OCS Study
BOEM 2020-002
NOAA NCCOS 270

Regional Essential Fish Habitat Geospatial Assessment and Framework for Offshore Sand Features

Volume 4: Development of ShoalMATE: Shoal Map Assessment Tool for Essential Fish Habitat

US Department of the Interior
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Volume 4: Development of ShoalMATE: Shoal Map Assessment Tool for Essential Fish Habitat

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DISCLAIMER

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REPORT AVAILABILITY

To download a PDF file of this report, go to the US Department of the Interior, Bureau of Ocean Energy Management Data and Information Systems webpage (http://www.boem.gov/Environmental-Studies-EnvData/), click on the link for the Environmental Studies Program Information System (ESPIS), and search on 2020-002. The report is also available at the National Technical Reports Library at https://ntrl.ntis.gov/NTRL/.

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List of Abbreviations and Acronyms

AOI	area of interest
BMP	best management practices
BOEM	Bureau of Ocean Energy Management
DOI	US Department of the Interior
EFH	Essential Fish Habitat
ETL	Extract-Transform-Load
fGDB	file geodatabase
GIS	Geographic Information System
HAPC	Habitat Areas of Particular Concern
MGET	Marine Geospatial Ecology Tools
MMP	Minerals Management Program
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
ShoalMATE	Shoal Map Assessment Tool for EFH
SST	sea surface temperature

Abstract

QSI was contracted to build a standardized reporting tool to facilitate better communication between BOEM and NOAA during Essential Fish Habitat (EFH) assessments required for dredging projects on the Outer Continental Shelf (OCS). QSI initiated development by gathering requirements from BOEM's Marine Minerals Program and NOAA's Habitat Conservation Division. We then designed the database architecture and workflow to meet the needs of access and usability for stakeholders with varying levels of familiarity with GIS. We ran the data necessary to support the tool (e.g., habitat descriptors, species models, project boundaries) through a series of custom scripts that store information describing each identified shoal in a database specifically designed for expedited queries within the front-end application. The front-end application presents this queried information within a web browser and generates a template report, as a Microsoft Word document, that can be edited by analysts to create a final, tangible product.

1 Background to the Tool Development Process

One of the primary goals of this project was to develop a standardized geographically and temporally based reporting tool for use by the Bureau of Ocean Energy Management's (BOEM's) Marine Minerals Program (MMP) practitioners in the Atlantic and Gulf of Mexico region to support Essential Fish Habitat (EFH) consultations for dredging. The ShoalMATE (Shoal Map and Assessment Tool for EFH) tool allows a user to share their assessment logic in a consistent manner. Having the information readily available to review will improve communications between agencies and provide more power and transparency in the EFH consultation process.

The results of the literature review completed as part of Volume 1 of this report, and additional data exploration associated with the tool development revealed numerous data sources that could help to characterize bottom habitats, particularly those of sandy shoals utilized for dredging operations. The development team identified a set of required information to be included in a template version of an assessment document in consultation with members of the MMP and the National Oceanic and Atmospheric Administration (NOAA) Habitat Conservation Division, as well as external subject matter experts, and through review of previous EFH Assessments for dredging projects, (**Table 1-1**).

Table 1-1. List of required components in an EFH Assessment document.

Requirement
A description of the proposed project area
Overview of the location
Bathymetry
Bottom current direction
Substrate type
Recovery potential/accretion of sand resource
Previous dredge events
A list of federally managed species with overlapping EFH polygons (from NOAA)
Evaluation of potential impacts on those species based on known habitat affinities or predicted distribution of fish and shrimp species
Proposed mitigations and best management practices
Results and conclusions
References

Data to support these requirements were compiled into an ESRI file geodatabase (fGDB) if hosted web services were not available. Data sources included MarineCadastre.gov, BOEM's Marine Minerals Information System, and personal communications with BOEM and NOAA stakeholders. Remotely sensed data (sea surface temperature (SST), chlorophyll-*a*, current velocity, etc.) were compiled as 10-year monthly averages using the Marine Geospatial Ecology Tools (MGET) developed by the Marine Geospatial Ecology Lab at Duke University (Roberts et al. 2010). We utilized NOAA's EFH polygons but created additional related tables to store information digitized from EFH source documentation compiled by regional Fishery Management Councils. The table also documents where Volume 1 identified additional sources of information on managed species exceeding the information in the official documentation. Once all available datasets were combined into a fGDB, the data was loaded into ESRI MXD files and published as web services for use in the application.

2 Application Development

BOEM was interested in creating a simple interactive mapping application for users with minimal to moderate Geographic Information System (GIS) skills and experience. This ruled out developing an add-in package to be used in conjunction with desktop mapping software such as ESRI ArcMap, as access to software licenses would be limiting. We determined the solution to be a web-based mapping application that could be operated through any internet browser. The chosen technologies (**Figure 2-1**) were selected to be consistent with other applications developed for BOEM. A more detailed description of the technical architecture can be found in **Appendix A**.

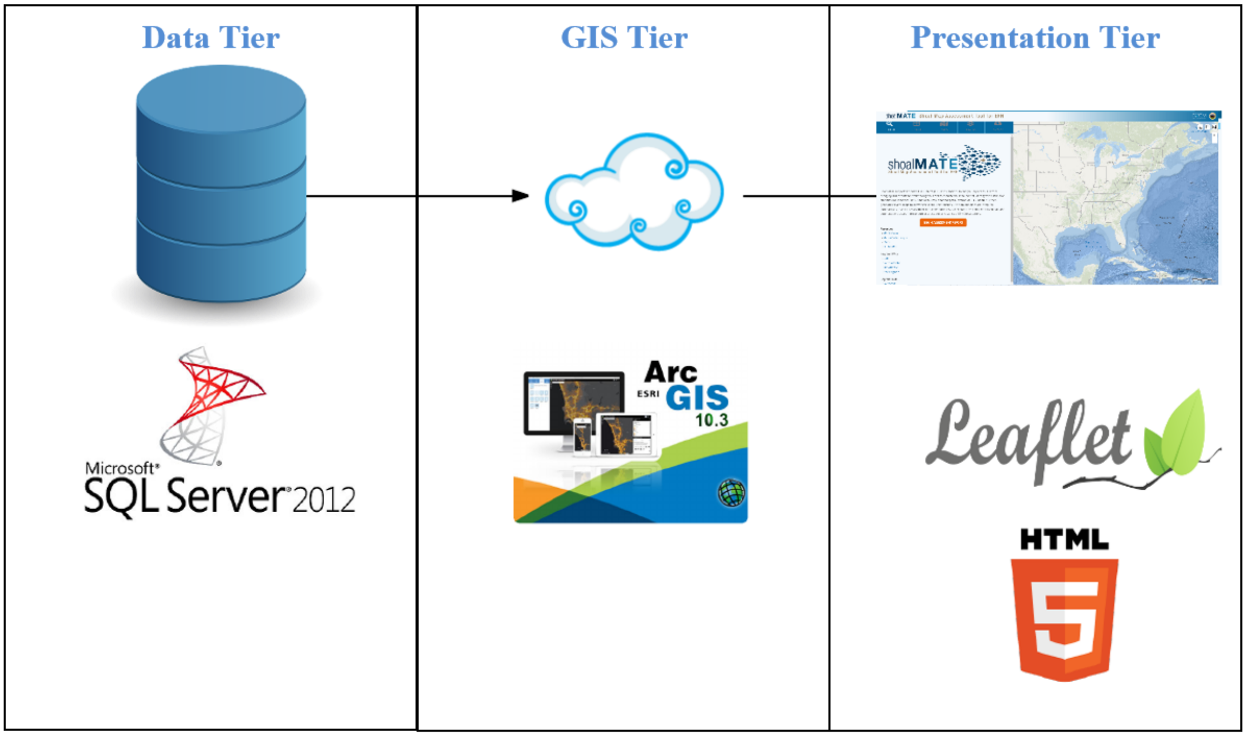

Figure 2-1. High-level architecture for the ShoalMATE application.

The high-level workflow for ShoalMATE involves five main steps (**Figure 2-2**).

- **Step 1: Select Shoal** – The user chooses an area of interest (AOI) and selects the relevant seasons in which dredging may occur.
- **Step 2: Review Results** – The user can review the results of intersecting the selected shoal feature with various data that will be utilized in the generated report.
- **Step 3: Review Maps** – The user can select and review a set of default maps with preset layers.
- **Step 4**: **Create Custom Maps** – To tell a more detailed story of the shoal, the user can choose to generate additional maps to include in the report by choosing from a variety of provided data layers.
- **Step 5: Generate Report** – The Reporting Tool compiles all the user inputs and results into an editable report in Microsoft Word document format.

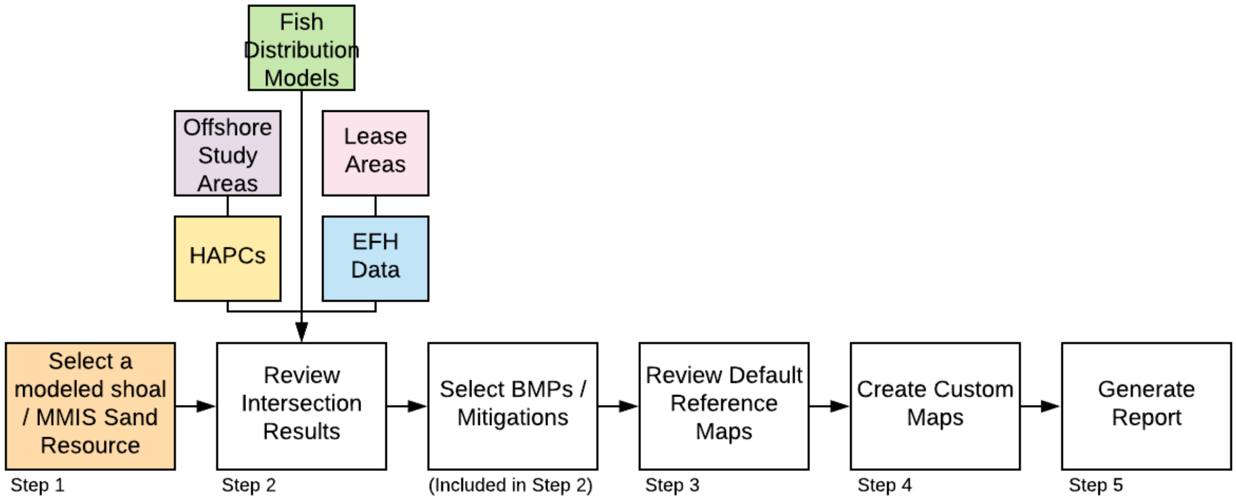

Figure 2-2. High-level workflow for the ShoalMATE application.

2.1 Data Development

To optimize the application's processing time, an Extract-Transform-Load (ETL) script was developed utilizing Python to compile data layer values into a shoal feature class, which became the scale of analysis for the tool. The feature class is a combination of the modeled shoals developed as part of this project and existing Marine Minerals Sand Resources. The analysis area available for ShoalMATE (**Figure 2-3**) includes Federal waters of the OCS to a 50-m depth. This range was driven by the depth limitations of dredge operations. Because of the large area covered, this "canning" of the data allows for significant performance improvements over conducting the analyses on the fly with each run of the tool.

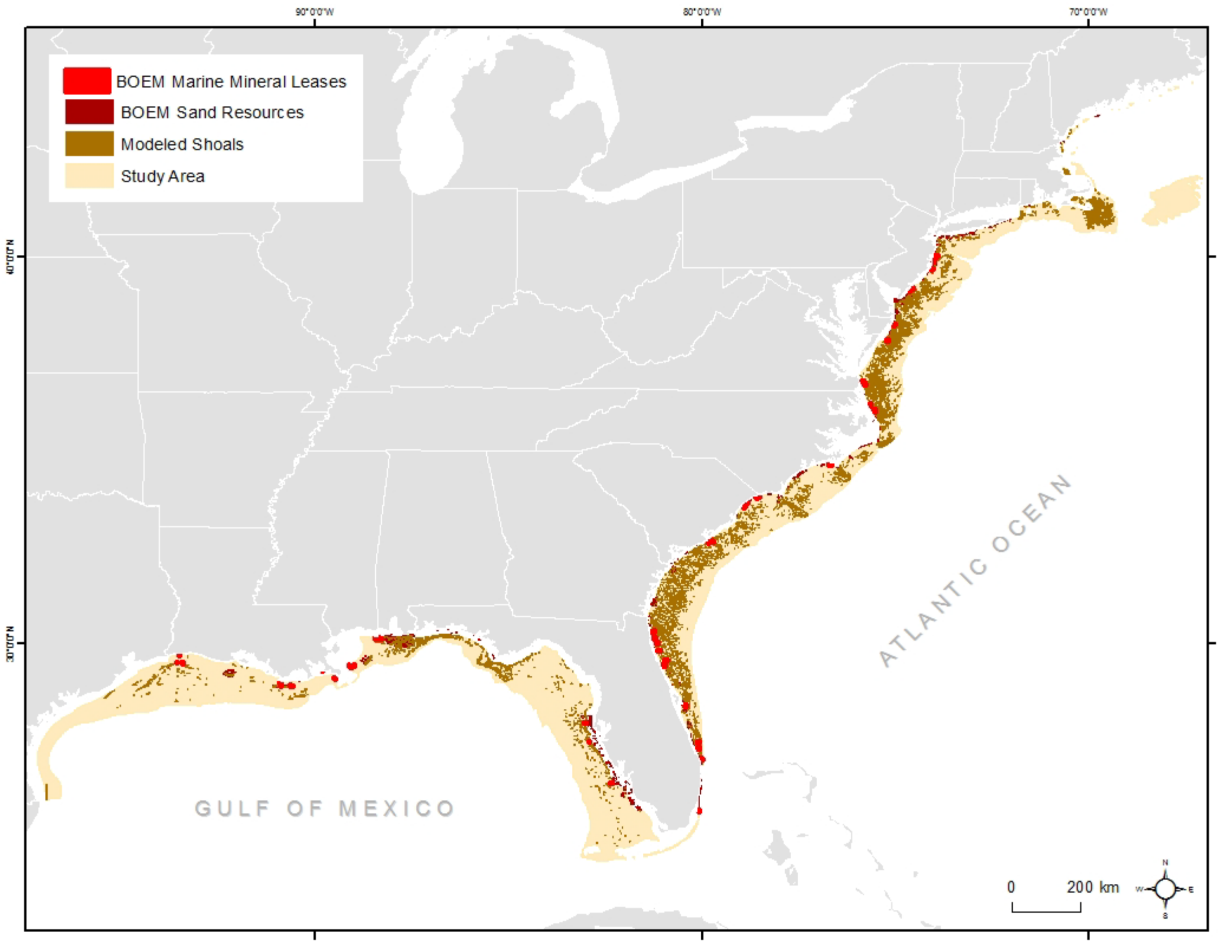

Figure 2-3. Extent of the ShoalMATE Tool represented in beige. Shoals and MMIS sand resources within this boundary are available for analysis within the tool.

Two primary categories of data exist within the ShoalMATE source database: vector data that characterizes presence, absence, or count of a seabed or political feature (e.g., seagrass or MMP leases) and continuous data (point and raster) that indicate a value (e.g., depth and SST).

For each shoal, the ETL performs one of two analyses on each data layer. For vector data, the script runs a spatial intersect and records the intersecting features as attributes for each shoal. For continuous data, a minimum, maximum, average or sum is calculated over the extent of the shoal and the value is stored as an attribute for each feature. This process was iterated for temporally discrete data layers so that an attribute exists for SST in January, SST in February, etc. The result is a set of over 10,000 shoals with a variety of information associated that can be used to describe the habitat of each one.

A second ETL was also developed to store the results of six intersections completed between individual shoals and six key datasets that provide critical information about a particular shoal's use (by fish species and humans) along with external resources to aid in further describing the shoal habitat in sufficient detail for meeting the requirements of a complete EFH Assessment. These results are presented in the tool and are populated in the generated report to resolve the requirements established in **Table 1-1** or to provide the user with additional resources to reference in the completion of the EFH Assessment document.

- **EFH Species Intersection** – Comparison between the shoal feature and the EFH polygons. Generates a list of species/life stage combinations that intersects with the shoal. Perform additional analysis to rank the potential for a species/life stage to be impacted by dredge operations within a certain time frame. Assign a qualitative value of High, Medium, or Low to each combination based on if the shoal habitat meets the documented habitat preferences of the species/lifestage (**Figure 2-4**).

- **Predicted Relative Abundance Models Intersection** – Summarizes shoal features with fish and invertebrate species distribution models developed or acquired as part of this study. Reports values of predicted mean relative abundance within the shoal alongside the predicted mean abundance for the surrounding area (within 20 km) and predicted abundance within each species' geographic range within each region (e.g., Gulf of Mexico). In this way, the data shows the importance of the shoal in the context of other available habitat in the region.
- **Predicted Probability of Presence Models Intersection** – Summarizes shoal features with fish and invertebrate species distribution models developed or acquired as part of this study. Reports values of predicted probability of presence within the shoal alongside the predicted probability of presence for the surrounding area (within 20 km) and within each species' geographic range within each region (e.g., Gulf of Mexico). In this way, the data shows the importance of the shoal in the context of other available habitat in the region.
- **Habitat Areas of Particular Concern (HAPC) Intersection** – Knowing what, if any, HAPCs intersect the shoal will allow for additional consideration of those areas and the species that may be affected.
- **MMIS Lease Area Intersection** – The intersection of a shoal with a previous lease indicates that the shoal has likely been dredged in the past. Information on the volume removed and what is still available as well as information to direct the user to the lease documentation which may include prior EFH Assessments that can aid in the completion of the manual portions of the generated report. This table is empty if there has been no prior dredging at the site.
- **MMIS Study Intersection** – This intersection may provide additional resources the user can reference when developing the report. A list of BOEM-funded studies by the MMP is provided and a link to the reports are included if available.

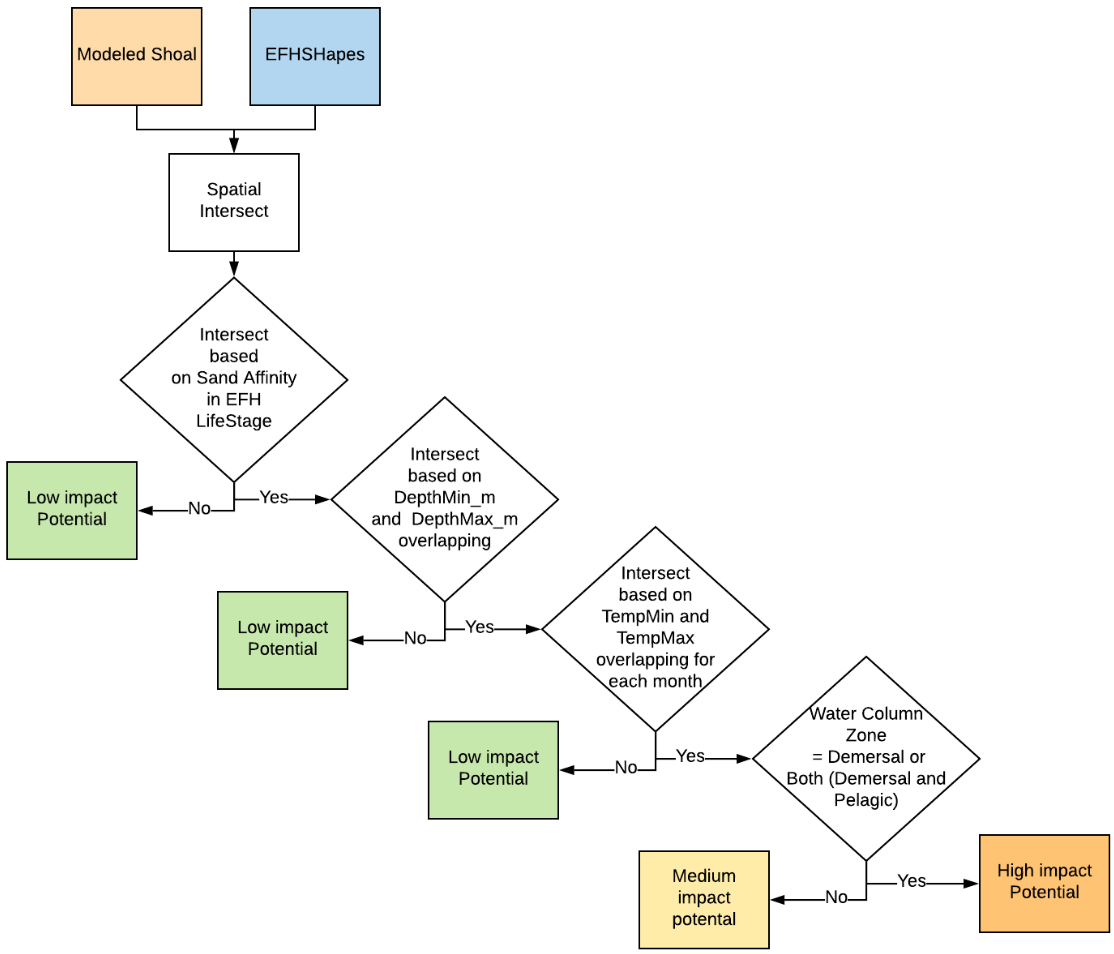

Figure 2-4. Impact potential logic.
Sand dredging impact potential for marine fish is assumed to be based on four main factors as depicted in the diagram: sand affinity, depth range, temperature range, and water column zone. The rankings result in either low, medium, or high potential impact.

A detailed user manual is provided in the Appendix, but a summary of the tool workflow is provided below.

2.2 Step 1 – Select Shoal

After initiating ShoalMATE, the user can zoom in to their AOI to select a shoal or sand resource of their choice. If multiple shoals are present where the user clicked, the user will have to specify by selecting one (**Figure 2-5**). The user must also select one or more seasons during which dredge is anticipated to occur.

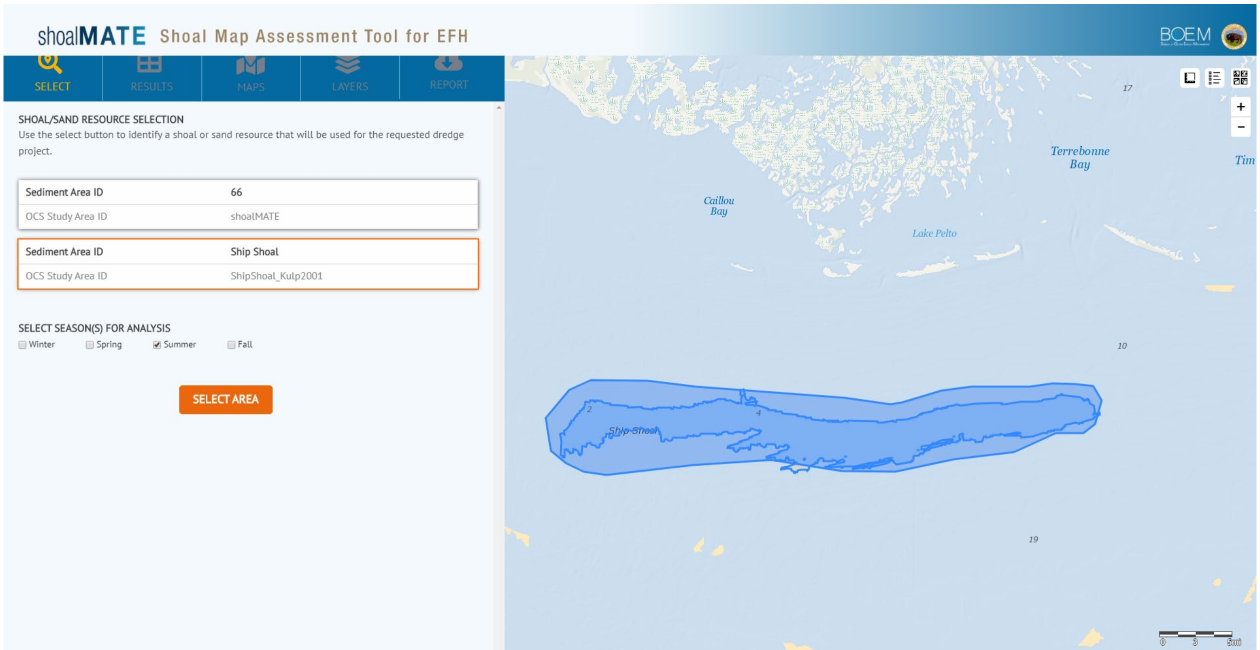

Figure 2-5. Selecting shoal/sand resource.
Available shoals in the selected area are shaded in blue. The shoal highlighted in orange on the left is the one selected for analysis during the summer season.

2.3 Step 2 – Review Results

Each "View" button will display the tabular information that will be carried into the generated report. The user can review this information before selecting mitigations and best management practices from the final "Continue" button. The tool provides a list of standard options that are found among the many existing EFH Assessment documents reviewed for this study (**Figure 2-6**). Several Best Management Practice (BMPs) and Mitigation Measure options have been included to capture past NOAA Conservation Recommendations, and these should be considered for each project.

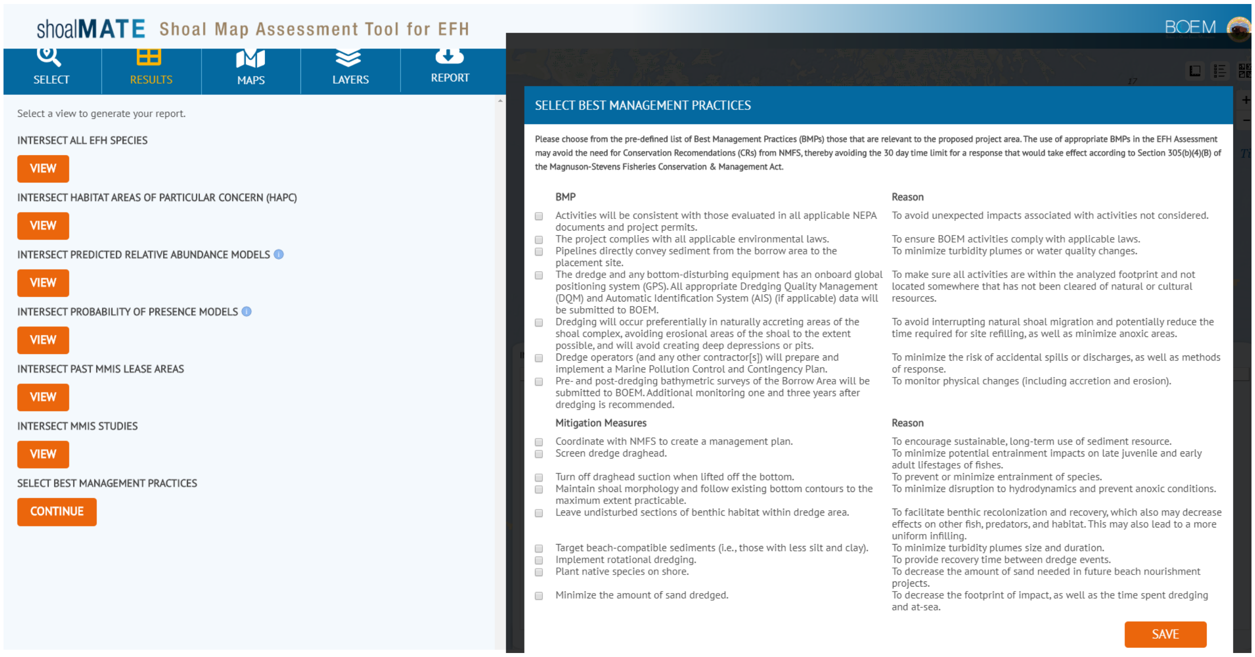

Figure 2-6. Pop up window for selecting BMPs and mitigation measures to be included in the report.

2.4 Step 3 – Review Maps

Step three of the workflow contains five preset maps (**Figure 2-7**) developed to meet the requirements of the EFH Assessment.

1) Overview Map – to provide a sense of location of the shoal
2) Bathymetry Map – to provide a view of the surrounding elevation as well as the prevailing current directions for the seasons selected at the start of the tool.
3) Substrate Map – to indicate the characteristics of the surrounding substrate and any substrate features that are known to influence fish distribution (e.g., artificial reef, oil platforms, natural reefs)
4) Accretion Map – for areas where two or more previous dredge events have occurred, accretion maps are generated by determining the difference between dredge events using pre- and post-dredge surveys. This allows some insight into how the area has recovered between events. Note that these data are still in prototype and not available in all dredged sites yet.
5) Dredge Exposure Map – displays in time units how long a dredge vessel was within an area. This data is currently only available for hopper dredges and is not available for all dredged sites.

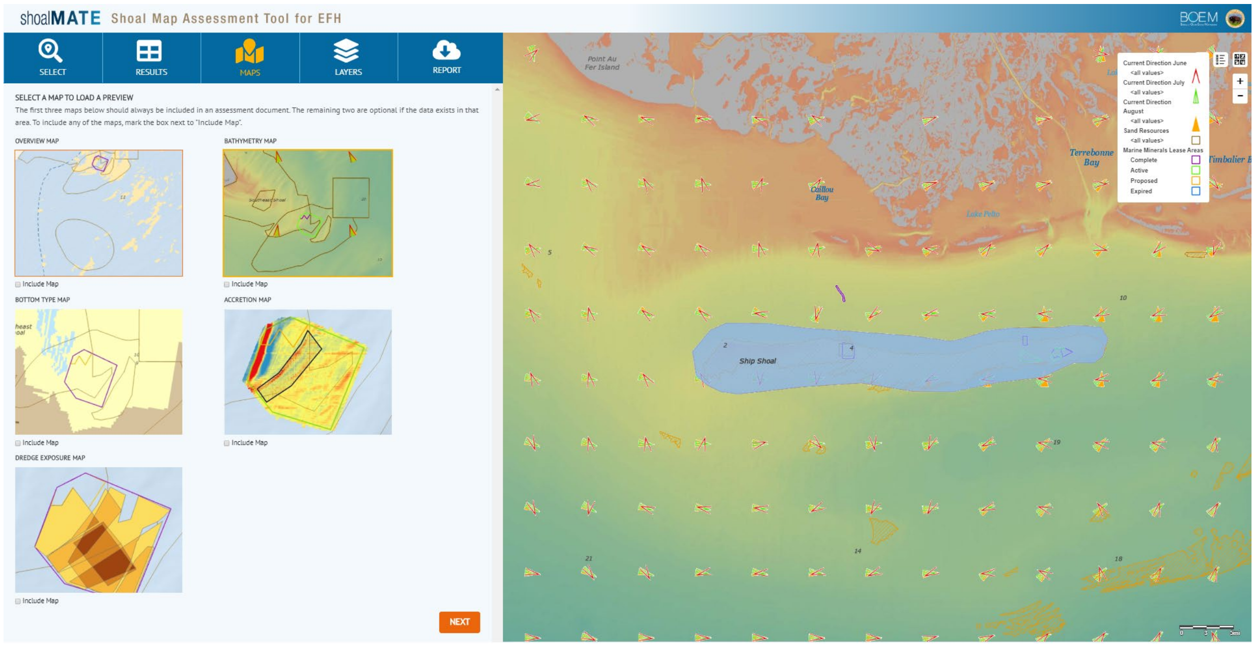

Figure 2-7. Selecting a map to load a preview.
(Left) Thumbnails of available preset maps. At a minimum, the overview, bathymetry, and bottom type maps should always be included. (Right) Bathymetry map with prevailing bottom current directions for summer months overlaid.

2.5 Step 4 – Create Custom Maps

Additional data sources accumulated for this project are also available to generate maps outside of the five default maps to include in the report. A selection of over 100 data layers are available to map. The user can create multiple custom maps (for individual species distributions, for instance) by saving them to the report and then clearing the layers and starting over (**Figure 2-8**).

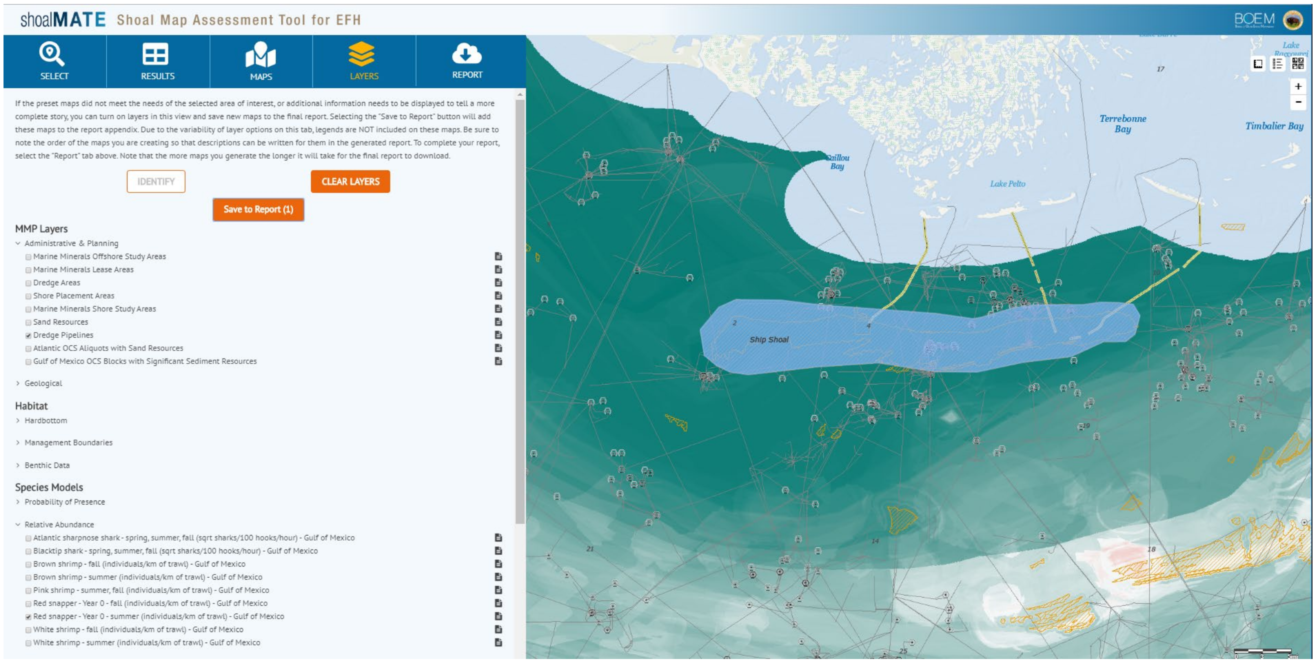

Figure 2-8. A custom map displaying juvenile red snapper relative abundance in relation to OCS drilling platforms and oil and gas pipelines.

2.6 Step 5 – Generate Report

User selections are stored throughout the run of the tool, so a report containing a summation of results can be generated upon completion (**Figure 2-9**). The report is exported as a Word document to be stored locally **(Appendix B: Example Report from ShoalMATE Reporting Tool)**. The generated report is formatted and includes all information gathered from the tool. Within the report are additional prompts that users must manually complete to satisfy the remaining requirements for the EFH Assessment. Having a large portion of this information already identified via the intersection tables gives the user easy access to share it with planning partners.

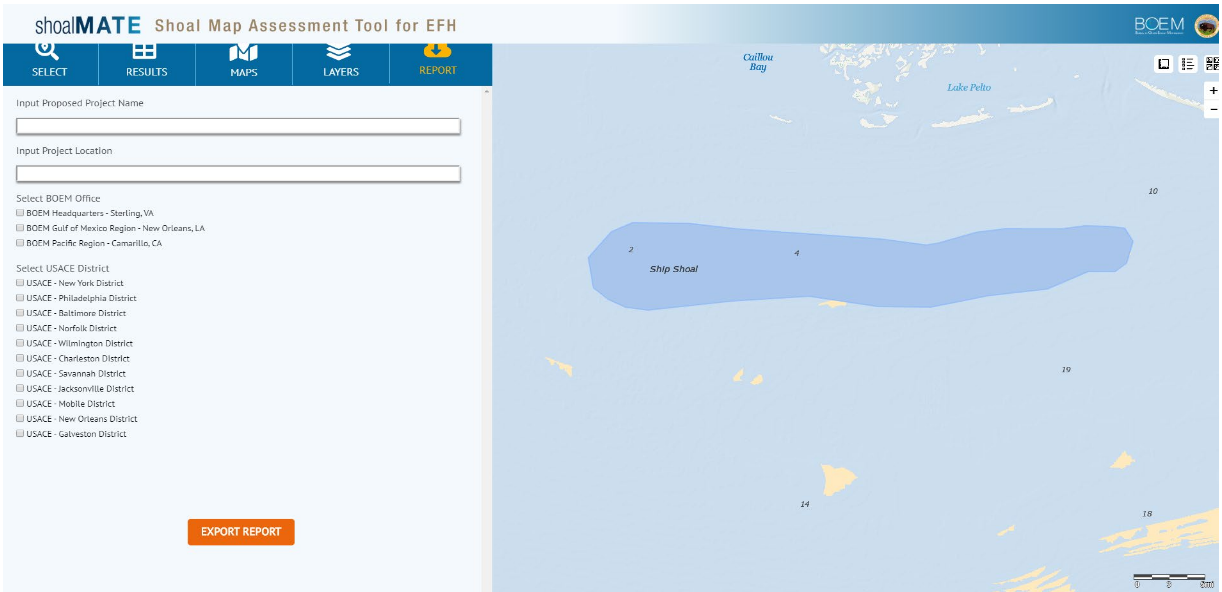

Figure 2-9. Preview of the report export page of the ShoalMATE tool.

2.7 Potential Improvements and Future Work

Through the course of development, new needs were generated that exceeded the scope and/or timeline of this project. The implementation of these needs would result in a more accurate and/or more robust tool and should be considered. A list of key suggestions is provided in **Table 2-1**.

Table 2-1. Suggested improvements to the ShoalMATE tool for future development

ID	Improvements	Logic	Effort
1	Create a user-friendly interface for the back-end data processing	To update the shoal feature class on regular intervals as new MMIS sand resources are identified, the ETL processes need to be re-run to include the new feature in the tool. Currently, the process is run through a series of Python scripts with minimal graphical user interface (GUI). Advanced users only should update the database.	Low
2	Incorporate additional project data	Identify how to incorporate cutter head dredge operations into the exposure raster generation process so that those maps can be completed. Determine workflows for fully developing the accretion rasters to make that information more widely available.	Medium
3	Add additional habitat descriptors to the report	Provide distance to hard bottom features in the study region.	Low

Appendix A: User Manual for ShoalMATE: Shoal Map Assessment Tool for EFH

The following pages contain the complete user manual for ShoalMATE. It is presented in original format to be consistent with the ShoalMATE reporting tool.

Appendix B: Example Report from ShoalMATE Reporting Tool

The following pages contain an example EFH assessment report from ShoalMATE. It is presented in original format to be consistent with the ShoalMATE reporting tool.

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