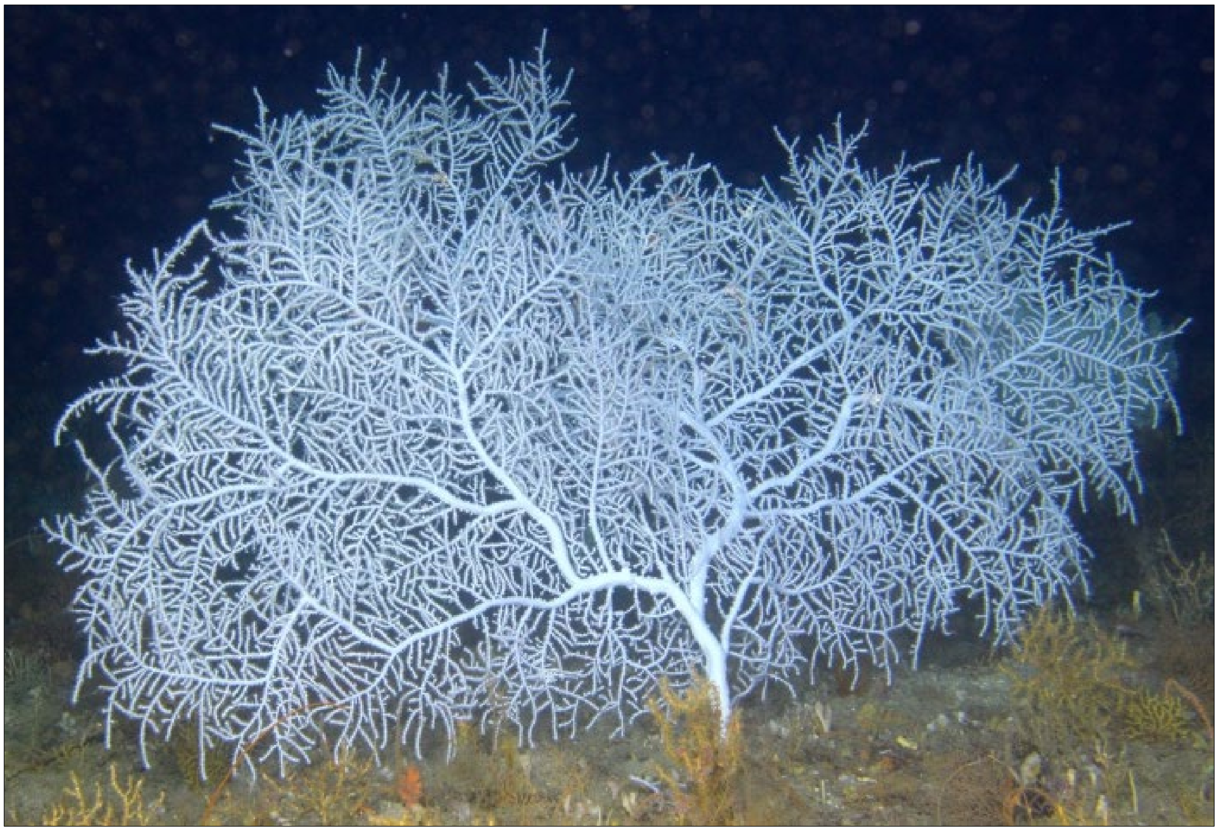
Gulf of Mexico Fishery Management Council
Gulf of Mexico Mesophotic and Deepwater Coral Assessment

Final Report

25 March 2022



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Gulf of Mexico Mesophotic and Deepwater Coral Assessment

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1.0 Introduction

CSA Ocean Sciences Inc. (CSA) was contracted by the Gulf of Mexico Fishery Management Council (Council) to compile and synthesize information on deep-water coral and coral related habitats throughout the Gulf of Mexico (GoM) Exclusive Economic Zone (EEZ). The project focused on mesophotic (30 to 150 m) and deep-water corals (deeper than 50 m) (hereafter termed deep reef corals) in federal waters of the GoM from 9 to 200 nautical miles offshore. The project includes the production of a report, along with the development of a corresponding geodatabase and web-based dashboard that will comprise coral presence, coral density, coral species diversity, and benthic habitat composition of areas that support corals more broadly, such as deep-water banks, hard-bottom habitats, and isolated patch reefs. The design and content of the project was the result of continual coordination and consultation with Council staff throughout the completion of the scope of work.

1.1 PROJECT BACKGROUND

In 2014, the Council's Coral Working Group identified potential areas, including existing Habitat Areas of Particular Concern (HAPCs), to be considered for additional conservation and management measures due to the presence of deep-water coral communities recorded in these areas. As defined by the Magnuson-Stevens Fishery Conservation and Management Act of 2007 (NOAA Fisheries, 2022), a HAPC is a discreet subset of Essential Fish Habitat (EFH) that meets one or more of the following criteria:

Importance of ecological function provided by the habitat.

The area or habitat is sensitive to human-induced degradation.

The habitat is stressed.

Is considered rare.

EFH comprises those waters and substrate necessary to fishes for spawning, breeding, feeding, or growth to maturity, and includes all types of aquatic habitat where fishes spawn, breed, feed, or grow to maturity, such as wetlands, coral habitats (including deep reef habitats), seagrass habitats, and rivers (NOAA Fisheries, 2021).The purpose of HAPCs is to highlight priority areas within EFH to focus conservation, management, and research efforts (Marinecadastre, 2021).

In 2018, after review by the Council's advisory bodies, the list of northern GoM HAPCs presented in the 2014 Council report was shortened and, along with the National Marine Fisheries Service, the 'Coral Amendment 9' was implemented, which established 13 new HAPCs within the northern GoM with fishing regulations that prohibit deployment of bottom-tending gear and anchoring by fishing vessels and eight GoM HAPCs without development of specific, associated fishing regulations (Gulf of Mexico Fishery Management Council, 2018) (**Table 1, Figure 1**).

Table 1. Habitat Areas of Particular Concern (HAPCs) established by the Gulf Council Coral Working Group in 2018 (Coral Amendment 9). (GMFMC, 2018). HAPCs listed in alphabetical order.

Newly Established HAPCs	HAPCs with Fishing Regulations	HAPCs without Fishing Regulations
Alabama Alps	•	
AT 047	•	
AT 357	•	
Garden Banks 299		•
Garden Banks 535		•
Green Canyon 140/272		•
Green Canyon 234		•
Green Canyon 354		•
Green Canyon 852	•	
Harte Bank	•	
L&W Pinnacles	•	
Mississippi Canyon 118	•	
Mississippi Canyon 751		•
Mississippi Canyon 885		•
Rough Tongue Reef	•	
Scamp Reef	•	
South Reed Site		•
Southern Bank	•	
Viosca Knoll 826	•	
Viosca Knoll 862/906	•	
West Florida Wall	•	

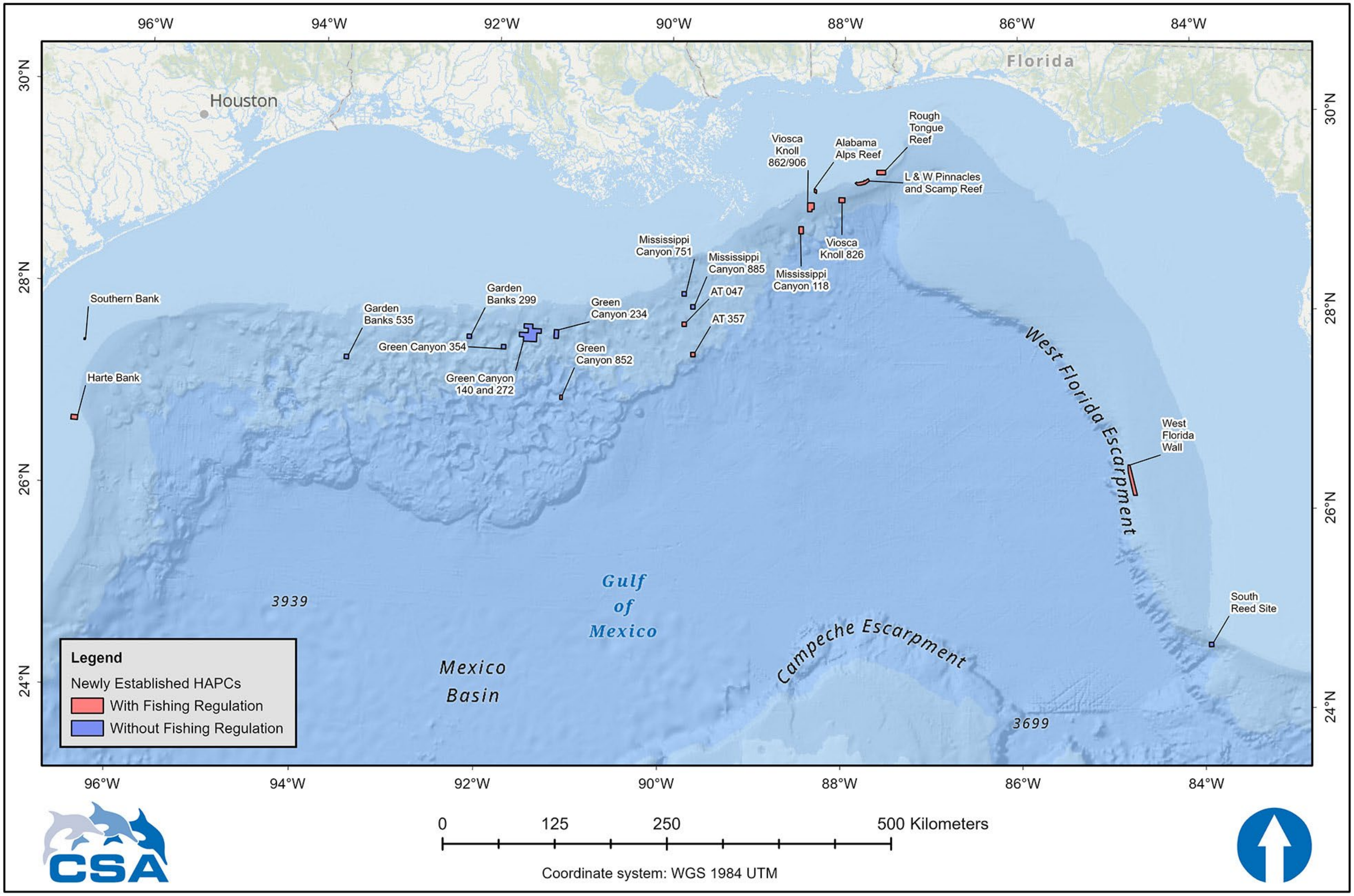

Figure 1. Gulf of Mexico Habitat Areas of Particular Concern (HAPCs) established by the Gulf of Mexico Fishery Management Council (Council) in 2018 (Coral Amendment 9).

After the release of Coral Amendment 9, the Council reconvened the Coral Advisory Panel and Coral Statistical and Scientific Committee to reevaluate priority areas to be considered as HAPCs through a subsequent 'Coral Amendment 10'. This reexamination included, but was not limited to factors such as depth, habitat type, abundance, density, and diversity information for areas included in Coral Amendment 9 that the Council selected to move forward with, as well as any new information on other deep reef sites (banks and reefs) within the northern GoM project area for the development of Coral Amendment 10.

1.2 PROJECT PURPOSE AND OBJECTIVES

This project was designed to address the Council's request to compile and synthesize information on GoM coral and coral-related habitats in mesophotic (30 to 150 m) and deep-water (deeper than 50 m) areas that were proposed but not included in Coral Amendment 9, as well as the identification and review of other habitats in the region that might warrant similar conservation and management measures.

Objectives of the project to meet the goals of the Council include:

- Site Selection – Select a set of sites, or areas initially identified by the Coral Working Group for the focus of the project, considering both historical survey reports or recent data and reports for new, additional information on site conditions.

- Literature Review – Conduct a comprehensive literature review of the selected deep reef coral areas and identify other ecologically important coral habitat that may benefit from management measures. Conduct a separate data search of available information on the vulnerability of corals found within the selected areas of the GoM to disease (e.g., scleractinian (Order Scleractinia) coral tissue loss, disease spread) and potential impacts to these corals from environmental changes (e.g., changes in ocean circulation patterns, temperature, pH). Identify informational data gaps during the data compilation task.

- Data Compilation – Compile the most up-to-date information on selected sites as it relates to the presence of deep reef corals, coral diversity, as well as other benthic habitat attributes more broadly for those areas where corals have been documented to occur. Identify informational data gaps.

- Geodatabase – Construct a geodatabase for spatial data using format templates provided by Council staff for point datasets and include metadata in Federal Geospatial Data Committee (FGDC) standard.

- Ecological Assessment – Design and conduct a general ecological assessment of those areas where corals are identified as a conspicuous element of the bottom, providing, to the extent practical, a consistent level of detail for comparison across and among areas. Include an assessment of potential risks to corals in those areas and the services that they provide. If available, include economically important fishery species and their association with the benthic habitat. Provide an assessment of vulnerability of corals to disease and potential impacts of environmental changes. Rank the areas based on physical and ecological data to provide objective criteria which the Council could use to prioritize the development of management measures.

- Web-based Dashboard – Design and provide a web-based dashboard with an interactive map displaying the shape/area and coordinates of the areas to be considered and associated information.

2.0 Methods

2.1 ECOLOGICAL ASSESSMENT

The Ecological Assessment included the systematic completion of several project objectives, including the selection of suitable and approved sites for study, a search and review of pertinent data sources on these sites, a compilation of these sources by site, and the design of the ecological assessment using available information. The design and methods for the assessment are provided below.

2.1.1 Site Selection

In 2014, the Council Coral Working Group (Coral Working Group, 2014) convened a working group of scientists to discuss which areas in the Gulf may warrant more specific coral protection. The group identified 47 discrete areas, including existing HAPCs, that it believed should be recognized as containing documented presence of deep-water coral communities and recommended that the Council consider designating these areas as HAPCs and establishing management measures that prohibit fishing with bottom tending gear. After a subsequent review by the Council's advisory bodies, the list of these potential areas (hereafter termed sites) was shortened to those sites included in the Council's Coral Amendment 9 (Gulf of Mexico Fishery Management Council, 2018). Subsequently, the Council reconvened the Coral Advisory Panel and Coral Statistical and Scientific Committee to reexamine priority sites to be considered as HAPCs through the planned Coral Amendment 10. This examination included previously considered sites in Coral Amendment 9 that the Council selected not to move forward with, as well as any new information on sites within the project area. Sites identified by the Coral Working Group in 2014, but not included in Coral Amendment 9, served as initial candidate sites of this study.

The Council supplied the CSA Team with supportive information (reports) providing lists of the, including existing HAPCs, to be reviewed and analyzed for this project. These reports included the following: Joint Coral Scientific and Statistical Committee and Coral Advisory Panel Summary (Joint Coral Scientific and Statistical Committee and Coral Advisory Panel, 2015); Coral Working Group Summary, Gulf Council Office, Tampa, FL (Coral Working Group, 2014); and Coral Habitat Areas Considered for Habitat Area of Particular Concern Designation in the Gulf of Mexico (Coral Amendment 9) (Gulf of Mexico Fishery Management Council, 2018).

Additional candidate sites in the project area were selected by the CSA Team, based on CSA Team experience in these areas. The final selection of project sites is presented below in **Section 3.1.1**.

2.1.2 Data Search and Review

Identification of relevant source material began with an extensive search of scientific and technical databases on Proquest Dialog™[1]. Proquest Dialog™ is a unique aggregation of the world's leading

[1] http://dialog.proquest.com/professional

bibliographic and full text sources and offers the largest collection of authoritative[2] content that can be searched at one time. The Proquest Dialog™ databank search was led by CSA's Librarian/Information Specialist, who was responsible for all literature searches and acquisition of relevant documents. The following databases were searched:

- Aqualine (1960-current);
- Aquatic Sciences & Fisheries Abstracts (1971-current);
- BIOSIS Previews® (1926-current);
- Ecology Abstracts (1982-current);
- Environmental Impact Statements: Digests (1985-current);
- GEOBASE™ (1980-current);
- Georef (1693-current);
- Meteorological & Geoastrophysical Abstracts (1950-current);
- NTIS: National Technical Information Service (1964-currrent);
- Oceanic Abstracts (1981-current);
- Proquest Dissertations and Theses Professional (1743-current); and
- Scisearch® (1974-current).

Initially, a broad topic search was conducted using the following search statement combinations[3]:

- (coral or corals or octocoral* or cnidaria*);
- (deepsea or mesophotic or "deep sea" or coldwater or "cold water" or "deep ocean"); and
- ("gulf of mexico" or atlantic).

This preliminary search generated 1,474 citations.

A subset of the above search was selected to address disease, temperature, and stress using the following search statement combinations[4]:

- (coral or corals or octocoral* or cnidaria*);
- (temperature or disease? or stress*);
- (deepsea or mesophotic or "deep sea" or coldwater or "cold water" or "deep ocean"); and
- ("gulf of mexico" or atlantic).

This search generated 517 citations.

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[2] "authoritative" refers to peer-reviewed documents but also documents published under the auspices of an agency or conference especially where the authors can be identified.

[3] Search statements are not case sensitive. In these search statements, a question mark (?) indicates one letter truncation, an asterisk (*) indicates unlimited truncation, and quotation marks (") enclosing topics indicate a phrase search. Parentheses () indicate Boolean nesting of search terms.[4] Search statements are not case sensitive. In these search statements, a question mark (?) indicates one letter truncation, an asterisk (*) indicates unlimited truncation, and quotation marks (") enclosing topics indicate a phrase search. Parentheses () indicate Boolean nesting of search terms.

These searches resulted in an unmanageable number of citations relative to the scope of the project. Attempts to narrow the results by specifying that search terms must be found in the title or key word fields and limiting results to the last 10 years did not solve the problem (The numbers of citations listed above [1,474 and 517] were reduced to 524 and 239, respectively, when narrowed to the last 10 years.). Although valuable references were located and acquired in these searches, CSA determined that a search for each specific reef or bank name as well as the larger sub-regions was required to produce a body of information that was informative at the site level but capable of being reviewed within existing resources.

Relevant books, proceedings, technical reports, and gray literature were also located using OCLC WorldCat. WorldCat is a cooperative database of a billion bibliographic records contributed by more than 72,000 libraries in 170 countries, making it the world's largest, most complete, and most consulted library union catalog. Items found in WorldCat may be purchased or borrowed via the OCLC Interlibrary Loan System. For Internet accessible documents, Google/Bing searches and searches from digital repositories such as Aquadocs https://aquadocs.org/, Biodiversity Heritage Library https://www.biodiversitylibrary.org/ and ESPIS https://marinecadastre.gov/espis/#/ were made.

All search results were reviewed by the CSA Team and the documents of interest were identified and returned to the librarian for acquisition. PDFs of all requests were acquired online, via interlibrary loan request, personal request to authors or other marine librarians, or downloaded from the existing CSA library collection.

From the search and review tasks, an Endnote™ X9 library was created for all documents used in the project. The library includes full citations with a PDF of the document attached. The citations can be exported as simple document files or may be converted for use in other bibliographic management software such as Mendeley, Zotero and Refworks.

2.1.3 Ecological Assessment Design Overview

Pertinent, site-specific data were compiled within an ecological assessment data matrix to characterize and assess current environmental status and vulnerability of deep coral and other hard-bottom sites in the GoM (and potentially other regions). Because analysis of newly acquired field data from recent studies were beyond the scope of this project, the assessment used data that were currently available for the selected GoM deep-reef sites; however, the assessment was also designed to be modified and improved as needed and as new, authoritative data become available. During this process, additional data needs (data gaps) were identified, leading to recommendations for new studies. The assessment matrix also allowed for an objective approach to site comparisons across the GoM.

The matrix was organized as follows. Each selected project site was entered on a separate row of the table and constituted the left column. The project sites were organized regionally to facilitate comparisons. Primary regions included the Southeastern, Northeastern, Southwestern, and Northwestern GoM. Regions were further subdivided into Areas, as follows:

Region	*Area*
Southeastern GoM	Northern West Florida Slope
	Southern West Florida Slope
Northeastern GoM	Pinnacles Reefs
	DeSoto Canyon
	Destin Dome
Northwestern GoM	Shelf-edge Banks
Southwestern GoM	South Texas Banks – North
	South Texas Banks – South

A list of physical and environmental factors was developed and entered as separate columns on the horizontal axis (top row) of the data compilation matrix. All included factors have known, accepted, and defensible ecological relevance.

The following list provides a brief overview of environmental factors selected for this analysis. Details of each factor and how values associated with each factor for a specific site are described in **Section 2.1.5**.

- **Area**: Units = hectares. For this project, site boundaries were provided by the Gulf Council (and/or its committees) from previous designations. Using the provided site boundaries, CSA calculated site areas using ArcGIS.

- **Relief**: Units = meters. For sites with multibeam bathymetric data the relief used for the matrix was the maximum profile of the largest reef feature (e.g., wall, pinnacle, mound, etc.) within the site boundary determined from GIS analysis. Without multibeam or other geospatial data, it was not possible to estimate relief unless that was available from relevant literature.

- **Depth**: Units = meters. For sites with multibeam bathymetric data, the depth range was reported as the deepest and shallowest depths within the site boundary. For sites without multibeam or other geospatial data, depth range was estimated from NOAA navigation charts or from available literature.

- **Base Substratum**: This factor was restricted to represent the main material from which the reef feature was built (e.g., coral, rock (type, if known), consolidated muds, etc.).

- **Temperature Regime**: Units = degrees centigrade or generic designation if no explicit units were provided. The goal here was to determine not only the benthic temperature values but the degree of stability. If available, a range of temperatures was reported to infer variability.).

- **Salinity Regime:** Units = standard salinity units or generic descriptors if no explicit data were available. As above, the goal was to describe benthic salinity values and variability. If available, a range of salinity values was reported.

- **Proximity to Shore**: Units = kilometers. A geodesic (shortest path between two points on a curved surface) measurement using ArcGIS (Esri ArcGIS Pro version 2.3) from the center of each site to the nearest mainland. Here, and in all ArcGIS measurements, the center of the site or site polygon and latitude and longitude of each selected feature was determined using the Feature to Point tool in ArcPRO: https://pro.arcgis.com/en/pro-app/2.8/tool-reference/data-management/feature-to-point.htm. For an input polygon feature: the output point will be located at the centroid of the polygon. The NOAA Shoreline Website (NOAA / Medium Resolution Shoreline https://shoreline.noaa.gov/data/datasheets/medres.html) was used to determine the nearest shoreline.

- **Proximity to Nearest Major River**: Units = kilometers. A geodesic measurement using ArcGIS from the approximate center of each site to the mouth (visually approximated) of the nearest major river. The CSA in house database was used to determine the latitudes and longitudes of the site centers as well as the selected feature endpoint at the river mouth.

- **Proximity to Active Oil/Gas Activity**: Units = kilometers. A geodesic measurement using ArcGIS from the approximate center of each site to the nearest active offshore oil and gas platforms or facilities. The BOEM Geographical Mapping Data in Digital Format website (https://www.data.boem.gov/Main/Mapping.aspx) was used to determine the nearest offshore platform or rig and to determine the latitudes and longitudes of the site centers as well as the selected feature endpoint.

- **Proximity to Wind Fields**: Units = kilometers. A geodesic measurement using ArcGIS from the approximate center of each site to the nearest offshore wind facility. Current offshore wind sites exist solely off the Northeast coast of the US, although Federal administration goals predict renewable energy development within the GoM (USDOI BOEM, 2021). Therefore, wind fields were included as a placeholder in the data matrix but were not included in this analysis.

- **Proximity to Offshore Mining**: Units = kilometers. A geodesic measurement from the approximate center of each site to the nearest offshore mining facility was made using ArcGIS. There were no mining facilities identified in the GoM project area. Therefore, offshore mining was included as a placeholder in the data matrix but was not included in this analysis.

- **Proximity to Shipping Lane**: Units = kilometers. A geodesic distance was measured using ArcGIS from the approximate center of each site to the nearest major shipping lane. The CSA in house database was used to determine the latitudes and longitudes of the site centers as well as the selected feature endpoint.

- **Proximity to Other Protected Areas (already designated)**: Units = kilometers. A geodesic distance was measured from the center of each site to the nearest edge of the nearest site currently protected by state or federal law (e.g., Marine Sanctuaries, HAPCs, etc.). The USGS PAD-US Data Web Services (https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/science/pad-us-data-web-services?qt-science_center_objects=0#qt-science_center_objects) and the Gulf Council Coral 9 HAPCs and Regulations portal (Coral 9 HAPC and Regulations Viewer [gulfcouncil.org]) were used to determine the nearest protected area as well as the selected feature endpoint.

- **Proximity to Consistent Military Operations**: Units = kilometers. A geodesic distance was measured from the approximate center of each site to the nearest active military operations using ArcGIS. The CSA in house database was used to determine the latitudes and longitudes of the site centers as well as the selected feature endpoint.

- **Proximity to Dumping Areas (military, hazardous wastes, municipal, etc.)**: Units = kilometers. A geodesic measurement was made from the approximate center of each site to the nearest known dumping ground using ArcGIS. For ordinance disposal areas, the CSA in house database was used to determine the latitudes and longitudes of the site centers as well as the selected feature endpoint. For other dumping areas, the EPA Ocean Dumping website (https://www.epa.gov/ocean-dumping/managing-ocean-dumping-epa-region-4) was used to determine the latitudes and longitudes of the site centers as well as the selected feature endpoint.

- **Proximity to Benthic Methane Seeps**: Units = kilometers. This is a geodesic measurement using ArcGIS from the approximate center of each site to the nearest known methane seep location. Methane seep-related anomalies were selected from the following BOEM Seismic Water Bottom Anomalies websites:
    - https://services1.arcgis.com/Hp6G80Pky0om7QvQ/arcgis/rest/services/BOEM_Seismic_Water_Bottom_Anomalies/FeatureServer; and
    - https://www.boem.gov/oil-gas-energy/mapping-and-data/map-gallery/seismic-water-bottom-anomalies-map-gallery.

The following methane seep-related anomalies were selected from these data sources to plot their proximity to selected project sites:

- Seep-Related Confirmed Carbonate Anomalies.
- Seep-Related Confirmed Coral Anomalies.
- Seep-Related Confirmed Hydrate Anomalies.
- Seep-Related Confirmed Mud Volcano Anomalies.
- Seep-Related Confirmed Mud Volcano Gas Anomalies.
- Seep-Related Confirmed Organism Anomalies.
- Seep-Related Positive Confirmed Gas Anomalies.
- Seep-Related Positive Confirmed Oil Anomalies.

- **Scleractinian Coral Taxonomic Richness**: Numbers of documented hermatypic (reef-building) species, genera, or families derived from available literature or in some cases from unpublished, but reputable sources. These are generally colonial hermatypic scleractinian corals of the genera *Lophelia*, *Enallopsammia*, *Madrepora, Oculina, Madracis,* and *Agaricia*.

- **Octocoral Taxonomic Richness**: Numbers of all documented species, genera, or families derived from available literature or in some cases from unpublished, but authoritative sources.

- **Hydrozoan Coral (Orders Milleporina and Stylasterina) Taxonomic Richness**: Numbers of all documented species, genera, or families derived from available literature or in some cases from unpublished, but authoritative sources.

- **Antipatharian Coral Taxonomic Richness**: Numbers of all documented species, genera, or families derived from available literature or in some cases from unpublished, but authoritative sources.

- **Fish Taxonomic Richness**: Numbers of all documented species, genera, or families derived from available literature or in some cases from unpublished, but authoritative sources.

- **Benthic Fishing Activity/Intensity – Bottom Long Line (BLL)**: Estimates of BLL fishing activity on reef fishes were identified from aggregated spatial distributional and relative density data of reef BLL vessels across the GoM from NOAA's Office of Law Enforcement and Southeast Fisheries Science Center (SEFSC) Vessel Monitoring System (VMS) data from years 2015 to 2018. These data were obtained from the Council at the onset of the project and are summarized here. BLL gear is prohibited shallower than 50 fathoms (91 m) west of Cape San Blas, FL. East of San Blas it is prohibited out to 20 fathoms (37 m) most of the year (September to May), and that closure extends out to 35 fathoms (64 m) from June through August (GMFMC, 2019). Given the restricted inshore effort and deep coral habitat focus of the analysis, the data were further restricted to fishing activity in waters deeper than 45 m. These filters resulted in a preliminary dataset of 373,605 VMS points from 83 vessels. VMS data are described and analyzed as number of estimated fishing positions. The SEFSC VMS data recorded during 2015 to 2018 included GPS position and directional and speed measurements, typically recorded once per hour. Vessel fishing activity was not recorded but may be interpreted from vessel speed information. The VMS dataset was queried for vessels that possessed both the reef fish commercial permit and the BLL endorsement at the time of fishing. While the BLL endorsement is only required for fishing in the eastern Gulf, the presence of the annually renewed endorsement increased the likelihood that a vessel was engaged in bottom longlining and no other fishing methods encompassed by the commercial reef fish permit (e.g., handline, bandit reel). The NOAA data set plotted the spatial distribution of BLL fishing effort (numbers of vessel positions) using ArcGIS and aggregated the vessel positions into a grid of 5 × 5 km cells across the Gulf to visualize summary data and obscure individual vessel movement. The CSA team then superimposed the suite of project site polygons on the NOAA ArcGIS BLL data, and the estimated values (minimum, maximum, and mean numbers of positions) of the BLL fishing effort (positions) for the area within the project site polygon were recorded. If VMS BLL fishing activity from the 2015 to 2018 data set was not reported within a project site polygon, it was logged as a zero in the data compilation matrix (**Appendix B, Table B-1**). If activity was recorded within only a portion of the project site polygon, or if two values occurred within the polygon, the higher estimate was logged in the matrix.

- **Benthic Fishing Activity/Intensity – Bottom Trawl:** The spatial distribution of bottom trawl (assumed to be nearly all shrimp related) effort used for this analysis was derived from NMFS SEFSC data from 2006 to 2013 that was summarized and published by Clark et al. (2018). Specific vessel data in the ELB program are confidential; therefore, relative trawl effort (i.e., the estimate of hours trawled within a given area) was plotted by Clark et al. (2018) in ArcGIS and aggregated into a grid of 10 × 10 km cells across the Gulf to visualize summary data and obscure individual vessel movement. The Clark et al. (2018) graphic data were superimposed on the project's site map, and values of trawl effort (minimum, maximum, and mean hours trawled) for each project site polygon were recorded. As stated above for BLL fishing data, if ELB bottom trawl activity from the 2006 to 2013 data set was not reported within a project site polygon, it was logged as a zero in the data compilation matrix. If activity was recorded within only a portion of the project site polygon, or if two values occurred within the polygon, the higher estimate was logged in the matrix.

- **Benthic Fishery Types and Gears at Site**: General bottom contact type and gear (e.g., shrimp, bottom trawl; recreational, hook and line, etc.). These data were primarily derived from Gulf Council and/or NOAA sources. In some cases, CSA experience in the region was used to modify categories. Although listed in the data matrix, these data were not used in site ranking evaluation.

- **Invasive Species**: Noted numbers and species where known derived from available literature or in some cases from unpublished, but reputable, sources. A note was made if it was known if this topic was ever addressed for a site.

- **Disease Incidence**: Types of disease and taxa affected derived from available literature or in some cases from unpublished, but reputable, sources. A note was made if it was known if this topic was ever addressed for a site.

- **Research History**: This category was given a qualitative descriptor of Extensive, Moderate, Low, or None based on the number and type of publications found for each site in CSA's literature search. The number and types of publications and studies were compiled for each project site.

- **Current Protections**: Existing federal or state rules that protect the habitat and or the associated biota were considered and noted for each site. Proposed or eminent rules were also considered if well documented.

- **Vulnerability to Climate Change**: This factor was difficult to assess, and information was often subjective. Specific literature on a site basis is generally lacking but the effects of climate change usually occur on a broad scale. This vulnerability cannot be accurately assessed until additional authoritative information becomes available. Some brief discussion of potential general climate change impacts to deep reefs is provided in **Section 4.0**.

Results from the data search and review were compiled by project site, and distances of each site to selected areas calculated and placed in the matrix (**Section 2.1.4**). Each environmental factor was assigned a relative value rating in terms of affecting environmental integrity and quality, resulting in an "index" that allowed a rapid evaluation of individual sites and comparisons among sites (**Section 2.1.5**).

2.1.4 Data Compilation

From the beginning of the project contract period, the CSA Team worked closely with the Council to refine the structure and content of the data review and compilation task. Information collected for each project site during the data search and review was examined, and information pertaining to the selected environmental factors was entered into corresponding cells for each project site. This resulted in a synoptic presentation of area-specific information that was used for site comparisons and rankings as part of the ecological assessment (**Section 2.1.5**). Sources of data used to populate each cell were embedded in the cell as notes. In cases where information (or reliable information) was not located, the cell was left blank. In cases where the cell was not applicable to the site, 'n/a' was entered in the cell.

The distance/proximity analysis was conducted in ArcPro version 2.8.3. Coral site centroids were created from a coral site polygon feature using a "Feature to Point" tool. The coral site centroids are representative of center points for each coral site. A "Near" analysis was then performed between the coral site centroids and each proximity feature. Proximity feature data sources are listed in the Coral Matrix Spreadsheet. Endpoints at the proximity features and lines connecting the coral site centroids to the endpoints were created using the "XY to line" tool. Geodetic distances were then calculated for each line using the "calculate geometry attributes" tool. Where information was not applicable, 'n/a' was entered in the cell.

2.1.5 Ranking of Environmental Factors and Final Scoring Methods

The main tool developed for the Ecological Assessment was the data matrix approach described in **Section 2.1.3**. The most difficult aspect of this project was assigning rank values to each environmental factor. Factor rankings are relative and consider a set of attributes either on quantitative (e.g., distance from shore) or qualitative (e.g., "degraded" versus "healthy") scales based on subjective, visual assessments of data distributions, and may incorporate generalized scaling terms (Altman et al. 2011). For example, publications (e.g., Moffitt et al. 2011; Vandeperre et al. 2011) usually suggest that for Marine Protected Area (MPA) design, bigger sites or linked sites are better than smaller or isolated sites. But exactly how many hectares are required for an MPA to meet conservation objectives in a given region is rarely known, an exception being described by McLeod et al. (2009).

Factors are not equal in terms of their real or potential negative or positive impacts to deep reefs. For example, bottom trawling activity near or on a site would likely have much larger impact than would the site's proximity to shipping lanes. Thus, some factor rankings may be weighted in regard to the perceived likelihood of their influence (positive or negative) on reef ecology. Ranking criteria and values were defined after factor cells of a site's data matrix were filled in and their variabilities assessed. Each cell of the site data matrix contains a value for the factor for the given site. Site factors represented by numerical values were plotted as frequency distributions, which were used to categorize the range of factor values as well as the continuity of data and the shapes of frequency plots. A relative ranking using a point system was then assigned to each factor's data based on the distribution and range of values across all sites. Ranking numbers for all factors were totaled per site, and the higher the summed number the healthier (and thus less vulnerable) the site. Data for some factors were not available, or so variable or potentially arbitrary that they could not be used for rankings. It should be noted that the greatest utility of this type of analysis or evaluation is realized by including all known sites within a region (in this case, the GoM project area), thus including all known ranges of variables. The current project does not include all GoM deep reef sites (see **Section 3.1.1**), and so the subset of sites evaluated here imposes some limits to the ecological assessment.

Ranking methods for each environmental factor are described below. Note that actual ranked point values that were assigned do not have intrinsic ecological meaning; rather, they were used to position the sites on a relative and comparative basis. What matters most is whether a site factor rated relatively high, low, or medium, not whether high was assigned a particular point value. Ranked point assignments allowed all factors to be totaled to deliver a single ranking value for each site.

- **Area Ranking**: Because larger protected areas or ecosystems typically have more ecological or biodiversity buffering and thus, should be less vulnerable to disease or other impacts, the largest sites were ranked highest (least vulnerable). McLeod et al. (2009) suggested that MPAs should be a minimum of 10 to 20 km in diameter, which converts to a circular area of 78.5 to 314 sq km (7,850 to 31,400 ha). We assumed this criterion could be relevant to GoM deep reefs and thus assigned higher weighting (3 extra points) to sites that were >17,671 ha in area. This represented the midpoint of size suggested by McLeod et al. (2009). Visual examination of the frequency plots of site areas (see **Figures 2** and **3** for area and distributions of area by site, respectively) suggested three groups of area useful for ranking. Group I (largest area with sites >27,800 ha) was arbitrarily assigned 5 points, followed by Group II (area between 229 and 27,800 ha) with 4 points and finally Group III (area <229 ha) with 2 points.

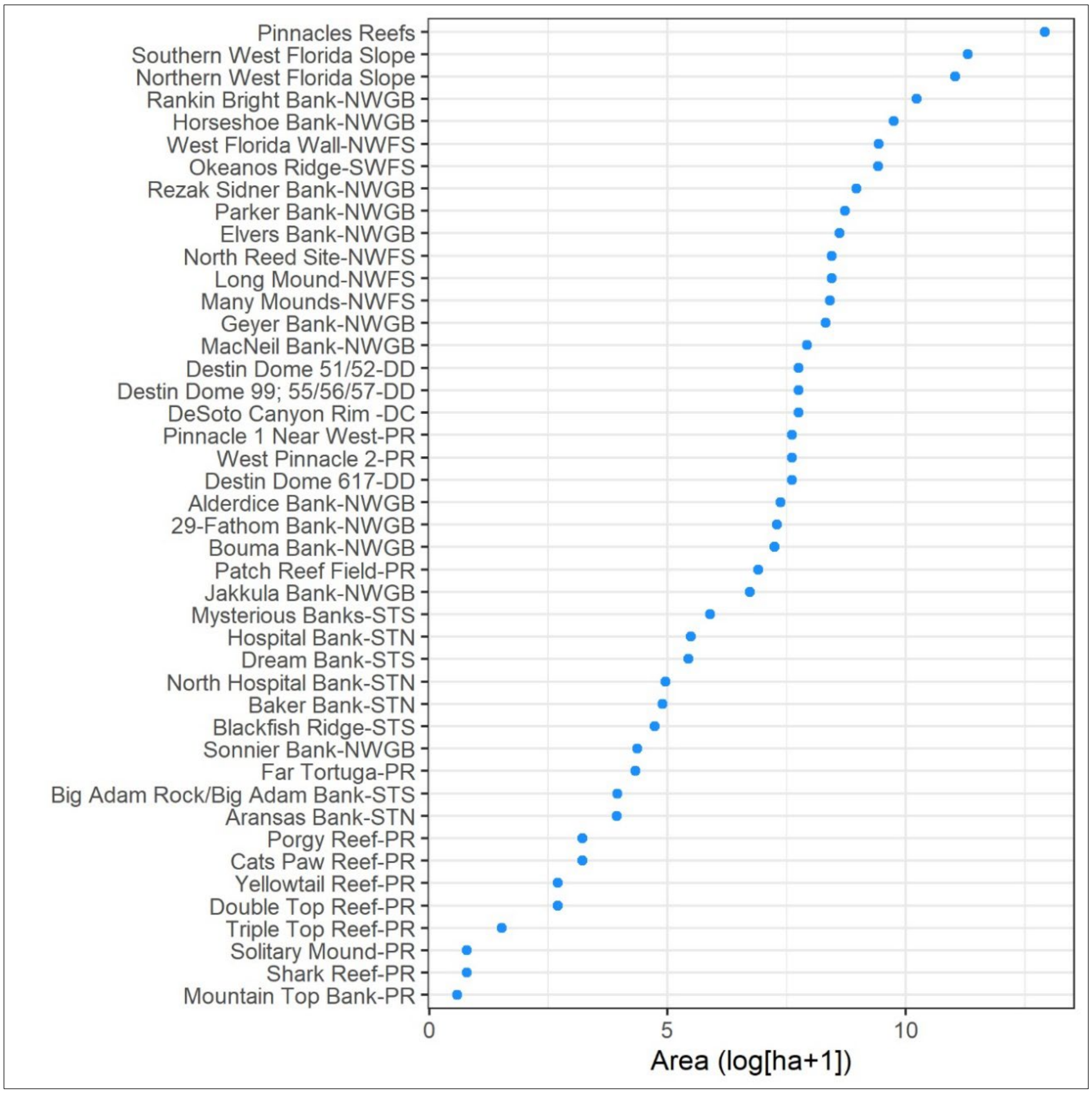

Figure 2. Area (log[ha+1]) for selected Project Sites. Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS).

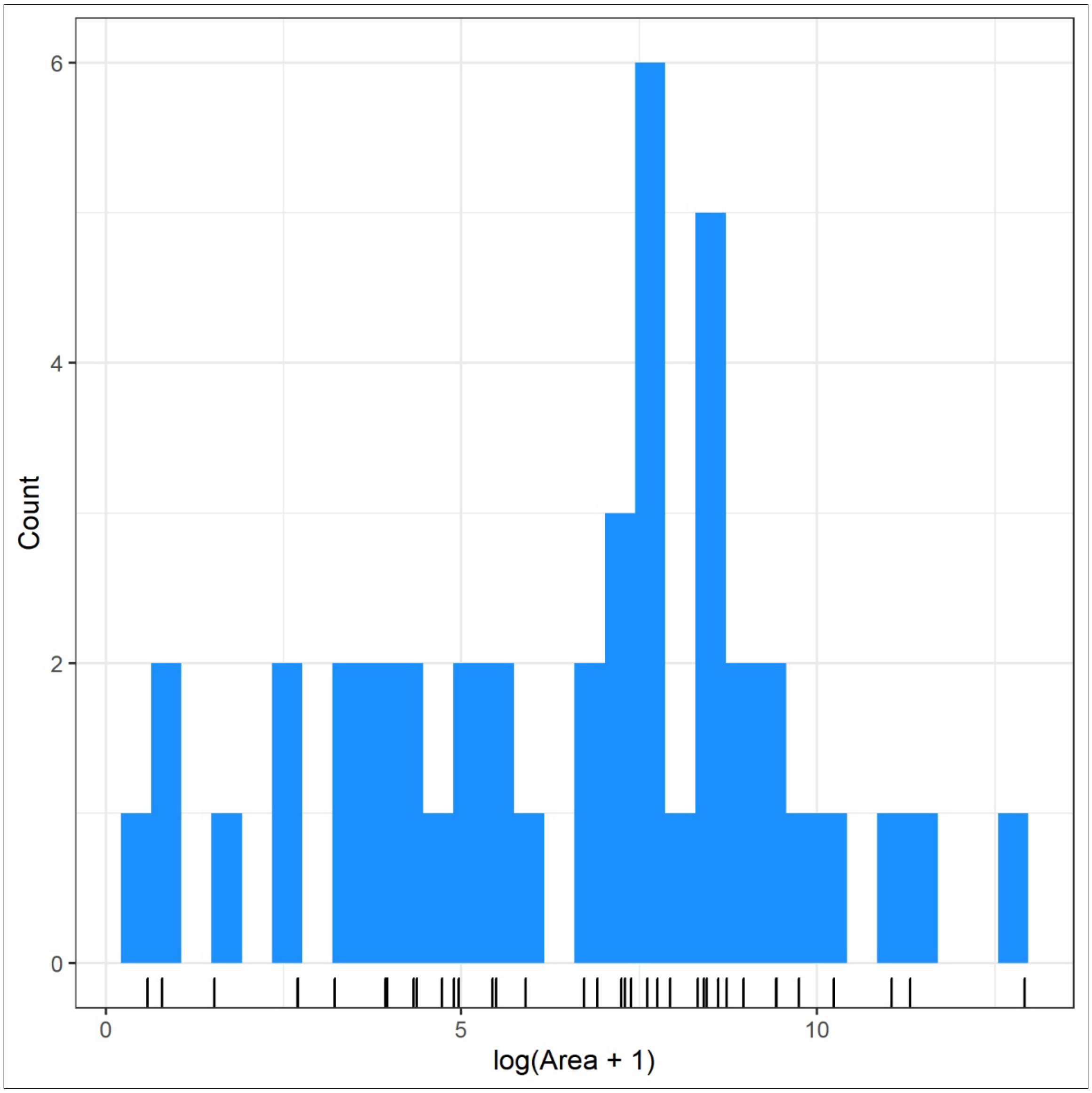

Figure 3. Distribution of area (log[ha+1]) data for selected Project Sites. Black tick marks along the x axis represent individual sites.

- **Vertical Relief Ranking**: In general, areas with larger physical relief have more biodiversity and perhaps ecological buffering, and thus may be less vulnerable to disease or other impacts. Thus, areas with the greatest relief were ranked highest. Visual examination of the frequency plot of site relief (see **Figures 4** and **5** for vertical relief and distributions of vertical relief by site, respectively) was used to assign sites to one of three relief groups. Group I (highest relief) for sites with maximum relief >20 m was assigned 5 points followed by Group II sites with relief between 6 and 20 m (4 points), and Group III sites with relief <6 m (2 points). Note that the frequency plot did not clearly separate Groups I and II, but because of the large range of data and because levels of low and moderate relief should be better defined, we chose the somewhat arbitrary division of 6 m.

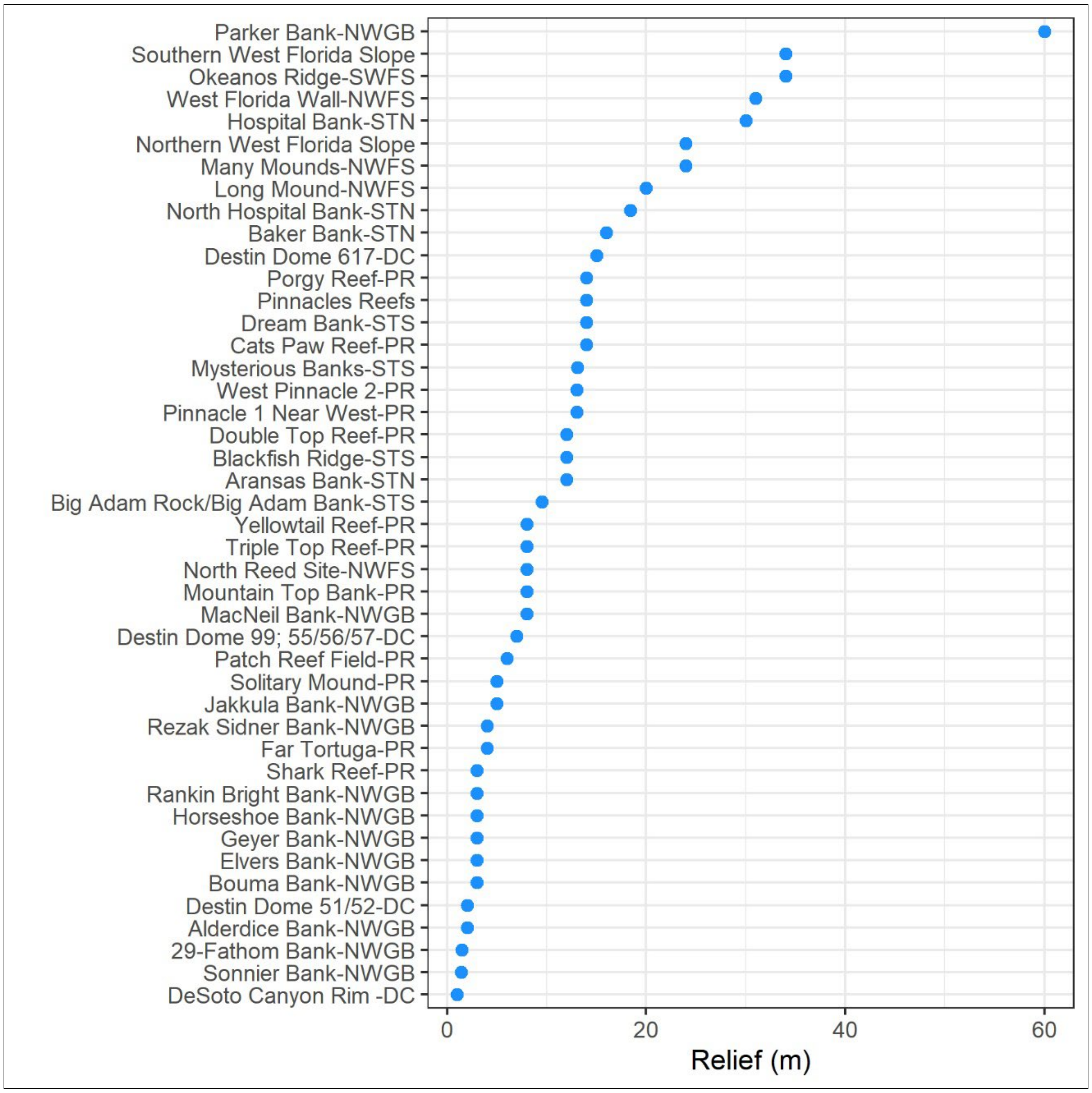

Figure 4. Relief (m) for selected Project Sites. Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS).

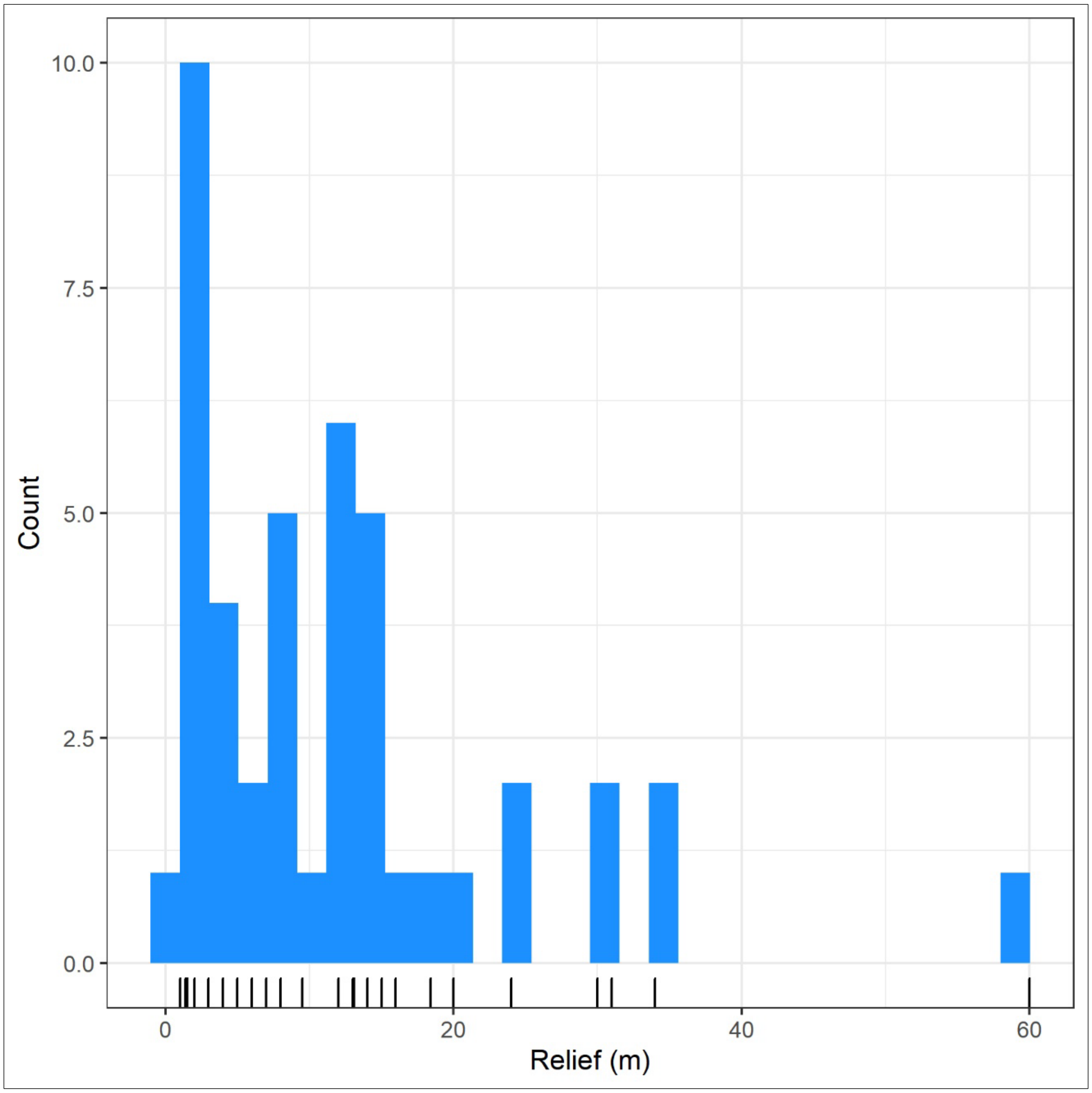

Figure 5. Distribution of relief (m) data for selected Project Sites. Black tick marks along the x axis represent individual sites.

- **Water Depth Ranking**: While a variety of factors (e.g., species richness) normally change with depth, objective criteria to evaluate the value or ecological impact of depth are lacking. In other words, increasing or decreasing depth are difficult to rank as inherently good or bad. However, in general deeper sites are likely to be more environmentally stable and farther removed from most potential impact sources. For this analysis, frequency plots of the depth data (see **Figures 6** and **7** for depth and distributions of depth by site, respectively) revealed two widely separated depth zones (basically “shallow” and “deep”). Two points were assigned to Group I (deep zone, >500 m depth) and one point was assigned to Group II (shallow zone, <250 m depth).

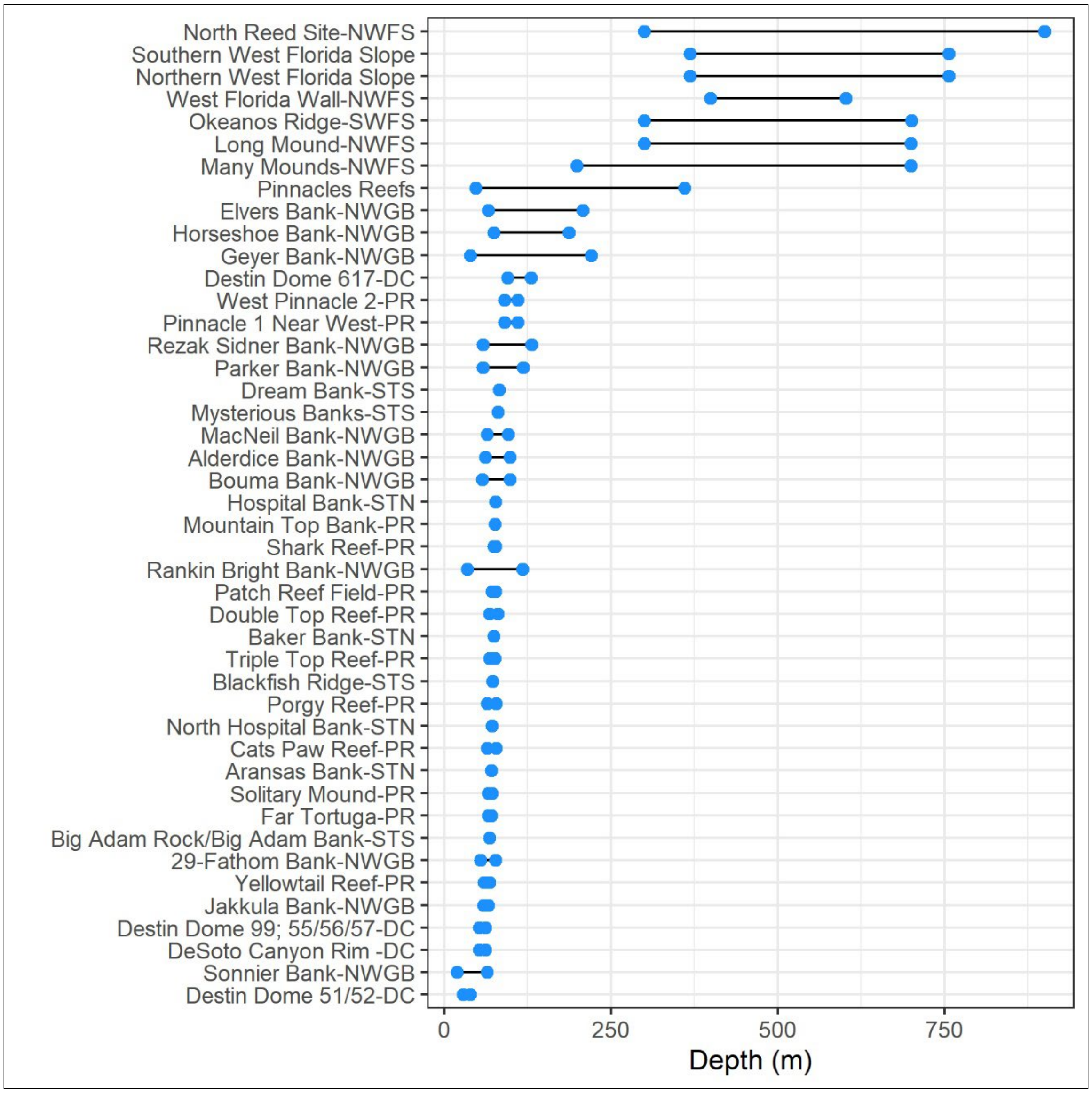

Figure 6. Water depth or depth range (m) for selected Project Sites. Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS).

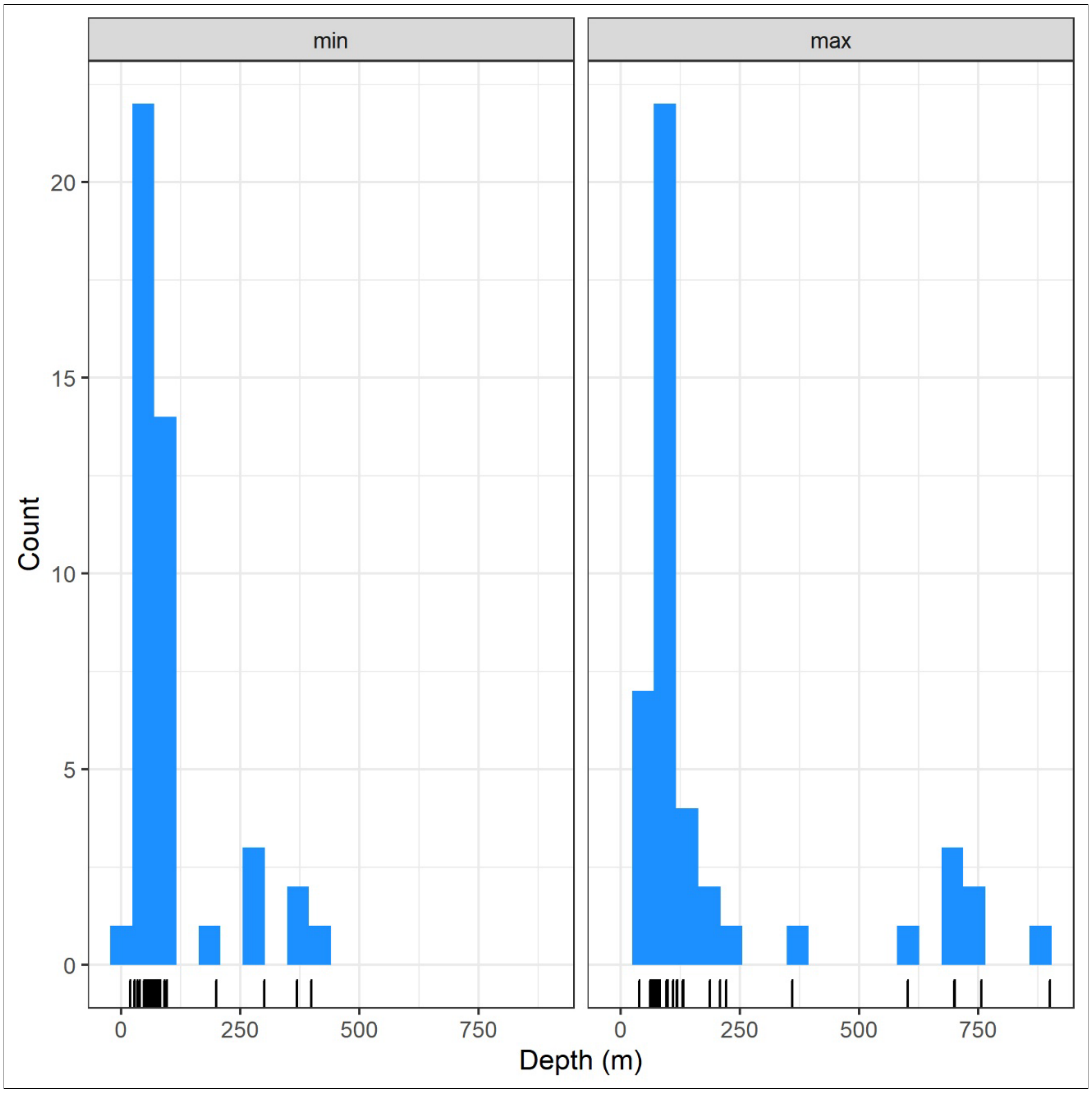

Figure 7. Distribution of depth (m) data for selected Project Sites. Black tick marks along the x axis represent individual sites.

- **Base Substratum Ranking**: It was assumed that living coral substratum had high ecological value but also would be the most vulnerable, and so sites with coral substratum (Group I) were assigned the most points (5 points). In decreasing order, living coral substratum was followed by carbonate rock (Group II,3 points), and consolidated sediments such as siltstone (Group III,2 points).

- **Temperature Regime Ranking**: We proposed to assign higher rankings to sites with greater temperature stability. Temperature stability (i.e., low variability) is usually correlated with distance from shore, depth, and distance from rivers. For example, sites closer to shore and river outflow, such as the Pinnacles Reefs, have greater variability in temperature than sites farther offshore, like Elvers Bank. However, the availability and highly variable nature of these data, as well as the uncertainty surrounding how they were measured made this factor difficult to evaluate. For now, we decided not to use this factor in rankings.

- **Salinity Regime Ranking**: In general, areas with stability in salinity may be less vulnerable to disease or other impacts. Sites closer to shore and/or near major river systems, such as the Pinnacles Reefs, have greater variability in salinity than sites farther offshore, like Elvers Bank. Thus, after all salinities for sites are documented, areas with the smaller salinity range (i.e., less variable) will rank highest. As above, however, the availability and highly variable nature of these data, as well as the uncertainty surrounding how they were measured made this factor difficult to evaluate. For now, we decided not to use this factor in rankings.

- **Proximity to Shore Ranking**: Sites closer to shore have relatively greater variability in environmental conditions and are often closer to sources of impact compared with sites farther offshore. Thus, highest ranking was given to sites farther offshore. Visual examination of the frequency distributions suggested three patterns of shore ranking proximities, roughly divided at 110 km and 220 km (see **Figures 8** and **9** for distances and distributions of distances by site, respectively); however, since negative impacts are more probable with decreasing distance to shore (noted above), we divided the frequency distribution less than 110 km into two sections, arbitrarily divided at 70 km. We combined all sites beyond 110 km into one group. Thus, category I (<70 km from shore) received one point, Category II (70 to 110 km from shore) received two points, and Category III (>125 km from shore) received 4 points.

  Proximity to Active Oil/Gas Activity Ranking: Based on the potential for negative impacts associated with offshore oil and gas activities to benthic habitats and communities from construction, decommissioning, and both routine and accidental impact producing factors, the closer the distance to this activity, the higher the vulnerability and the lower the ranking score. Frequency distributions of proximity revealed two widely separated data groups (see **Figures 8** and **9** for distances and distributions of distances by site, respectively). Because the smaller distance distribution group still represented a wide range of distances, we split the close distance group into two subgroups. The farthest group (Group I) at distances >300 km was assigned 5 points, Group II (distances between 10 and 80 km) was assigned 3 points, and Group I (distances of <10 km) was assigned one point.

- **Proximity to Wind Fields or Mining Ranking**: Based on the potential for negative impacts to benthic habitats and communities from construction and both routine and accidental impact producing factors associated with offshore wind field development activities, and physical disturbances to the seafloor associated with seafloor mining activities, the closer the distance to these activities, the higher the vulnerability and the lower the score. However, at this time wind energy and ocean mining are not relevant in the GoM, and so these were not ranked.

- **Proximity to Shipping Ranking**: The closer the distance to this activity, the lower the score, and the higher the vulnerability. Most sites were close to (<40 km) or within known shipping lanes and were assigned 1 point. A few sites >50 km from shipping were given 3 points. See **Figures 8** and **9** for distances and distributions of distances by site, respectively.

- **Proximity to Nearest Major River Ranking**: Sites closer to river discharges usually have greater variability in environmental conditions and are closer to many sources of impact compared with sites farther offshore. Thus, highest ranking was given to sites farther from river mouths. Visual examination of the frequency plots (see **Figures 8** and **9** for distances and distributions of distances by site, respectively) revealed a trimodal distribution, which we used to assign three rank groupings. Group I, at distances >220 km from a river mouth received 3 points, Group II, at distances between 110 to 220 km received 2 points, and Group III, at distances <110 km was assigned one point.

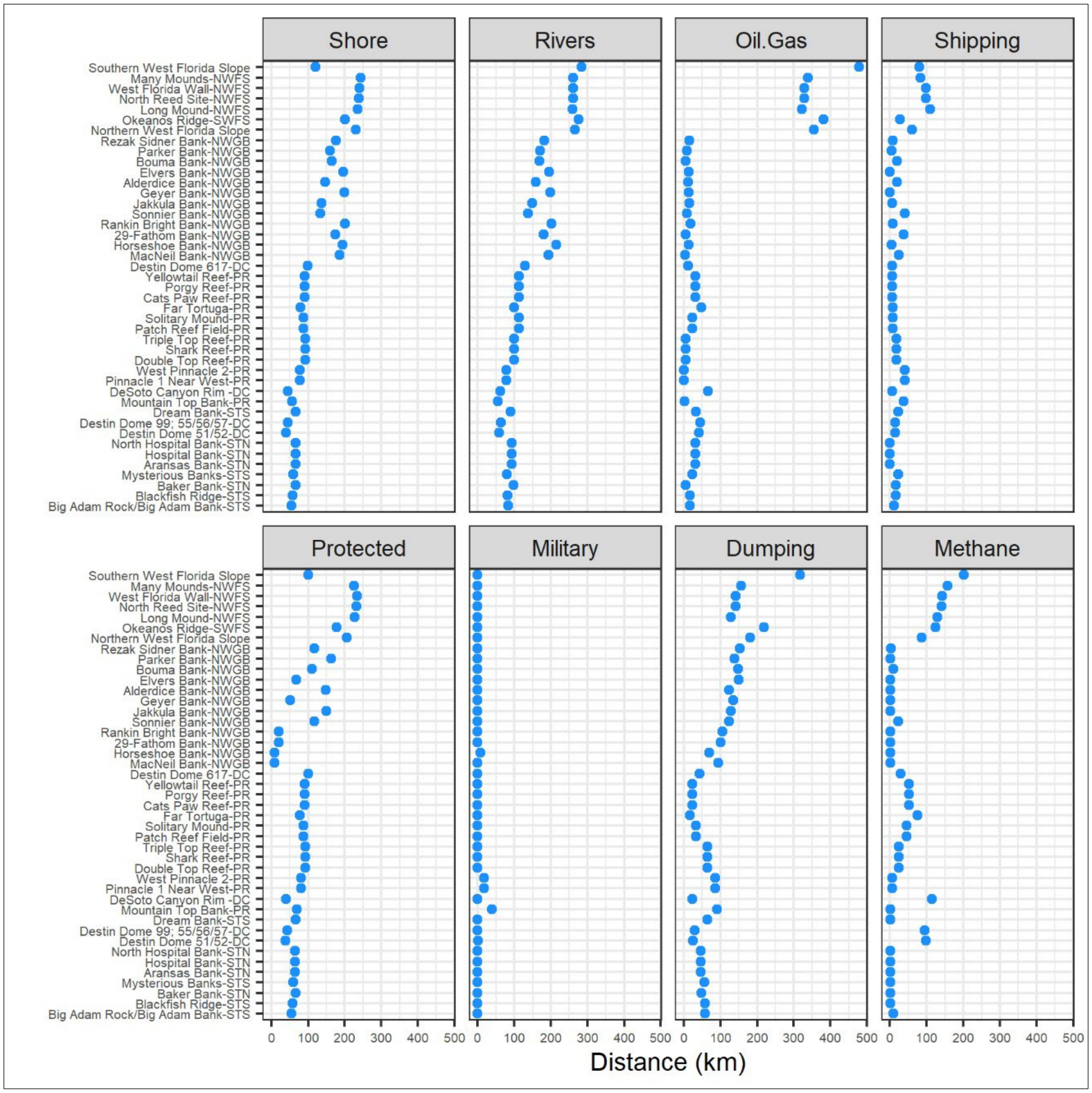

Figure 8. Distance (km) of selected Project Sites from shore, rivers, oil and gas operations, and shipping lanes, protected areas, military areas, dumping areas, and methane seeps. Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS).

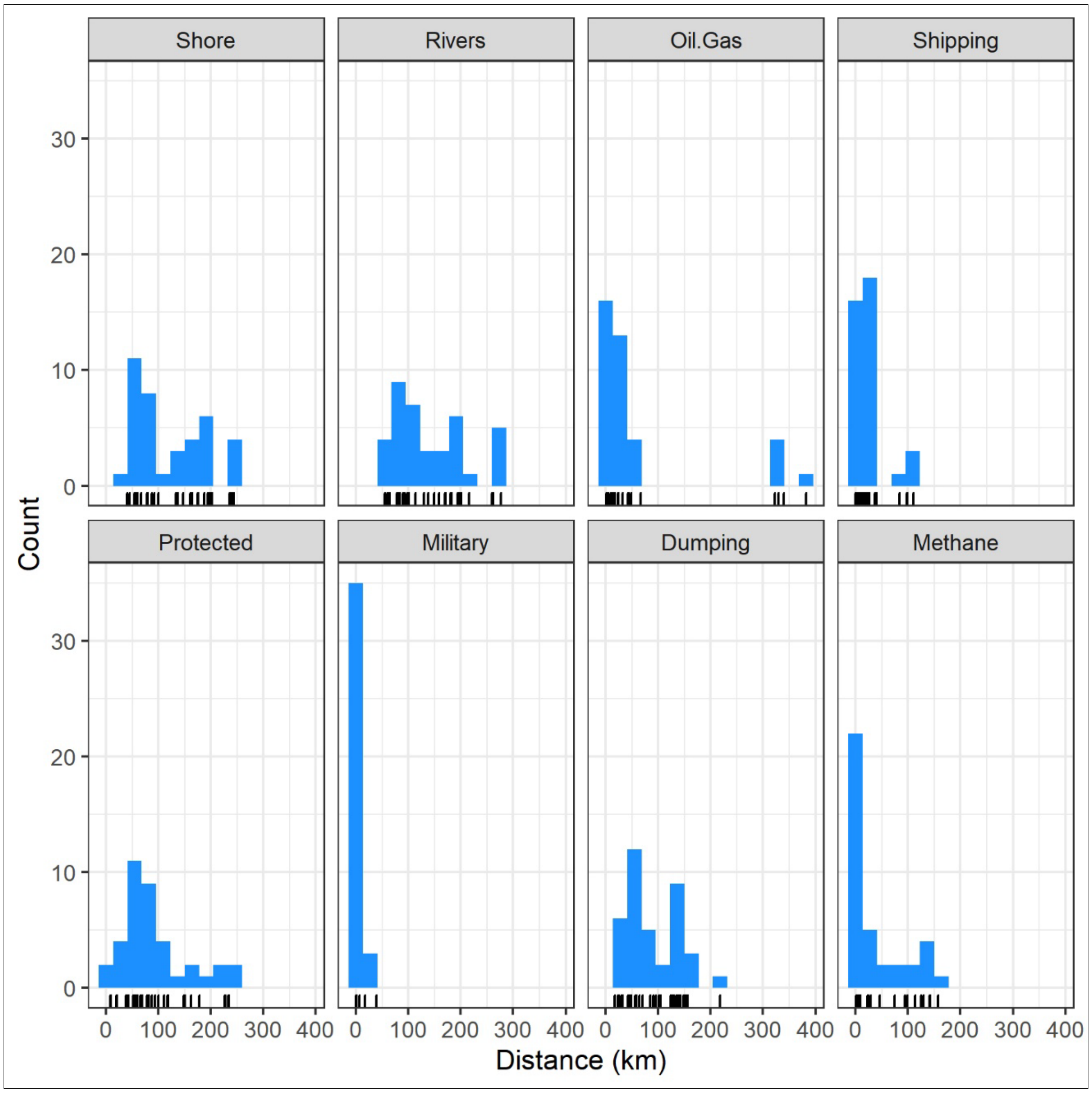

Figure 9. Distribution of distance (km) data of shore, rivers, oil and gas operations, and shipping lanes, protected areas, military areas, dumping areas, and methane seeps from selected Project Sites. Black tick marks along the x axis represent individual sites.

- **Proximity to Other Protected Areas (already designated) Ranking**: Sites closer to locations already receiving protection are more likely to exhibit benefits from that site compared with sites farther from protected areas. Although the size of the protected area also has impact, analyzing size as well as distance of these MPAs was beyond the current project scope. Thus, the closer the site to such areas the higher the ranking. Visual inspection of the frequency plots (see **Figures 8** and **9** for distances and distributions of distances by site, respectively) indicated three main groupings as follows: Group I at distances <50 km was given 5 points, Group II at distances from 50 to 120 km received 3 points, and Group III at distances >130 km received zero points.

- **Proximity to Consistent Military Operations Ranking**: Because military associated operations may increase probabilities for negative impacts, the closer the distance to this activity, the lower the score, and the higher the vulnerability. Frequency distributions (see **Figures 8** and **9** for distances and distributions of distances by site, respectively) indicated that most of these sites were close to or within some type of military operation. One reason for this is that the designated military areas are often very large. The nature of these data did not allow determination of details about the operations (e.g., type of operation, frequency, duration, exact locations), and so ranking was problematic. The most conservative approach was not to use this factor for ranking until more detail could be acquired.

- **Proximity to Dumping Areas (military, hazardous wastes, municipal, etc.) Ranking**: The closer the distance to this activity, the lower the score, and the higher the vulnerability. Visual inspection of the frequency plots (see **Figures 8** and **9** for distances and distributions of distances by site, respectively) suggested three possible categories assigned as follows: Group I, at distances >150 km was assigned 5 points, Group II (50 to 150 km) 3 points, and Group III, with distances <50 km from dumping was given one point.

- **Proximity to Benthic Methane Seeps Ranking**: There are few, if any, known detrimental effects for coral or reef communities being in proximity to active methane seeps. In fact, some research has suggested that being near such areas may enhance benthic productivity and provide additional structured habitats, such as emergent authigenic carbonate substrate. For this project, it was assumed that being closer to methane seeps provides some environmental and/or structural enhancement and so has higher value. There were two major distributions of the distance frequencies (see **Figures 8** and **9** for distances and distributions of distances by site, respectively), but because the closer group represented a wide range of distances and would have higher probability impacts, it was subdivided into two groups for a total of three groups. Group I at distances <10 km was assigned 5 points, Group II at distances of 10 to 50 km received 3 points, and Group III at distances >80 km was likely too far away to impact any site and so was not given any points.

- **Invertebrate Taxonomic Richness Rankings:**

  The greater number of structure-forming species or taxa, the higher the score and the higher the ecosystem stability and the lower the vulnerability. There were widespread differences in the taxonomic resolution of fauna recorded at project sites between various references. Due to these inconsistencies in reviewed literature, it was necessary to rank taxonomic richness of scleractinian corals, octocorals, hydrozoan corals, and antipatharian corals by numbers of genera rather than by species.

  - **Scleractinian Coral Taxonomic Richness Ranking**: See **Figures 10** and **11** for richness (numbers of genera) and distribution of richness by site, respectively. Although, as with the fishes (see below), this factor could be assessed for different depth ranges, for now we examined it over the whole depth range. Visual inspection of the distribution figures suggested three general genera richness groupings. Group I with numbers of genera >10 was assigned 5 points. Group II with 5 to 10 genera was assigned 4 points, and Group III with <5 genera was assigned 3 points.

- **Octocoral Taxonomic Richness Ranking**: See **Figures 10** and **11** for richness (numbers of genera) and distribution of richness by site, respectively. Visual examination of the genera richness distributions suggested three groupings. Group I with >10 genera was assigned 5 points, Group II was less distinct but was classified as having 4 to 6 genera and was assigned 4 points, and Group III with <4 genera was assigned 3 points.

- **Hydrozoan Coral (Orders Milleporina and Stylasterina) Taxonomic Richness Ranking**: We found hydrozoan data for 16 sites; however, these data seemed incomplete or lacking in general. Thus, this factor was not used at this time for site comparisons.

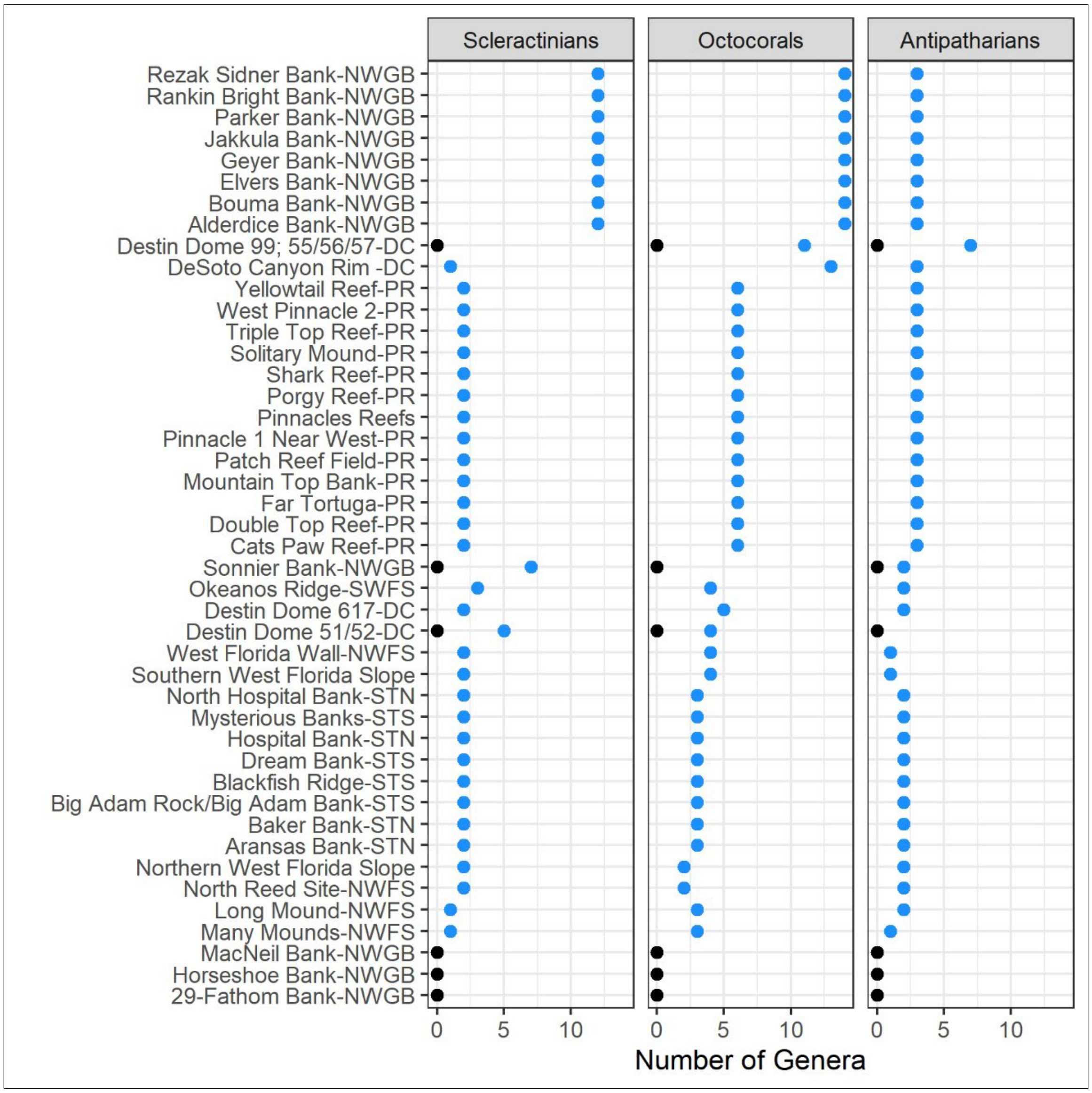

Figure 10. Reef-building scleractinian coral, octocoral, and antipatharian coral taxonomic richness (number of genera) for selected Project Sites (black symbols indicate missing data). Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS).

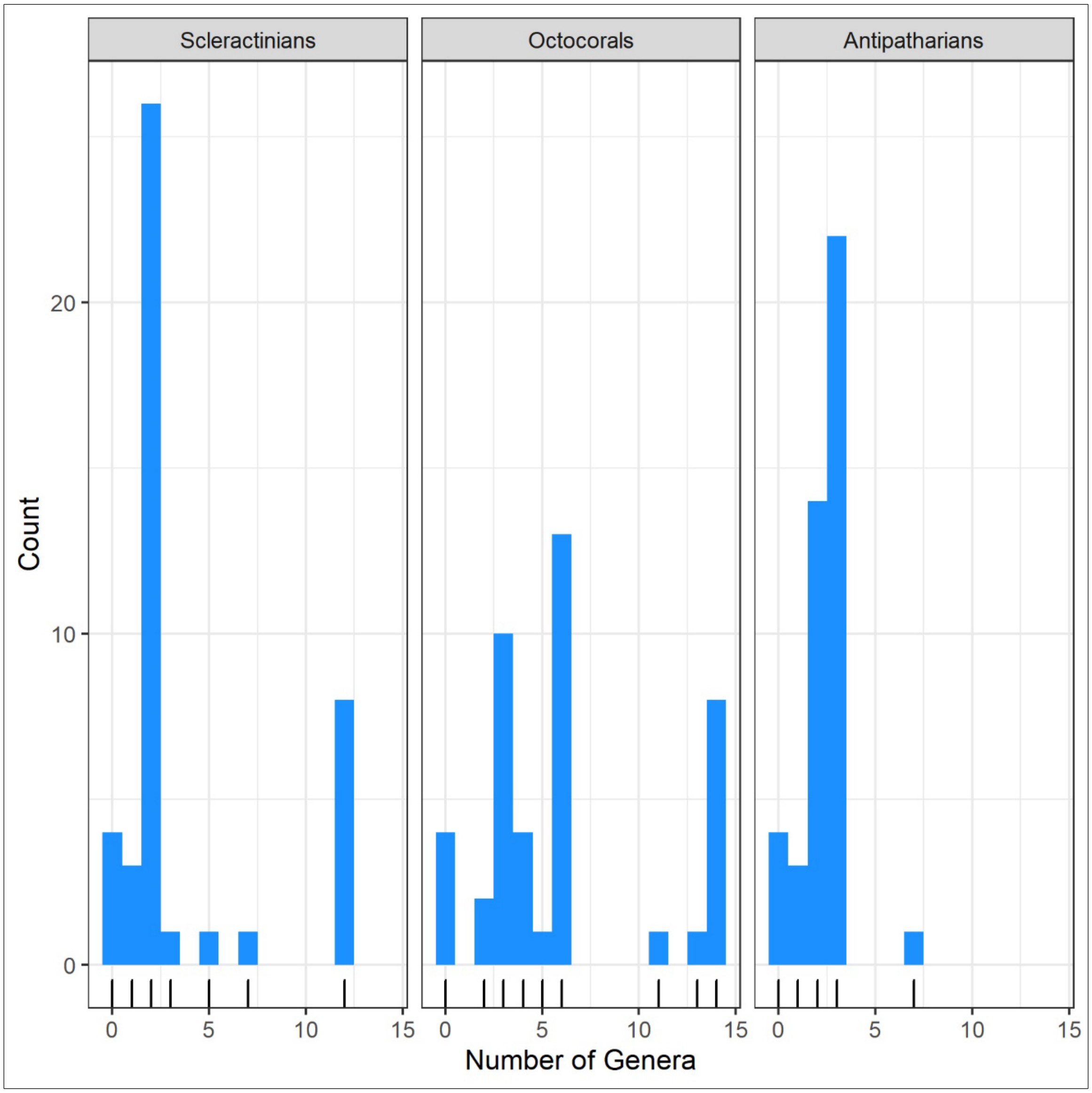

Figure 11. Distribution of reef-building scleractinian coral, octocoral, and antipatharian coral taxonomic richness (number of genera) data for selected Project Sites. Black tick marks along the x axis represent individual sites.

- **Anthipatharian Coral Taxonomic Richness Ranking**: See **Figures 10** and **11** for taxonomic richness (numbers of genera) and distribution of richness by site, respectively. Based on the genera richness distributions by site, we assigned sites having data to one of two groups. Group I with >5 genera was assigned 4 points, and Group II with <5 genera was assigned 3 points.

- **Fish Taxonomic Richness Ranking**: The greater number of species or taxa, the higher the score and the lower the vulnerability. Because depth zones play a major role in deep reef fish species community structure (Ross and Quattrini, 2007; Ross et al., 2015), fish taxonomic richness was ranked within two depth zones: mesophotic (<200 m depth) and deep-sea (>200 m depth) (see **Figures 12** and **13** for taxonomic richness (numbers of species) and distribution of richness by site and depth zone, respectively. For the deep zone, there was only one data set and so all sites in that zone received 5 points. For the shallower zone, visual examination of distribution graphs suggested three groupings may be appropriate. Group I with species richness of 30 to 50 species was assigned 5 points; Group II with richness between 20 to 29 species was assigned 4 points and Group III, with richness <20 species was assigned 3 points. Sites plotted with "0" indicate no data available.

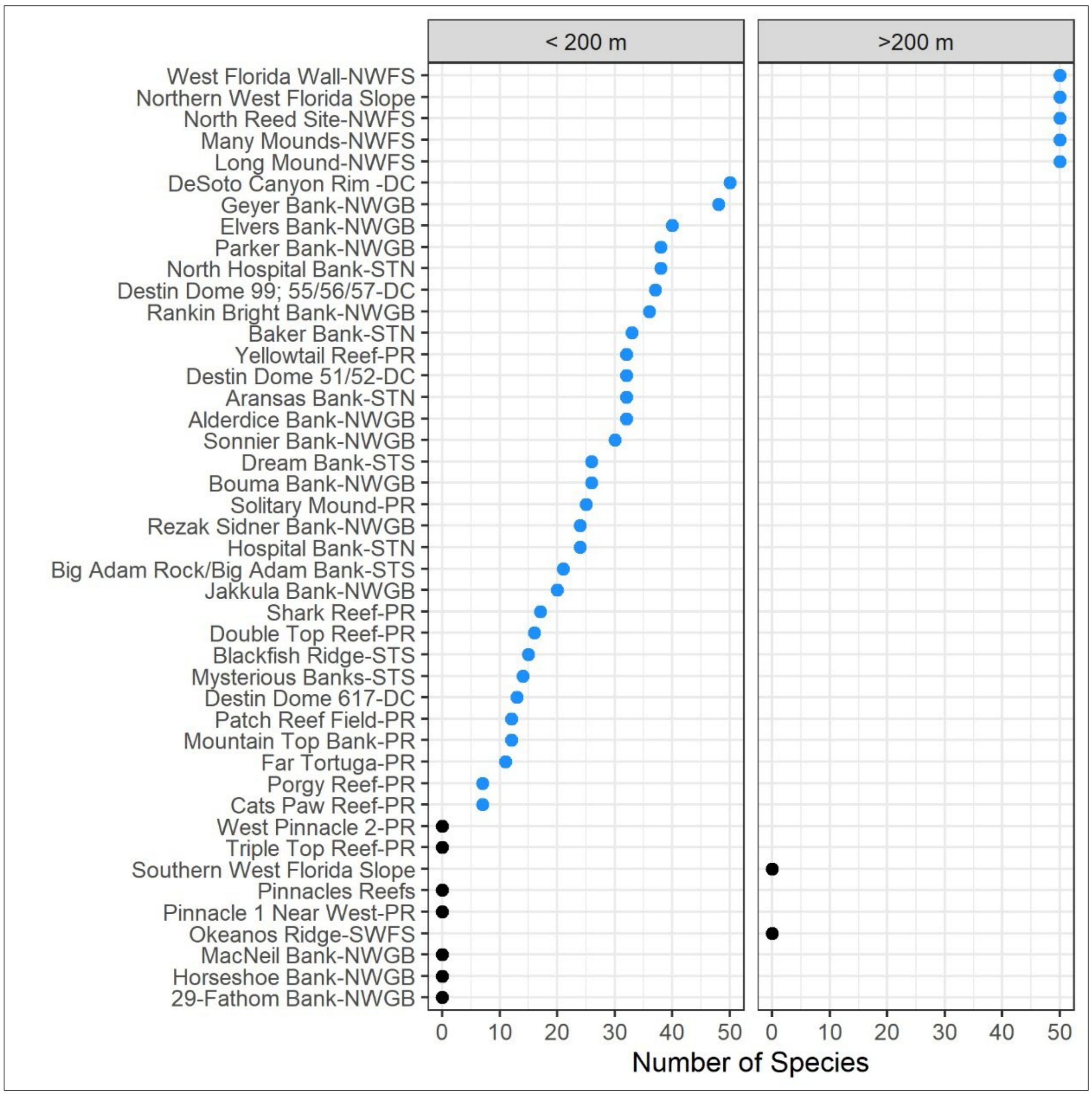

Figure 12. Fish taxonomic richness (number of species) for selected Project Sites within two depth zones: mesophotic (<200 m depth) and deep-sea (>200 m depth) (black symbols indicate missing data). Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS).

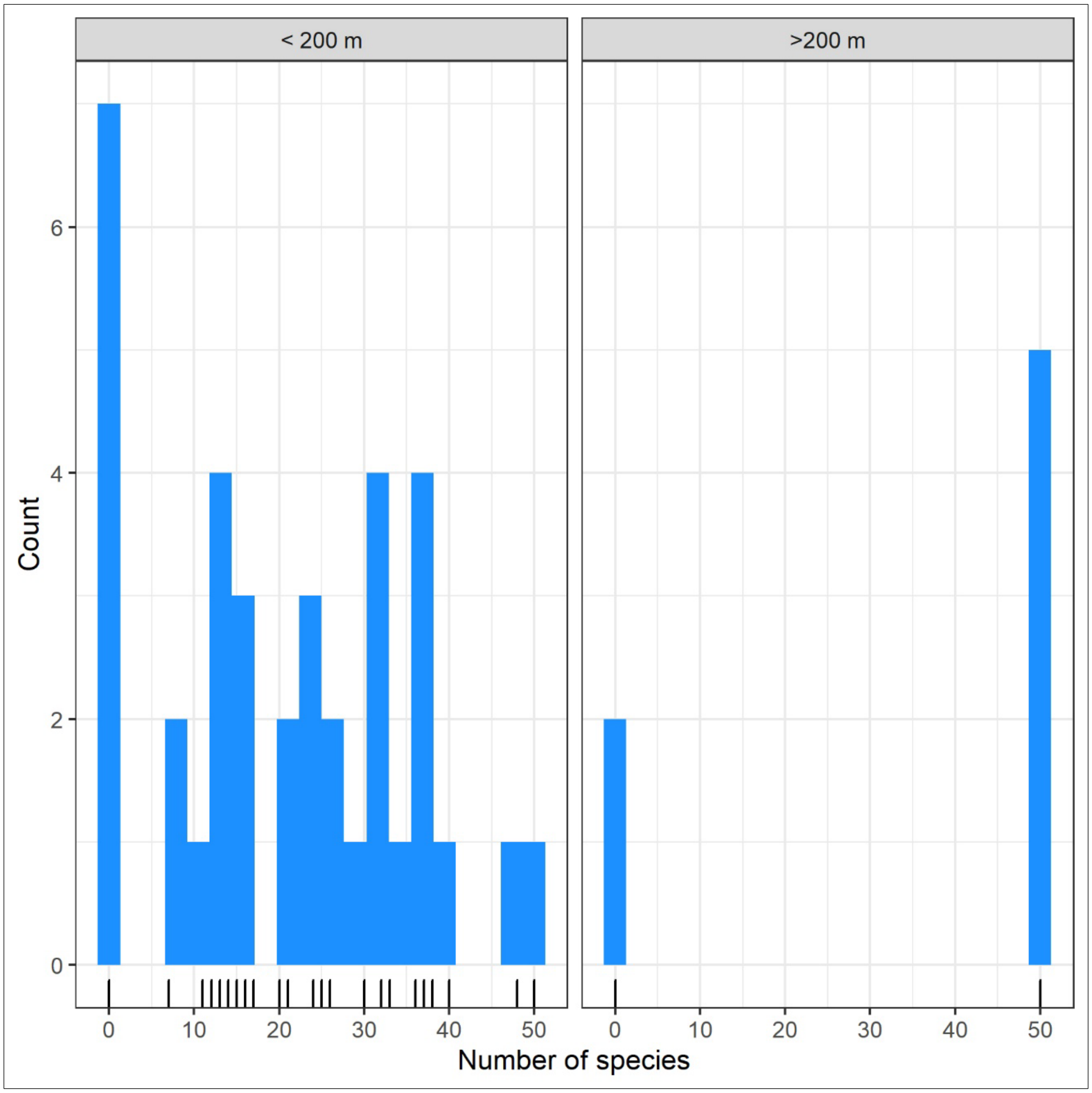

Figure 13. Distribution of fish taxonomic richness (number of species) data for selected Project Sites within two depth zones: mesophotic (<200 m depth) and deep-sea (>200 m depth). Black tick marks along the x axis represent individual deep reefs.

- **Bottom Longline (Reef Fish) Fishing Activity/Intensity Ranking:** Estimates of the frequency/intensity of the bottom longline (BLL) gear for reef fishes (derived from NOAA SEFSC VMS data from years 2015 to 2018, as supplied by the Council; see **Section 2.1.3**) was considered in rankings(See **Figures 14** and **15** for estimated BLL fishing intensity and distribution of intensity by site, respectively). Eleven sites either supported no BLL fishing activity or there were no data, and it was not possible to determine which was the case. We assumed no activity for these sites and assigned 5 points for that case (Group I). Group II sites with 1 to 1,000 VMS counts were assigned 4 points, Group III sites with 1,001 to 2,000 counts received 3 points, and Group IV sites with counts greater than 2000 received 0 points.

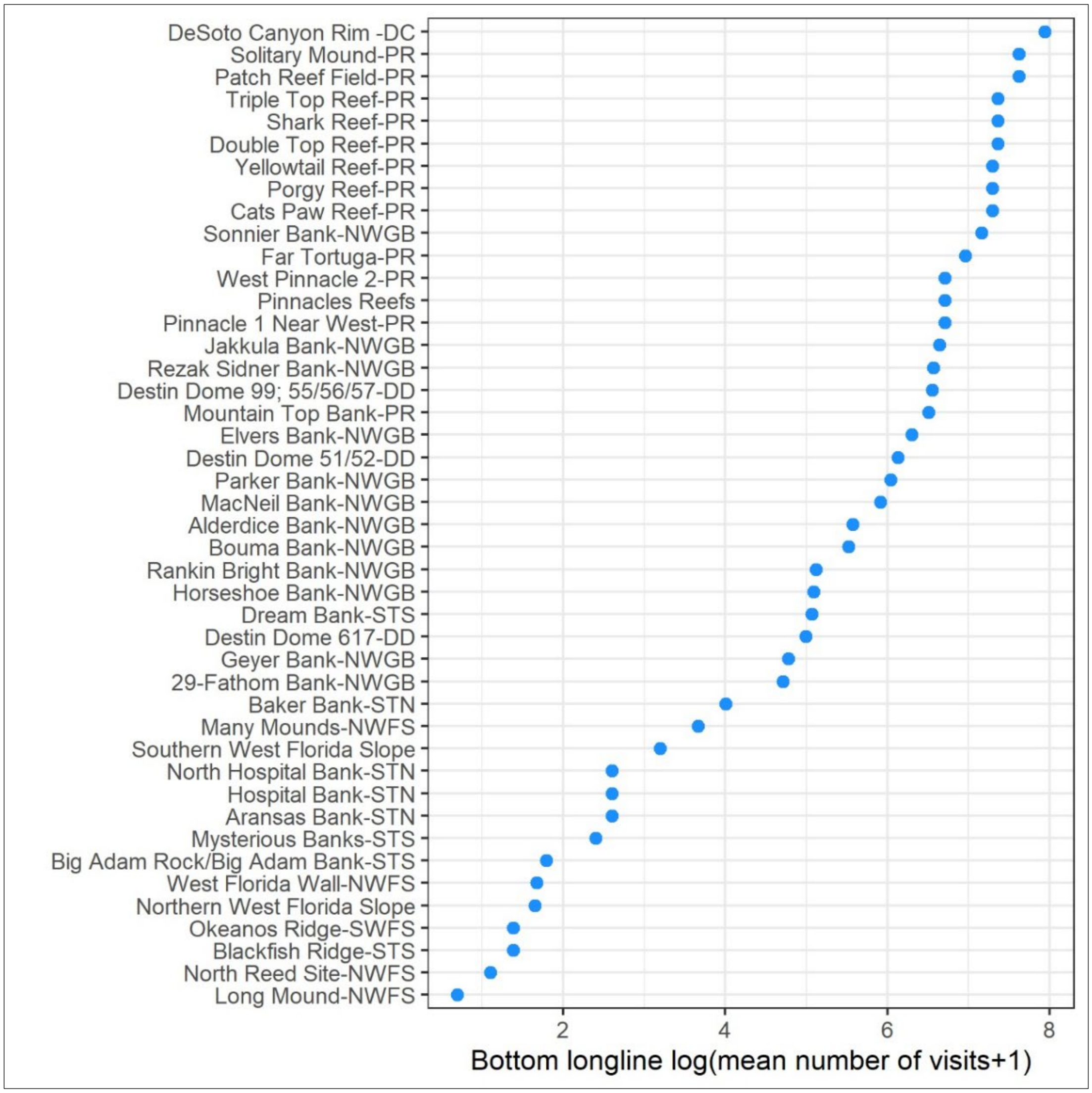

Figure 14. Estimated bottom longline fishing activity (VMS counts) for spatial grids encompassing selected Project Sites (from NMFS SEFSC and Council). Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS). (Source: NMFS SEFSC and Gulf of Mexico Fishery Management Council).

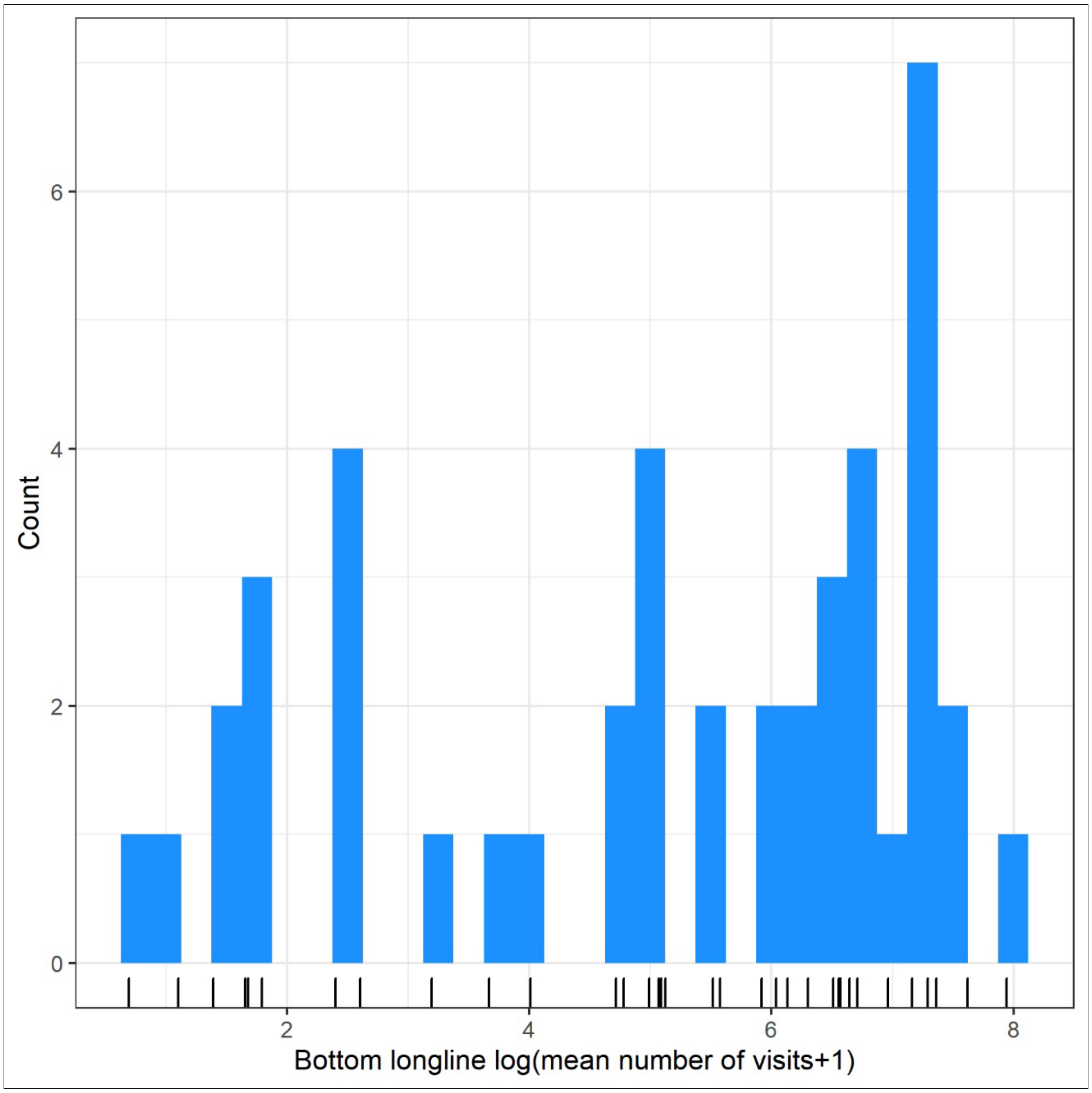

Figure 15. Distribution of estimated bottom longline fishing activity (vessel monitoring systems counts) for selected Project Sites (Source: NMFS SEFSC and Council). Black tick marks along the x axis represent individual sites.

- **Bottom Trawling Activity:** Distribution graphs of estimated mean bottom trawling hours by site (derived from Clark et al., 2018; see **Section 2.1.3**) illustrated three separate groups of data (see **Figures 16** and **17** for trawling hour intensity and distribution of intensity by site, respectively). We assumed sites with no data (Group I) had no apparent bottom trawl activity and these were given 4 points. Group II with mean hours from 1 to 50 was assigned 3 points. Group III with hours between 50 to 3,000 was assigned 2 points, and Group IV with hours >3,000 was assigned 1 point.

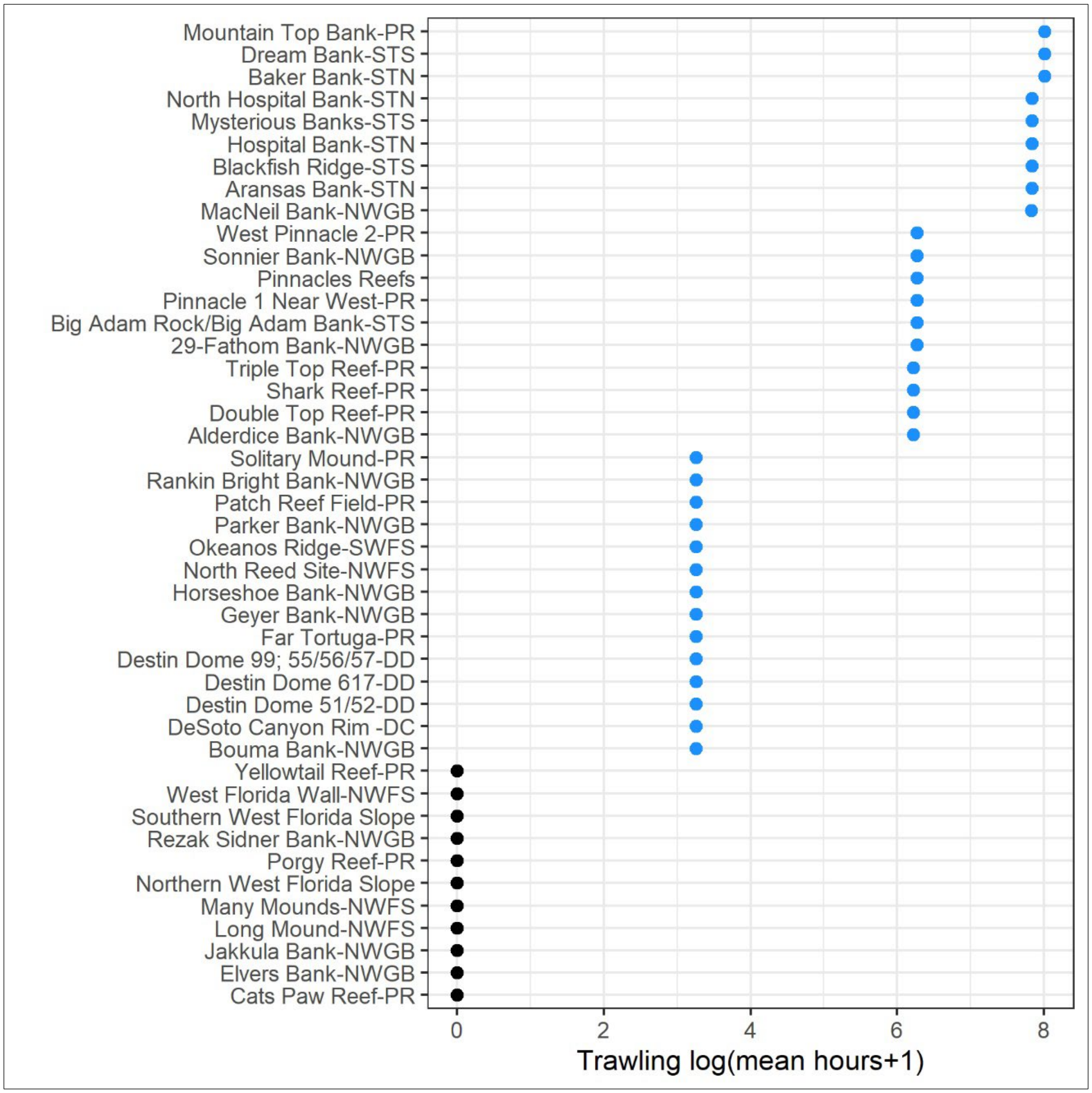

Figure 16. Bottom trawl fishing activity (vessel hours) within spatial grids encompassing selected Project Sites (from Clark et al., 2018). Black dots indicate areas with no trawl fishing data. Area abbreviations are as follows: Northern West Florida Slope (NWFS), Southern West Florida Slope (SWFS), Pinnacles Reefs (PR), DeSoto Canyon (DC), Northwestern Gulf of Mexico Banks (NWGB), South Texas Banks North (STN), South Texas Banks South (STS). (Source: Clark et al., 2018).

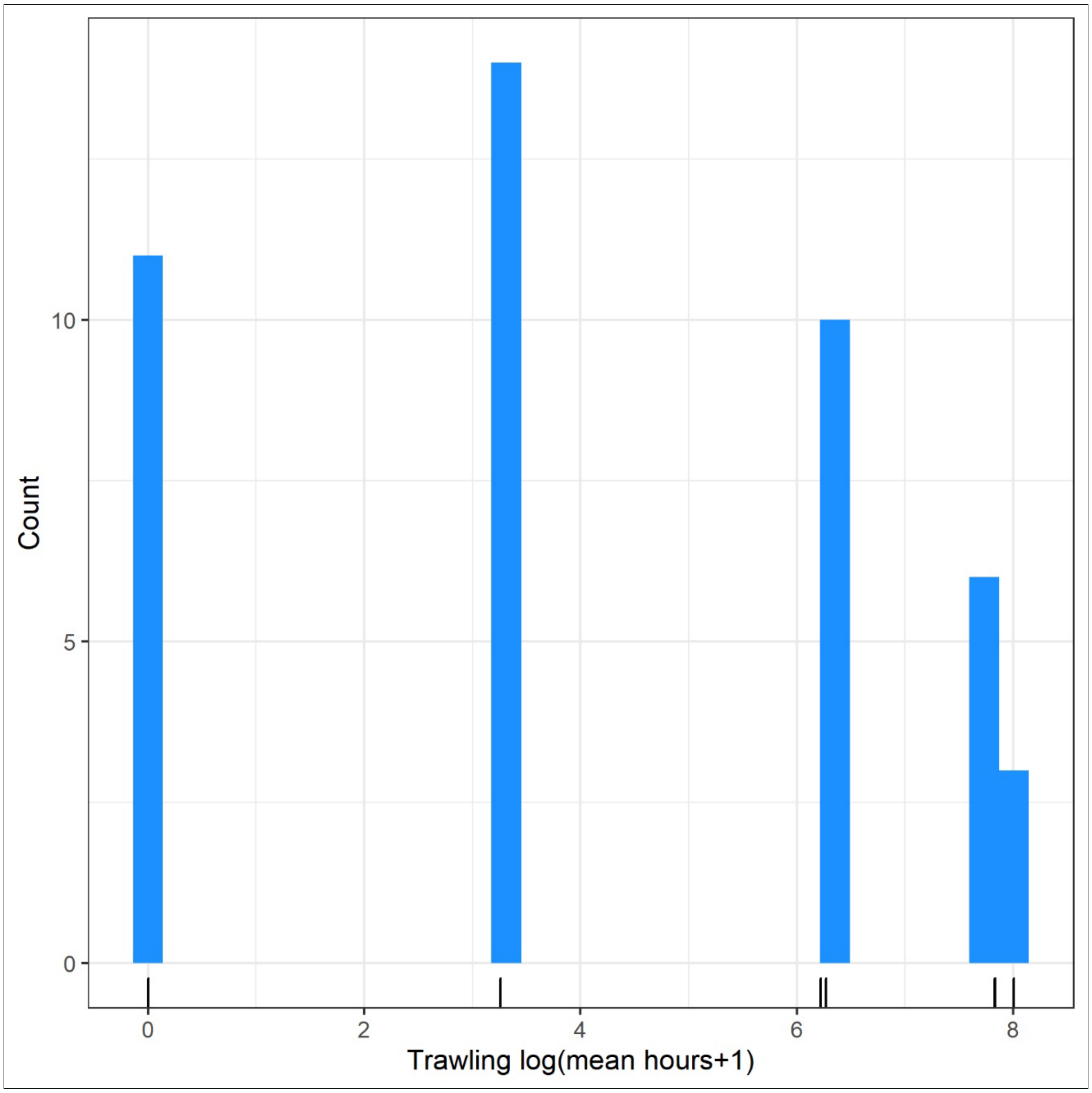

Figure 17. Distribution of benthic trawl fishing activity (vessel hours) for selected Project Sites (from Clark et al., 2018). Black tick marks along the x axis represent individual sites.

- **Invasive Species Ranking**: The higher the number of invasive species the higher the potential negative impact and the lower the ranking score. This category has limited data; however, we selected an arbitrary ranking criterion where sites without known invasive species received one point while sites with any reported invasive species received no points.

- **Disease Incidence Ranking**: Greater incidence of disease is considered to have higher negative impact and thus lower ranking score. This category also has limited data. We selected an arbitrary ranking criterion where sites without known coral diseases received one point while sites with any reported coral diseases received no points.

- **Research History Ranking**: Greater amounts of research data in general should lead to better understanding of a site's ecological value and its potential vulnerability. Available literature from CSA's literature search was used as a proxy for amount and quality of data. Higher scores went to sites with the most extensive and highest quality research. References were categorized in order of importance as peer-reviewed, graduate thesis/dissertation, agency report, or miscellaneous grey literature (**Table 3**). These categories were used to weight the literature frequencies. The number of peer-reviewed references for a site was multiplied by 4, graduate degree literature (Masters and PhD) was multiplied by 3, agency reports by 2 and other grey literature was not weighted (**Table 3**). This factor was assigned a qualitative descriptor based on the number and type of publications found for each site in CSA's literature search as follows: Extensive (5 points) if total weighted numbers of references was >33 , Moderate (4 points) if total weighted numbers of references equaled 10 to 32, Low (2 points) if total weighted numbers of references was <10, or None (0 points) if there was no research recorded for the site.

- **Current Protections Ranking**: Sites that currently have some degrees of protection or special management, in general have already received some assessment activity and protections. Such sites were assigned a higher ranking (3 points) than those sites without protections (0 points).

- **Vulnerability to Climate Change Ranking**: The higher the vulnerability to climate change, the lower the ranking. While this is an important factor that should be considered, data gathered in this exercise were either lacking or not appropriate to access climate change on a site scale basis. As discussed above for the temperature regime factor, the availability and highly variable nature of near bottom temperature data, as well as the uncertainty surrounding how they were measured made this factor difficult to evaluate. Similarly, aragonite saturation state (carbonate ion concentration) data are largely unavailable for the project sites. Nevertheless, although not used at this time for site comparisons, this factor is retained in the matrix for future evaluation (see **Section 4.0** for further discussion).

2.2 GEODATABASE

Spatial data obtained during the data search and review task were presented in geodatabase format using templates provided by Council staff. The geodatabase was created in Esri ArcMap Version 10.8 and included the selected project sites as a polygon feature class ("CoralSitesPolygon") and the site or polygon centers as a point feature class ("CoralSiteCentersPoint"). Both features include all the factor measurements calculated during the study. The data are in WGS 84. Federal Geospatial Data Committee (FGDC) compliant metadata are also included.

2.3 WEB-BASED DASHBOARD

A web-based dashboard was designed and created to display project-related information to the Council, for decision making, and for outreach purposes. The dashboard was created using the Esri ArcGIS Online (AGOL) Web App Builder and features an interactive map displaying the shape/area and coordinates of the project sites and associated information. The coral site polygons and the project site center point features from the geodatabase were published to AGOL as hosted feature services. These data were added to a web map that included a GoM Benthic Communities dataset, a GoM USGS deep sea corals dataset, and a GoM BOEM Bathymetric dataset. This web map was then used to create the dashboard through the Web App Builder. The project sites polygons and site centers point features have "Pop Ups" enabled, which allows users to click on the features and see the attribute information on the screen. Other features of the application include a Legend tool, a Layer List tool, a Drawing Tool, a Print tool, a Measure tool, a Basemap tool, and a Bookmarks tool.

3.0 Results

3.1 ECOLOGICAL ASSESSMENT

3.1.1 Site Selection

After reviewing Coral Amendment 9 (GMFMC, 2018) and other supportive information provided by the Council, a preliminary list of 67 project sites within four major regions of the GoM (Southeastern, Northeastern, Northwestern, and Southwestern) were proposed by the CSA Team for this project. On October 19, 2021, communications between the Council and the CSA Team determined that some proposed reef/bank locations would be eliminated from the project site list because they had already received some level of protection. Initial data search acquisitions, including PDFs and Endnote citations related to these locations were deleted. Listed alphabetically, the deleted sites included:

Region	*Area*	*Site*
SOUTHEASTERN GoM	n/a	Dry Tortugas
		Florida Keys National Marine Sanctuary
		Pulley Ridge
		North Reed Site
NORTHEASTERN GoM	Pinnacles Reefs	Alabama Alps
		L&W Pinnacles
		Rough Tongue Reef
		Scamp Reef
	n/a	Mississippi Canyon 118
		Viosca Knoll 826, 862 and 906
NORTHWESTERN GoM	n/a	AT 047 and 357
		Gardens Banks 299 and 535
		Green Canyon 140, 234, 272, 354 and 852
		Mississippi Canyon 118, 751 and 885
SOUTHWESTERN GoM	n/a	Southern Bank
		Unnamed Bank (Harte Bank)

The final list of sites selected for this project included 44 project sites, which includes three 'megasites' (defined as a larger conglomerate of reefs or banks which includes a subset of individual project sites) and eight sites recommended by the CSA team, based on their previous research in these areas (**Table 2**). The CSA sites were selected because they support ecologically important coral habitat that may benefit from management measures.

Individual selected sites and megasites within each of the four GoM Regions are shown below in **Figures 18** to **21**.

Table 2. Selected Project Sites and Megasites.

Region	Area	Site and Megasite	
		Number	Name
SOUTHEASTERN GoM	Northern West Florida Slope[1]	1	Northern West Florida Slope[1]
		2	North Reed Site
		3	Long Mound
		4	Many Mounds
		5	West Florida Wall
	Southern West Florida Slope[1]	6	Southern West Florida Slope[1]
		7	Okeanos Ridge
NORTHEASTERN GoM	Pinnacles Reefs[1]	8	Pinnacles Reefs[1]
		9	Triple Top Reef
		10	Double Top Reef
		11	Shark Reef
		12	Far Tortuga
		13	Patch Reef Field
		14	Solitary Mound
		15	Mountain Top Bank
		16	Pinnacle 1 Near West
		17	West Pinnacle[2]
		18	Cats Paw Reef[2]
		19	Porgy Reef[2]
		20	Yellowtail Reef[2]
NORTHEASTERN GoM	DeSoto Canyon	21	DeSoto Canyon Rim[2]
	Destin Dome	22	Destin Dome 51/52[2]
		23	Destin Dome 99; 55/56/57[2]
		24	Destin Dome 617[2]
NORTHWESTERN GoM	Shelf-Edge Banks	25	Sonnier Bank
		26	29-Fathom Bank
		27	MacNeil Bank
		28	Alderdice Bank
		29	Bouma Bank
		30	Horseshoe Bank
		31	Rankin Bright Bank
		32	Geyer Bank
		33	Elvers Bank
		34	Rezak Sidner Bank
		35	Parker Bank
		36	Jakkula Bank

Table 2. (Continued).

Region	Area	Site and Megasite	
		Number	Name
SOUTHWESTERN GoM	South Texas Banks - North	37	Baker Bank
		38	Hospital Bank
		39	North Hospital Bank
		40	Aransas Bank
	South Texas Banks - South	41	Dream Bank
		42	Mysterious Banks
		43	Big Adam Rock/Big Adam Bank
		44	Blackfish Ridge

[1] Megasite composed of a set of individual project sites.
[2] Additional sites recommended by the CSA team.

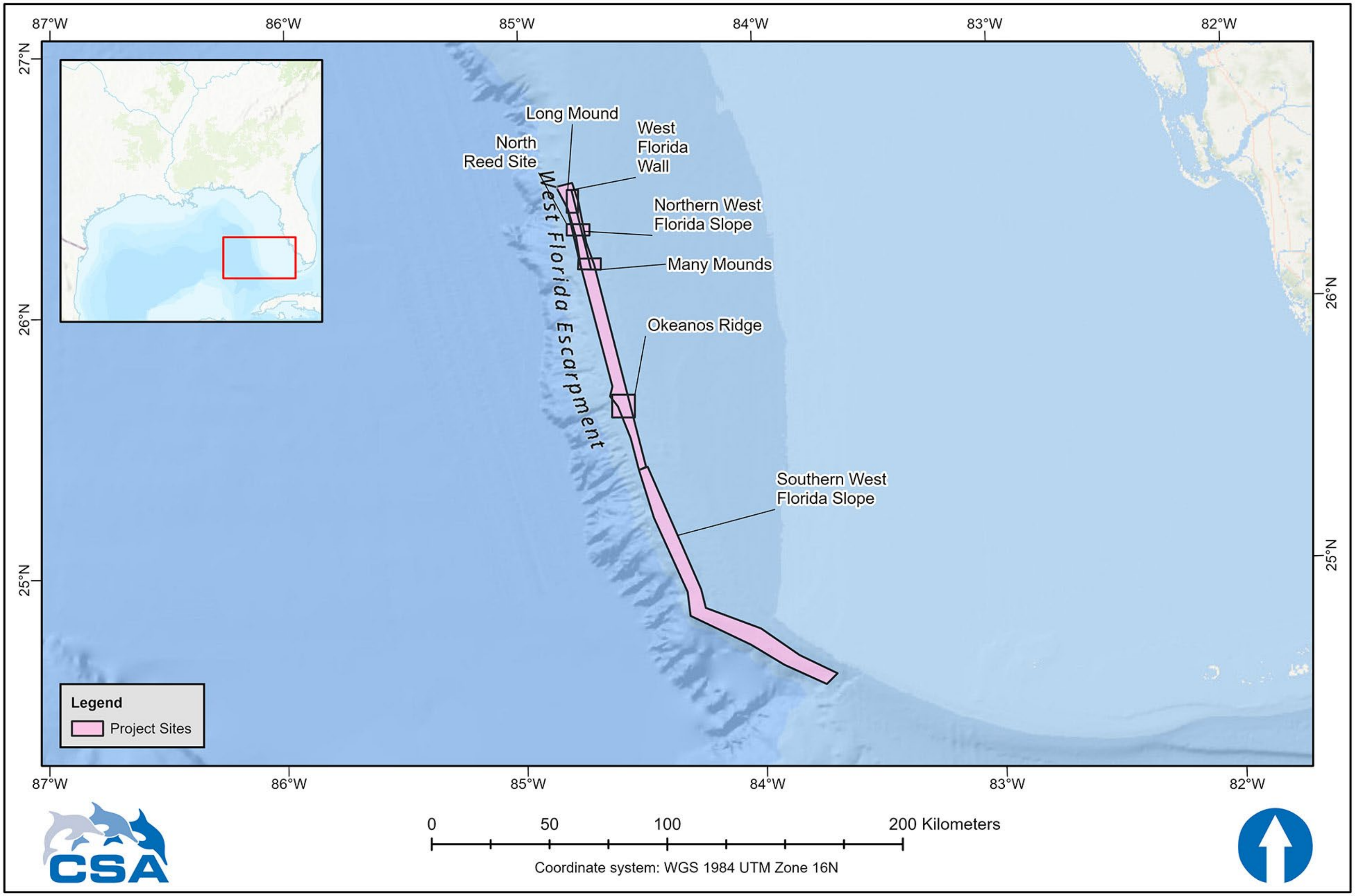

Figure 18. Southeastern GoM Region Project Sites and Megasites selected for this analysis.

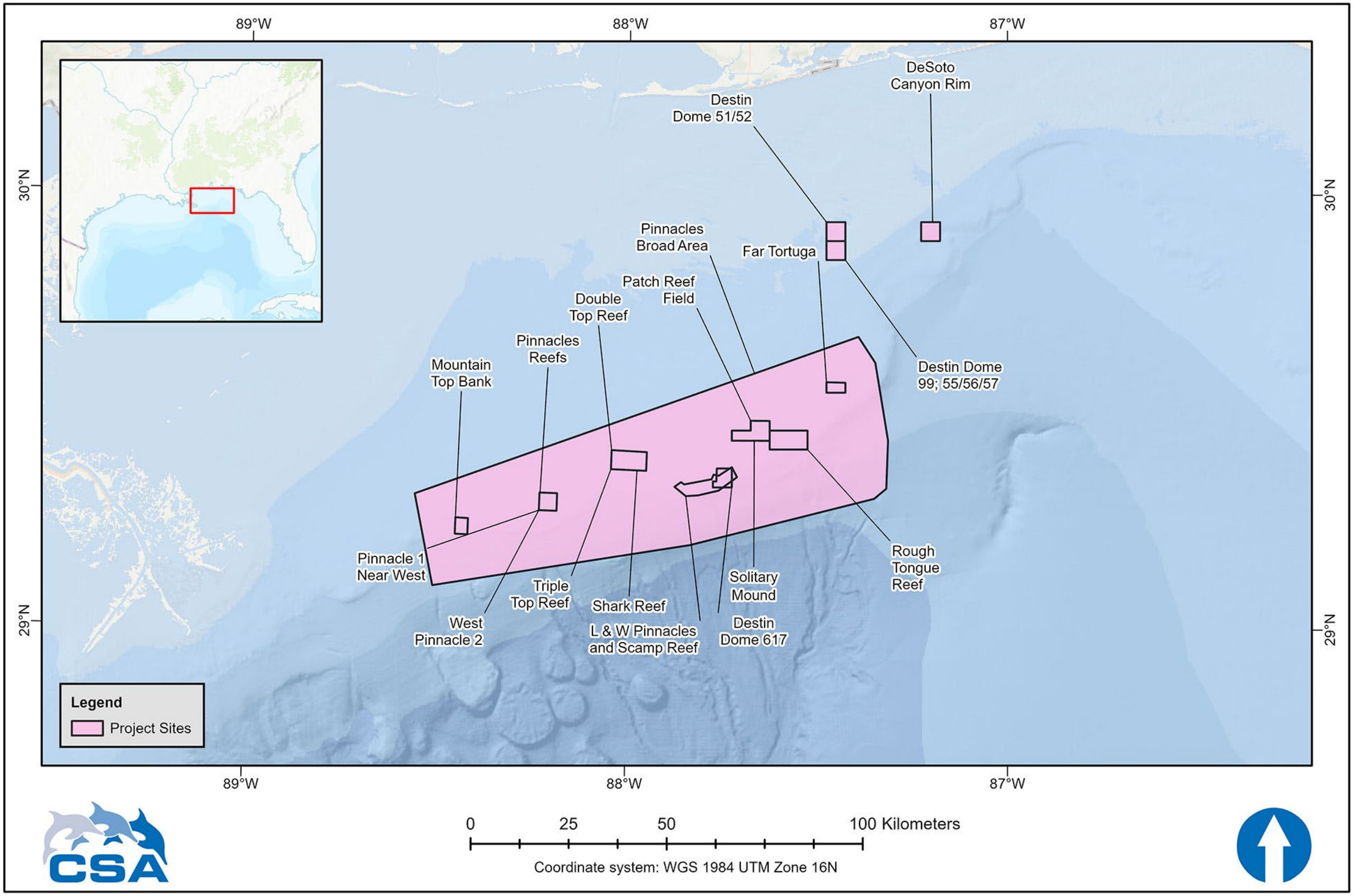

Figure 19. Northeastern GoM Region Project Sites and Megasite selected for this analysis.

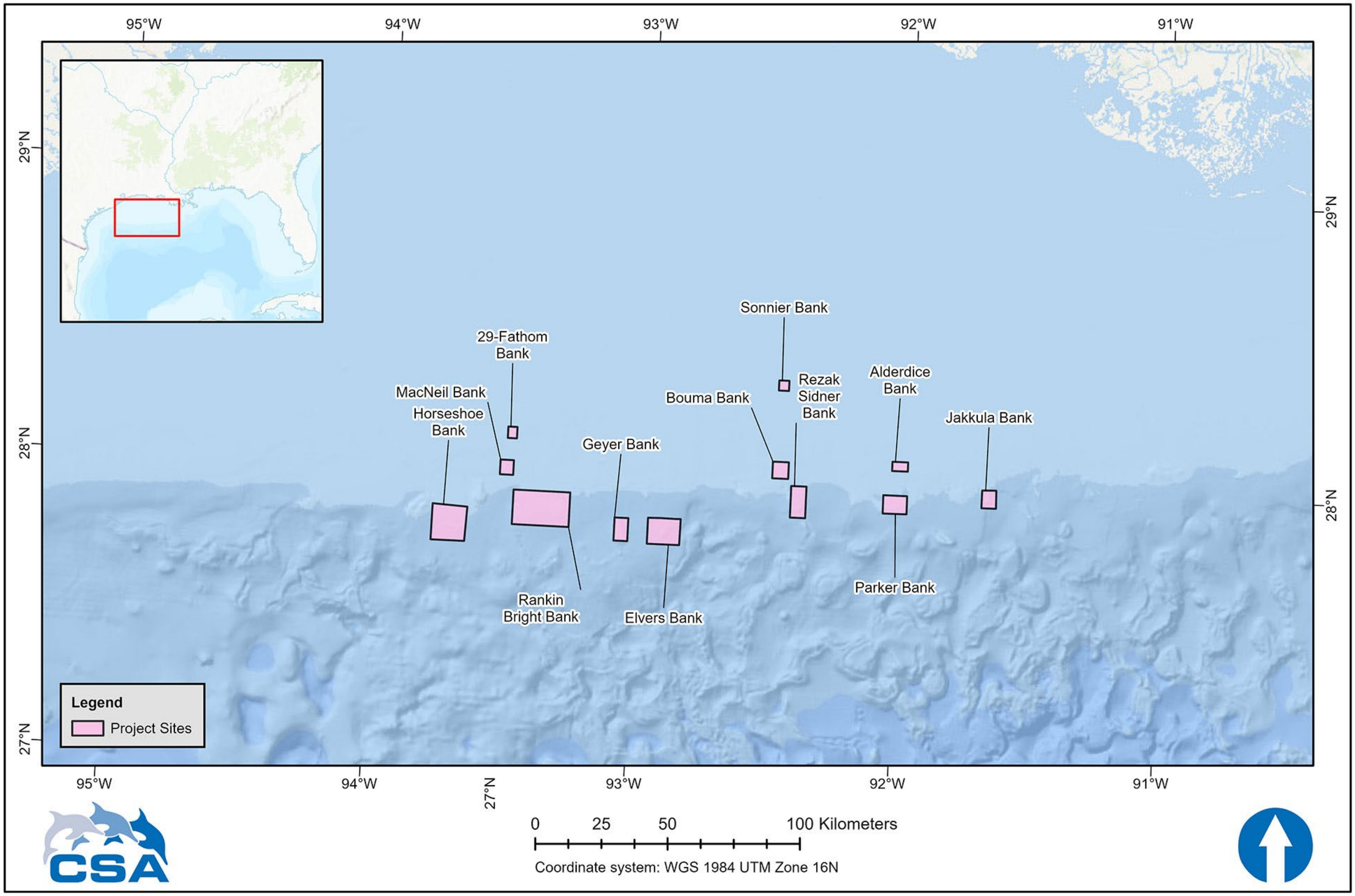

Figure 20. Northwestern GoM Region Project Sites selected for this analysis.

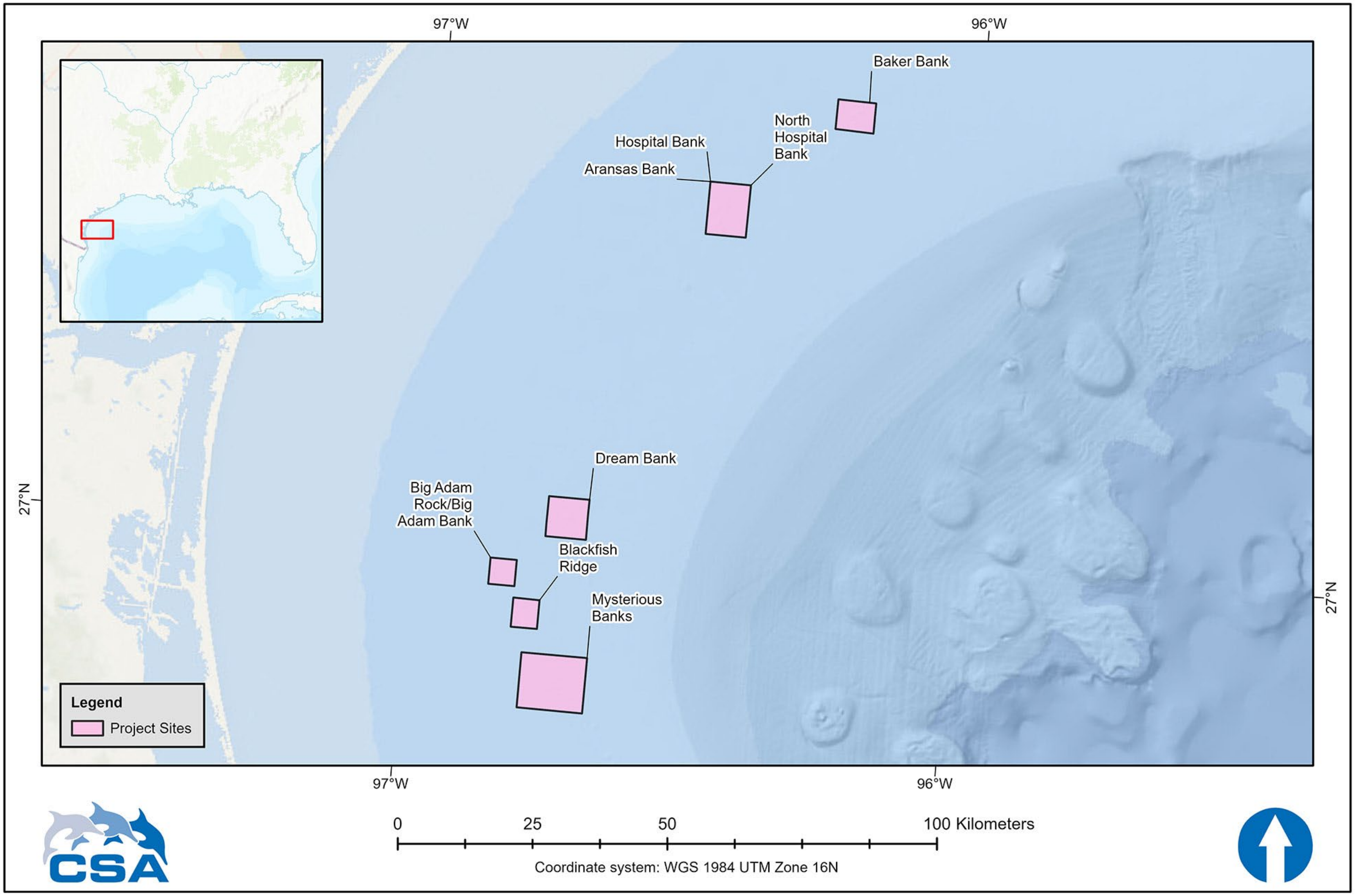

Figure 21. Southwestern GoM Region Project Sites selected for this analysis.

It is important to note that many of the colloquial names used for sites listed above are not necessarily in common usage, may not appear in peer reviewed literature or maps, and may not be consistently used or recognized. Some of the names appear to have been applied by researchers for their own projects or cruises, by geologists during hydrocarbon exploration, and by fishermen. Thus, in many cases where information was not identified for such smaller sites, it was necessary to default to the larger region, or megasite. For example, data were found related to the Northern West Florida Slope, but not identified explicitly to a specific colloquially named site (e.g., "Many Mounds") or other small research sites identified by scientists within that region.

3.1.2 Data Search and Review

A list of citations of articles, reports, etc. that were selected for each project site are presented in **Appendix A**. The complete database is provided as an EndNote Library as a separate electronic deliverable to the Council. A breakdown of citation types by project site and type are presented in **Table 3**.

Table 3. Breakdown of citation types by project site and megasite (marked with an asterisk), including totals. Blank cells indicate no data available or located during the literature search task.

Project Site and Megasite	Data Type					Total by Site
	Peer-Reviewed	Thesis or Dissertation	Agency Report	Miscellaneous Gray Literature	News Story	
Southeastern Gulf of Mexico						
Northern West Florida Slope*	13	3	3	1		**20**
North Reed Site	1	1	1	1		**4**
Long Mound	1	1	2	1		**5**
Many Mounds	2	1	1	1		**5**
West Florida Wall	4	1	1		1	**7**
Southern West Florida Slope*	13	3	3	1		**20**
Okeanos Ridge	1		2			**3**
Northeastern Gulf of Mexico						
Pinnacles Reefs*	5		6			**11**
Triple Top Reef			2			**2**
Double Top Reef			2			**2**
Shark Reef			2			**2**
Far Tortuga			2			**2**
Patch Reef Field			2			**2**
Solitary Mound			2			**2**
Mountain Top Bank			2			**2**
Pinnacle 1 Near West			1	2		**3**
West Pinnacle 2			1	2		**3**
Porgy Reef			2			**2**
Cats Paw Reef			2			**2**
Yellowtail Reef	2	1	3			**6**
DeSoto Canyon						
DeSoto Canyon Rim	3	1	1	2		**7**

Table 3. (Continued).

Project Site and Megasite	Data Type					Total by Site
	Peer-Reviewed	Thesis or Dissertation	Agency Report	Miscellaneous Gray Literature	News Story	
Destin Dome						
Destin Dome 51/52			1	1		**2**
Destin Dome 99; 55/56/57			1	1		**2**
Destin Dome 617				1		**1**
Northwestern Gulf of Mexico						
Sonnier Bank	3		3	1		**7**
29-Fathom Bank	2	2				**4**
MacNeil Bank	1		1	1		**3**
Alderdice Bank	4		7			**11**
Bouma Bank	2		1			**3**
Horseshoe Bank	2	1	1			**4**
Rankin Bright Bank	8	2	3			**13**
Geyer Bank	4	1	7			**12**
Elvers Bank	3	1	7			**11**
Rezak Sidner Bank	2	1	7			**10**
Parker Bank	2	1	3			**6**
Jakkula Bank	2		6			**8**
Southwestern Gulf of Mexico						
South Texas Banks - North						
Baker Bank	3	6	2			**11**
Hospital Bank	2	3	2			**7**
North Hospital Bank	2	4	2			**8**
Aransas Bank	3	6	2			**11**
South Texas Banks - South						
Dream Bank	2	5	1			**8**
Mysterious Banks	1	3	1			**5**
Big Adam Rock/Big Adam Bank	1	3	1			**5**
Blackfish Ridge	4	3	1			**8**
Total By Data Type	**98**	**54**	**103**	**16**	**1**	**-**

3.1.3 Data Compilation

The completed data compilation matrix is presented in **Appendix B**, **Table 1**. The distance/proximity analysis, which includes site center coordinates, referenced feature names (nearest river, disposal site, etc.) and coordinates of these features are presented in **Appendix B**, **Table 2**, and sources of information used to populate this Table are presented in **Appendix B**, **Table 3**.

3.1.4 Ranking of Environmental Factors and Final Scoring

Of the 28 factors listed in the data matrix, 20 included sufficient data for analysis. Following the criteria and scoring described in **Section 2.1.5**, all project sites received scores for relevant factors (**Table 4**). Ranking of individual data and literature citations for each project site are presented in **Appendix B, Table 4**.

Table 4. Project site scores for relevant factors and total scores.

Project Site	Weighted Environmental Factors																			Totals
	Area (ha)	Relief (m)	Depth (m)	Base Substratum	Closest Prox. to Shore (km)	Closest Prox. to Major River (km)	Closest Prox. to Active O&G Facility (km)	Closest Prox. to Major Shipping Lane (km)	Closest Prox. to Other Protected Area (km)	Closest Prox. to Dumping Area (km)	Closest Prox. to Active Methane Seep (km)	Scleractinian Coral Taxonomic Richness	Octocoral Taxonomic Richness	Antipatharian Coral Taxonomic Richness	Fish Taxonomic Richness	Fishing Intensity (BII-Mean)	Fishing Intensity (Trawl-Mean)	Invasive Species	Research History	Current Protections	
SOUTHEASTERN GULF OF MEXICO																					
Northern West Florida Slope*	8	5	2	3	4	3	5	3	3	5	0	3	3	3	5	4	4	1	5	3	72
North Reed Site	4	4	2	3	4	3	5	3	3	3	0	3	3	3	5	4	3	1	4	3	63
Long Mound	4	4	2	3	4	3	5	3	3	3	0	3	4	2	5	4	4	1	4	3	64
Many Mounds	4	5	2	3	4	3	5	3	3	5	0	3	4	2	5	4	4	1	4	3	67
West Florida Wall	4	5	2	3	4	3	5	3	3	3	0	3	4	2	5	4	4	1	4	3	65
Southern West Florida Slope*	8	5	2		4	3	5	3	5	5	0	3	3	2		4	4	1	5	0	62
Okeanos Ridge	5	5	2	3	4	3	5	1	3	5	0	3	4	3		4	3	1	8	0	62
NORTHEASTERN GULF OF MEXICO																					
Pinnacles Reefs*	8	4	1	3	2	1	2	1	3	3	3	3	4	3		4	2	0	4	0	51
Triple Top Reef	2	4	1	3	2	1	1	1	3	3	3	3	4	3		3	2	0	2	0	41
Double Top Reef	2	4	1	3	2	1	1	1	3	3	3	3	4	3	3	3	2	0	2	0	44
Shark Reef	2	2	1	3	2	1	1	1	3	3	3	3	4	3	3	3	2	0	2	0	42
Far Tortuga	2	2	1	3	2	1	3	1	3	1	3	3	4	3	3	3	3	0	2	0	43
Patch Reef Field	4	4	1	3	2	2	3	1	3	1	3	3	4	3	3	0	3	0	2	0	45
Solitary Mound	2	2	1	3	2	2	3	1	3	1	3	3	4	3	4	0	3	0	2	0	42
Mountain Top Bank	2	4	1	3	2	1	1	1	3	3	5	3	4	3	3	4	1	0	2	0	46
Pinnacle 1 Near West	4	4	1		2	1	1	1	3	3	5	3	4	3		4	2	0	2	0	43
West Pinnacle 2	4	4	1		2	1	1	1	3	3	5	3	4	3		4	2	0	2	0	43
Porgy Reef	2	4	1		2	2	3	1	3	1	0	3	4	3	3	3	5	0	2	0	42
Cats Paw Reef	2	4	1		2	2	3	1	3	1	0	3	4	3	3	3	5	0	2	0	42

Table 4. (Continued).

Project Site	Weighted Environmental Factors																					Totals
	Area (ha)	Relief (m)	Depth (m)	Base Substratum	Closest Prox. to Shore (km)	Closest Prox. to Major River (km)	Closest Prox. to Active O&G Facility (km)	Closest Prox. to Major Shipping Lane (km)	Closest Prox. to Other Protected Area (km)	Closest Prox. to Dumping Area (km)	Closest Prox. to Active Methane Seep (km)	Scleractinian Coral Taxonomic Richness	Octocoral Taxonomic Richness	Antipatharian Coral Taxonomic Richness	Fish Taxonomic Richness	Fishing Intensity (BII-Mean)	Fishing Intensity (Trawl-Mean)	Invasive Species	Research History	Current Protections	
Yellowtail Reef	2	4	1		2	2	3	1	3	1	0	3	4	3	5	3	4		4	0	45
DeSoto Canyon																					
DeSoto Canyon Rim	4	2	1			1	3	1	5	1	0	3	4	3	5	0	3	0	4	0	40
Destin Dome																					
Destin Dome 51/52	4	2	1	3	1	1	3	1	5	1	0	4	3		5	4	3	0	2	0	43
Destin Dome 99; 55/56/57	4	4	1	3	1	1	3	1	5	1	0	0	4	4	5	4	3	1	2	0	47
Destin Dome 617		4	1	3	2	2	3	1	3	1	3	3	3	2	3	4	3	1	2	0	44
NORTHWESTERN GULF Of MEXICO																					
Sonnier Bank	2	2	1	3	4	2	1	1	5	3	3	4	3	2	5	3	2	0	4	0	50
29-Fathom Bank	4	2	1		4	2	1	1	5	3	5					4	2	1	4	0	39
MacNeil Bank	4	4	1	2	4	2	1	1	5	3	5					4	2	1	2	0	41
Alderdice Bank	4	2	1	3	4	2	3	1	5	3	5	5	5	4	5	4	2	0	4	0	62
Bouma Bank	4	2	1	2	4	2	1	1	5	3	5	5	5	4	4	4	3	0	4	0	59
Horseshoe Bank	4	2	2	3	4	2	3	1	5	3	5					4	3	0	4	0	45
Rankin Bright Bank	8	2	1	3	4	2	3	1	5	3	5	5	5	4	5	4	3	0	5	0	68
Geyer Bank	4	2	1	3	4	2	3	1	5	3	5	5	5	4	5	4	3	0	5	0	64
Elvers Bank	4	2	1	2	4	2	3	1	5	5	5	5	5	4	5	4	4	0	4	0	65
Rezak Sidner Bank	4	2	1	2	4	2	3	1	5	5	5	5	5	4	4	4	4	0	4	0	64
Parker Bank	4	5	1	2	4	2	1	1	5	3	5	5	5	4	5	4	3	0	4	0	63
Jakkula Bank	4	4	1	2	4		3		5	3	5	5	5	4	4	4	4	1	4	0	62

Table 4. (Continued).

Project Site	Weighted Environmental Factors																				Totals
	Area (ha)	Relief (m)	Depth (m)	Base Substratum	Closest Prox. to Shore (km)	Closest Prox. to Major River (km)	Closest Prox. to Active O&G Facility (km)	Closest Prox. to Major Shipping Lane (km)	Closest Prox. to Other Protected Area (km)	Closest Prox. to Dumping Area (km)	Closest Prox. to Active Methane Seep (km)	Scleractinian Coral Taxonomic Richness	Octocoral Taxonomic Richness	Antipatharian Coral Taxonomic Richness	Fish Taxonomic Richness	Fishing Intensity (BII-Mean)	Fishing Intensity (Trawl-Mean)	Invasive Species	Research History	Current Protections	
SOUTHWEST GULF OF MEXICO																					
South Texas Banks - North																					
Baker Bank	2	4	1	2	2	1	1	1	3	1	5	4	3	2	5	4	1	1	5	0	48
Hospital Bank	2	5	1	2	2	1	3	1	3	1	5	4	3	2	4	4	2	0	4	0	49
North Hospital Bank	2	4	1	2	2	1	3	1	3	1	5	4	3	2	5	4	2	0	4	0	49
Aransas Bank	2	4	1	2	2	1	3	1	3	1	5	4	3	2	5	4	2	1	5	0	51
South Texas Banks - South																					
Dream Bank	4	4	1	2	2	1	3	1	3	3	5	4	3	2	4	4	1	1	4	0	52
Mysterious Banks	4	4	1	2	2	1	3	1	3	3	5	4	3	2	3	4	2	1	4	0	52
Big Adam Rock/Big Adam Bank	2	4	1	2	2	1	3	1	3	3	5	4	3	2	4	4	3	1	4	0	52
Blackfish Ridge	2	4	1	2	2	1	3	1	3	3	5	4	3	2	3	4	2	1	4	0	50

* - Megasite.

The total possible number of points a site could receive if it ranked highest in all factors was 106. Total summed factor scores (**Table 4**) produced a hierarchy of relative site rankings, ranging from a high of 72 points for the Northwest Florida Slope megasite and 68 points for Rankin Bright Bank to a low of 39 points for 29-Fathom Bank. The seven deepest sites, which were on the West Florida Slope, exhibited consistently high values (mean=65) and a relatively lower range of values (72 to 62 points). As might be expected the remaining shallower sites exhibited more variability in total ranking points, with an overall mean of 49 points. Regionally, the 12 Northwestern GoM sites scored the second highest with a group mean of 57 points, followed by the Southwestern GoM sites (mean=50 points) and the Northeastern GoM sties (mean=44 points).

3.2 GEODATABASE

The draft geodatabase was provided as a separate electronic deliverable to the Council. The final deliverable will be submitted along with all other final deliverables after review.

3.3 WEB-BASED DASHBOARD

The draft web-based dashboard was provided as a separate electronic deliverable to the Council. The final deliverable will be submitted along with all other final deliverables after review.

4.0 Discussion

One of the most difficult tasks in resource management and perhaps even the most controversial, is the objective ecological assessment of marine ecosystems. Although challenging, such assessments are necessary and have proved useful in reef ecosystem evaluation to guide management actions (DeVantier et al. 1998; Ruttenberg et al. 2018). This area of environmental science is evolving with assessments being accomplished in a variety of ways, and there are few guidelines for standardizing such evaluations.

A large array of descriptive physical and biological data were assembled and synthesized into a matrix that can be used to assess relative current status and future vulnerability of selected deep coral and hard-bottom sites in the GoM. The approach was thorough yet uncomplicated, allowing for an informed, repeatable, and quasi-objective approach to site comparisons across the GoM. This data synthesis and ranking exercise is suggested as one means to view an array of data across a large geographic space. However, as noted several places in this report, the actual population of the data matrix as well as the data themselves can be improved (see above and **Section 5.0** below). Persistent issues that impacted this exercise were: 1) the lack of consistency in the way data were collected and reported across a large array of studies, 2) a general lack of research for sites or for topics, 3) variable data quality, 4) lack of access to original data sets.

Overall, these 44 sites did not score very high in the point rankings. The mean score for the 44 sites of 52 points was far below the maximum possible score of 106. The individual factor rankings suggest that consistent issues were small size of sites and lack of research. Including a wider array of sites would help put these data into a broader perspective (see Recommendations).

Ongoing and future climate change is perhaps one of the most severe and long-term negative impacts to face marine ecosystems. While we included this factor in the site evaluation data matrix, the data available are generally lacking or not accurate enough to assess climate change on a per site basis, especially so for small area sites. However, most impacts of marine, deep-sea climate change occur over broad areas and not at local scales. Rising sea level, although devastating to coastal areas, likely has little direct impact to deep mesophotic and aphotic ecosystems. For depths in the range of this project, adding a few more meters is easily within the tolerance ranges of the fauna. Indirect impacts from rising sea levels, like changes in ocean currents (also controlled by other climate change factors) or temperature zones could have negative impact to deep GoM communities. Rising seawater temperatures and ocean acidification are two physical factors likely to have the highest impact to deep-sea ecosystems (Jones et al., 2014; Davies and Guinotte, 2011).

High atmospheric carbon dioxide concentrations released from the burning of fossil fuels are a major cause of global warming and acidification of the world's oceans (Turley et al., 2007; IPCC, 2007). Rising temperature (even in deeper waters) plays a role in environmental pressures as climate change has resulted in an increase of global mean sea surface temperature of 0.56–0.92◦C in the last 100 years with a further projected increase of approximately 3 to 4◦C by the end of this century (Büscher et al., 2017).

Scleractinian corals, particularly shallow water taxa, are severely threatened by anthropogenic warming, which has resulted in repeated mass coral 'bleaching' and mortality events (Martinez et al., 2021). Studies have also documented heat-induced stress on deeper mesophotic scleractinian species (Skutnik et al., 2020). In addition, upper ocean biomass is projected to decrease in response to surface ocean warming, as increased water mass stratification with reduced vertical mixing will reduce nutrient supplies for primary production at the ocean's surface, surface ocean production, and the flux of particulate organic carbon (POC) from the surface to deep water communities, including deep coral communities (Jones et al., 2014). Studies of the deep water scleractinian species *Lophelia pertusa* suggested that colonies from various parts of the North Atlantic are tolerant to a broad thermal range of temperatures (5 to 15°C), possibly because of the high thermal variability in their natural environment (Brooke et al., 2013). Colonies from the Gulf of Mexico are able to survive prolonged exposures to increased temperatures, depending on the genotype, making it a possibly robust species to ocean warming (Lunden et al., 2014). This species has been described as an opportunistic feeder and so temperature-related changes in local food webs may have only minimal consequences (Dorey et al., 2020). Individuals and populations of certain deep water octocorals (e.g., *Paramuricea clavata*) in the Mediterranean also showed different levels of tolerance to thermal stress observed during warming-induced mass-mortality events, suggesting the occurrence of warming-resistant conspecifics (Ledoux et al., 2020). As a result of increasing global temperature, some marine sessile species, including scleractinian corals have responded with range shifts towards higher latitudes through reproduction and larval dispersal. For example, such a shift was reported for a Mediterranean mesophotic scleractinian, *Oculina patagonica*, whose range moved from depths of less than 10 m to depths greater than 30 m (Martinez et al., 2021).

Along with ocean warming, the net uptake of carbon dioxide (CO_2) from the atmosphere is changing ocean chemistry, including a reduction in pH known as ocean acidification, and the carbonate ion concentration (CO_3^{-2}) which lowers oceanic saturation states (Ω) for calcium carbonate ($CaCO_3$) minerals. The Ω values for aragonite, one of the main $CaCO_3$ minerals formed by marine calcifying organisms, will influence the calcification rate and geographic distribution of scleractinian corals (García-Ibáñez et al., 2021). Historically, approximately 90% of all scleractinian hermatypic (bioherm-forming) cold-water corals lived in supersaturated waters with respect to aragonite; however, due to ocean acidification approximately 70% of known cold-water corals may be exposed to calcium carbonate undersaturated waters by the end of the century (Büscher et al., 2017). Somewhat in contrast, the scleractinian *Lophelia pertusa* has often been found to live and apparently thrive in North Atlantic waters, including the GoM, in areas of low aragonite saturation (Lunden et al. 2013, 2014; S.W. Ross, unpubl. data). In the Mediterranean, some deep corals, such as *Dendrophyllia cornigera,* showed fewer negative effects from ocean acidification on skeletal growth than others (e.g., *Desmophyllum dianthus*), suggesting a heterogeneous effect of low pH on the skeletal growth rate (Movilla et al., 2014).

5.0 Recommendations

1. An obvious aspect of constructing the site/environmental factor matrix was the amount of missing information. It is recommended that the Council evaluate the missing data and determine which data are most important to acquire. For example, based on perceived threats, certain sites may have a higher priority than others as targets for acquiring missing data.

The value of these site comparisons can be increased substantially by adding additional sites. Even adding sites that are already well documented or protected will increase the range of data and facilitate a more accurate and robust assessment of GoM deep reef sites. Since many sites that were already well known and even already protected were omitted from this exercise, this excluded what could be considered the “best” deep reef sites. Without these sites included, we had to evaluate a much smaller diversity of reefs. Ideally all deep-reef sites in the GoM should be included.

Related to number 1 above, detailed bathymetric mapping provides an array of data in addition to playing an important role in modelling exercises. It is recommended that acquiring, updating, or improving the multibeam sonar data should be undertaken with a priority being sites lacking such data.

Also related to number 1, the emphasis on and importance of deep-water corals throughout this process contrasted sharply with the lack of coral data and/or the variable quality of the data for many sites. Conducting targeted ROV or other remote visual surveys on sites with missing coral data is a cost-effective way to add important information. Comparisons of the corals present at each site were restricted to genera (as the lowest common taxonomic unit); however, improving site coral lists to the species level is desirable.

The utility of many of the factors in the matrix might be improved by more detailed analysis. For example, examining the impacts of regional and local oceanography on a factor would likely yield a more accurate assessment of its impact. Such data may indicate that ocean currents are more important than simple distance from an impact source.

Many sites appeared to be too small. For example, it is likely much more effective to protect the whole West Florida Slope reef complex (which runs along a large scarp; Ross et al., 2017) than a few small research sites within that complex. We recommend the Council examine site size and rational for site sizes. Related to this, we recommend the rational and consistency for site boundaries as used in this project be re-examined.

A table (or multiple tables) of fish and coral species matched to each site would be very useful but is beyond the scope of this project. Such tables would allow a better evaluation of biological data quality and consistency, as well as better delineate where data are missing.

Some data in the matrix can be improved. We recommend an evaluation of the matrix to determine where such improvements are necessary or cost effective.

6.0 References

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Appendices

Appendix A:
List of Data Search Citations by Project Site

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SOUTHEASTERN GoM

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Appendix B:
Data Compilation Results

Provided separately in Excel

Tab 1. Matrix showing literature review data compilation for individual project sites

Tab 2. Matrix showing distances and coordinates for individual project sites

Tab 3. Matrix showing data sources for distances and coordinates

Tab 4. Matrix showing data source type by site

Tab 5. Matrix showing vulnerability assessment