less than 500 ac. Thus, all HH clusters are shared here to further public information about the “most suitable HH clusters'' from the AOA planning exercise.

Due to guidance from the Department of Defense (DOD) precluding any siting in the <u>Southeast</u> study area, suitability analyses were conducted for the <u>West</u>, <u>Central</u>, and <u>East</u> study areas only.

Step 4.1: Study area polygons were created by first taking the US Economic Exclusive Zone (EEZ) and clipping it to the US state/federal water boundary and the Gulf of Mexico Fisheries Management Council boundary to create a polygon for the Federal waters in the Gulf of Mexico.

Step 4.2: Bathymetry within the created polygon was then extracted for depths between 50 and 150 m using the Coastal Relief Model (CRM). The CRM provides comprehensive bathymetric data at 3 arc-second horizontal resolution (~90 x 90 m pixels) for the Gulf of Mexico. For full bathymetric coverage for the Gulf of Mexico waters, the CRM requires download of (from east to west) the Florida and Eastern Gulf of Mexico, Volume 3 CRM (2001); Central Gulf of Mexico, Volume 4 CRM (2001); and Western Gulf of Mexico, Volume 5 CRM (2001). The extracted raster cells were then converted to a polygon shapefile.

Step 4.3: A 4.05 ha (10 ac) hexagonal grid was then created using the extent of the created study area polygon, which was only in the US Federal waters of the Gulf of Mexico and at depths between 50 and 150 m. In addition, Level III Marine Ecoregions were used to separate the grid into 4 distinct study areas (West, Central, East, and Southeast).

Step 4.4: A gridded suitability model, a type of multi-criteria decision analysis, was then used to assess the suitability for generalized marine aquaculture of the four study areas. This analysis calculated a suitability score ranging from 0 (less suitable) to 1 (more suitable).

Step 4.5: A Local Index of Spatial Association (LISA) analysis was performed on the suitability scores from the gridded suitability analysis (Anselin 1995) obtained in Step 3.3. 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.

Step 4.6: The statistically high, or High-High clusters, of grid cells were extracted and dissolved.

A total of 246 clusters of grid cells were identified as having the statistically highest ($p < 0.05$) relative suitability scores. There were 126 in the <u>West</u> study area, 91 in the <u>Central</u> study area, and 29 in the <u>East</u> study area.

(5) Suitability Analysis - Refined High-High Clusters:

This dataset is an intermediate product aimed to aid with visualization of the refined high-high (HH) clusters identified using the LISA method in an equally-weighted suitability model to determine potential analysis of aquaculture opportunity areas (AOAs) in the Gulf of Mexico. The refined HH clusters represent the geospatial extent of the most suitable areas derived from the AOA suitability analysis (HH clusters), all of which can at minimum, accommodate at least one 500 ac AOA option, which were then used as the foundation for the precision-siting analysis steps. Precision analysis steps were used to define the AOA options for the Gulf of Mexico region. Thus, all refined HH clusters are used in the precision-siting models and are shared to further public information about the “most suitable HH clusters” from the AOA planning exercise.

Shapefile of the refined High-High clusters (HH) (i.e., the most suitable areas) identified from the LISA (Local Index of Spatial Association) analysis performed in the Aquaculture Opportunity Area (AOA) in the Gulf of Mexico study, refined to clusters that could accommodate at least one 500-ac aquaculture opportunity area (AOA) option. A total of 60 clusters of grid cells were identified as having the statistically highest ($p < 0.05$) relative suitability scores, while also accommodating the needed space for at least one AOA option.

There were 43 in the West study area, 13 in the Central study area, and 4 in the East study area. HH were developed and refined in 2021 for identification of potential suitable space for AOAs in the Gulf of Mexico.

Step 5.1: The High-High clusters that were greater than 500 acres in size (see Steps 4.1-4.6) were then refined to ensure each cluster could accommodate a 500-acre square.

A total of 60 clusters of grid cells were identified as having the statistically highest ($p < 0.05$) relative suitability scores, while also accommodating the needed space for at least one AOA option. There were 43 in the West study area, 13 in the Central study area, and 4 in the East study area.

(6) Suitability Analysis - Options for Refined High-High Clusters:

This dataset is an intermediate product to aid with visualization of options for 500- to 2000-acre areas between 50 to 150 meters depth that have relatively high suitability for generalized marine aquaculture. The options represent the results of the AOA suitability model and output of the within-cluster precision siting analysis.

Step 6.1: A within cluster model was then performed on each individual cluster (see Step 5.1), to identify the most suitable option for generalized marine aquaculture. In this model logistics, vessel traffic, and fishing data were evaluated for each possible option between 500 and 2000 acres that could be formed within each high-high cluster area. Therefore, one option was identified for each refined high-high cluster, so for the 60 refined clusters there were 60 options identified.

A total of 60 options in all study areas (West, Central, and East) were identified during the precision siting model analysis. There are 43 options in the West Gulf of Mexico, 13 options in the Central Gulf of Mexico, and four options in the East U.S. Gulf of Mexico.

(7) Suitability Analysis - AOA Options:

This dataset is to aid with visualization of potential aquaculture opportunity areas (AOAs) options in the Gulf of Mexico. Three options per study area (West, Central, and East) were chosen. Each AOA Option represents a 500- to 2000-acre areas between 50 to 150 meters depth that has relatively high suitability for generalized marine aquaculture. The options represent the results of the AOA suitability model, the within-cluster precision siting analysis, the subsequent among cluster analysis, and the dispersion rule to identify the three highest scoring options among all clusters for each AOA study area.

Step 7.1: Next the options (see Step 6.1) were assessed using the among cluster model to identify the three highest scoring options for each study area (*e.g.*, all the options in the West study area were compared to each other to determine the most suitable three options). This model took into account logistics, vessel traffic, commercial fishing, and oceanography when ranking the options.

Step 7.2: Additionally, a dispersion rule was applied, which stated that the three options for each study area could not be within 30 nm of each other. When this occurred the next highest scoring option was used, and so on, until this criterion was met.

Step 7.3: All nine AOA options are contained within this dataset.

There are three options in the West Gulf of Mexico, three options in the Central Gulf of Mexico, and three options in the East U.S. Gulf of Mexico. The nine AOA options identified during the AOA Gulf of Mexico planning phase will move on to the next phase of AOA planning in the Gulf of Mexico.

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Suitability Analysis:

- 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
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Data Sources:

Study Areas:

- NOAA National Geophysical Data Center, Coastal Relief Model (CRM), https://www.ngdc.noaa.gov/mgg/coastal/crm.html
- NOAA Office for Coastal Management, Federal and State Waters, https://www.fisheries.noaa.gov/inport/item/54383
- Commission for Environmental Cooperation, Ecoregions of North America, Marine Ecoregions Level III, http://www.cec.org/north-american-environmental-atlas/marine-ecoregions-level-iii/

HAB Observations:

Harmful Algal BloomS Observing System (HABSOS) data from 1953 to 2018 from the National Centers for Environmental Information; NOAA Harmful Algal Bloom Operational Forecast System Dataset from 2007 to 2018, including samples from Florida, Louisiana, Mississippi, Alabama, and Texas that are not included in National Centers for Environmental Information data set; and Florida Fish and Wildlife Conservation Commission's Harmful Algal Bloom Monitoring Database.

- NOAA National Centers for Environmental Information. 2014. Physical and biological data collected along the Texas, Mississippi, Alabama, and Florida Gulf coasts in the Gulf of Mexico as part of the Harmful Algal BloomS Observing System from 1953-08-19 to 2021-03-09 (NCEI Accession 0120767). NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0120767
- NOAA Center for Operational Oceanographic Products and Services. 2017. Forecast products and associated satellite imagery from the Gulf of Mexico created by the NOAA Harmful Algal Bloom Operational Forecast System (HAB-OFS) from 2004-01-12 to 2021-07-23. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/NOS-HABOFS-GoMex
- *Karenia brevis* HAB observation data (2000 - 2018). NOAA National Ocean Service, Harmful Algal Blooms, https://oceanservice.noaa.gov/hazards/hab/
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- *Karenia brevis* HAB observation data (2000 - 2018). Louisiana Department of Health and Hospitals, https://ldh.la.gov/
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References for the HAB 100,000 cells/l lethal concentration:

- Quick JA, Henderson GE (1974) Effects of Gymnodinium breve red tide on fishes and birds:a preliminary report on behavior, anatomy, hematology and histopathology. In:Amborski RL, Hood MA, Miller RR (eds) Proceedings of the Gulf Coast regional symposium on diseases of aquatic animals. Louisiana Sea Grant, Louisiana State University, Baton Rouge, LA, p 85−113;
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J, Fernandez ML, Wyatt T (eds) Harmful Algae. Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Santiago de Compostela, p 97−100;

- Gannon DP, Berens McCabe EJ, Camilleri SA, Gannon JG and others (2009) Effects of Karenia brevis harmful algal blooms on nearshore fish communities in southwest Florida. Mar Ecol Prog Ser 378: 171−186

Associated Datasets:

- NCCOS Assessment: An Aquaculture Opportunity Atlas for the Southern California Bight. 2023. Morris, Jr., James A., MacKay, Jonathan K., Jossart, Jonathan A., Wickliffe, Lisa C., Randall, Alyssa L., Riley, Kenneth L. NOAA National Centers for Environmental Information. Dataset. (in prep). https://doi.org/10.25921/x1c5-2191.

People & Projects

Dataset Authors:

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- 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 Page: 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 Page: An Aquaculture Opportunity Area Atlas for the U.S. Gulf of Mexico, https://coastalscience.noaa.gov/data_reports/an-aquaculture-opportunity-area-atlas-for-the-u-s-gulf-of-mexico/

- OceanReports. NOAA Office for Coastal Management, National Centers for Coastal Ocean Science, and the Bureau for Ocean Energy Management, 2021 Harmful Algal Blooms (K. brevis), https://www.fisheries.noaa.gov/inport/item/58081.

Extents

Shapefiles: 1,3-7

Start Date: 2021-10-01
End Date: 2021-10-18

GOM_HABs

Start Date: 2000-01-01
End Date: 2018-12-31

Northern Boundary: 31.195472
Southern Boundary: 23.992988
Western Boundary: -97.548281
Eastern Boundary: -83.138889

Central:	NB 29.941926; SB 27.918817; WB -92.604594; EB -87.194524
East:	NB 30.135683; SB 25.627465; WB -87.233060; EB -82.970571
Southeast:	NB 25.688262; SB 24.366028; WB -84.241991; EB -82.888971
West:	NB 28.482207; SB 26.007637; WB -96.927860; EB -91.957811

Keywords

Sea Areas, Water Bodies, Marine Protected Areas:

- Gulf of Mexico

Theme:

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

NCCOS Keywords:

- NCCOS Research Priority > Marine Spatial Ecology
- NCCOS Research Priority > Stressor Impacts and Mitigation
- NCCOS Research Topic > Coastal Aquaculture Siting and Sustainability
- NCCOS Research Topic > Harmful Algal Bloom (HAB) Detection and Forecasting
- NCCOS Research Location > Region > Gulf of Mexico
- NCCOS Research Data Type > Geospatial
- NCCOS Research Data Type > Field Observation
- NCCOS Research Data Type > Long-term Monitoring
- NCCOS Research Data Type > Derived Data Product

File Information

Total File Size:	15.3 MB total, 98 files in 8 folders (unzipped), 5.93 MB (zipped)
Data File Format(s):	ShapeFile .SHP and ancillary files, ArcGIS Layer Files (symbology)
Data File Compression:	zip
Data File Resolution:	none
GIS Projection:	Geographic Coordinate System: NAD 1983 (WKID 4269). Projected Coordinate System for Gulf of Mexico: Albers equal area (GomAlbers84). False Easting: 1,200,000.0, False Northing: 0.0, Central Meridian: -88.0, Standard Parallel 1: 23.0, Standard Parallel 2: 28.0, Latitude of Origin: 16.0)

Data Files:

(1) Study Areas:
- AOA_GOM_Study_Areas.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)
- AOA_GOM_Study_Areas.lyr (ArcGIS Layer File)

(2) HAB Observations:
- HABS_2000_2018.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)

(3) Suitability Models:
- AOA_GOM_Suitability_Central.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)
- AOA_GOM_Suitability_Central.lyr (ArcGIS Layer File)

- AOA_GOM_Suitability_East.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)
- AOA_GOM_Suitability_East.lyr (ArcGIS Layer File)

- AOA_GOM_Suitability_Southeast.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)
- AOA_GOM_Suitability_Southeast.lyr (ArcGIS Layer File)

- AOA_GOM_Suitability_West.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)
- AOA_GOM_Suitability_West.lyr (ArcGIS Layer File)

(4) Suitability Analysis - High-High Clusters:
- AOA_GOM_HH_Clusters.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)

(5) Suitability Analysis - Refined High-High Clusters:
- AOA_GOM_HH_Clusters_Refined.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)

(6) Suitability Analysis - Options for Refined High-High Clusters:
- AOA_GOM_Options_for_Refined_Clusters.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)

(7) Suitability Analysis - AOA Options:
- AOA_GOM_Options.shp (.CPG, .DBF, .PRJ, .SBN, .SBX, .SHX, .XML)

Documentation Files:

- BrowseGraphic.PNG
- DataDocumentation.PDF
- 01_AOA_GOM_Study_Areas_Thumbnail.PNG
- 02_AOA_GOM_HABs_2000-2018_Example_Map.PNG
- 02_AOA_GOM_HABs_2000-2018_Thumbnail.PNG
- 03a_AOA_GOM_Suitability_Central_Thumbnail.PNG
- 03b_AOA_GOM_Suitability_East_Thumbnail.PNG
- 03c_AOA_GOM_Suitability_Southeast_Thumbnail.PNG
- 03d_AOA_GOM_Suitability_West_Thumbnail.PNG
- 04_AOA_GOM_HH_Clusters_Thumbnail.PNG
- 05_AOA_GOM_HH_Clusters_Refined_Thumbnail.PNG
- 06_AOA_GOM_Options_for_Refined_Clusters_Thumbnail.PNG
- 07_AOA_GOM_Options_Thumbnail.PNG

Table 1: Data Dictionary for AOA_GOM_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	3,401,653 - 8,868,117

Table 2: Data Dictionary for HABS_2000_2018.SHP

Column	Label	Definition	Units	Range
1	GRID_ID	Hexagon Grid Identifier	n/a	n/a
2-20	F20XX	Presence (1) or absence (0) of *K. brevis* blooms ≥100,000 cells/L. Yearly data from 2000 thru 2018.	n/a	0 or 1
21	Total	Total occurrences, sum of frequency of *K. brevis* bloom ≥100,000 cells/L from 2000 to 2018.	count	0 to 14

Table 3: Data Dictionary for AOA_GOM_Suitability_[Location].SHP

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

Table 4: Data Dictionary for AOA_GOM_HH_Clusters.SHP

Column	Label	Definition	Units	Range
1	StudyArea	Name of study area each cluster is in	n/a	n/a
2	Acres	Areal extent of each cluster	acres	10 to 385,415

Table 5: Data Dictionary for AOA_GOM_HH_Clusters_Refined.SHP

Column	Label	Definition	Units	Range
1	StudyArea	Name of study area each refined cluster is in	n/a	n/a
2	Acres	Areal extent of each refined cluster	acres	765 to 369,545

Table 6: Data Dictionary for AOA_GOM_Options_for_Refined_Clusters.SHP

Column	Label	Definition	Units	Range
1	Option	Name of each option	n/a	n/a
2	StudyArea	Name of study area each option is in	n/a	n/a
3	Acres	Areal extent of each option	acres	500 to 2,000

Table 7: Data Dictionary for AOA_GOM_Options.SHP

Column	Label	Definition	Units	Range
1	Option	Name of each AOA option	n/a	n/a
2	StudyArea	Name of study area each AOA option is in	n/a	n/a
3	Acres	Areal extent of each AOA option	acres	500 to 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:

Location and areal extent of Aquaculture Opportunity Area (AOA) Options representing 500- to 2000-acre areas between 50 to 150 meters depth that have relatively high suitability for generalized marine aquaculture. The options are the results of the AOA suitability model, the within-cluster precision siting analysis, the subsequent among cluster analysis, and the dispersion rule (greater than 30 nautical miles distance between locations) to identify the three highest scoring options among all clusters for each AOA study area. For more details, see Riley *et al*. 2021.

Data Quality Method:

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

Document Information

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