Gap Assessment of Geoscientific Data in Coastal Louisiana

Prepared for:

Coastal Protection and Restoration Authority of Louisiana

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1	12/04/2019	Report – 1st Revision
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Disclaimer

The information provided in this report is subject to change as new data are added to LASARD. This gap assessment is revised regularly to address this. The information provided in this report is up to date as of January 2023. The data and information used in this gap assessment were compiled from a variety of sources. As such, CPRA and APTIM make no warranties as to the accuracy or completeness of the original data or information compiled and used to perform this gap assessment.

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Abbreviations

APC	Armored Personnel Carrier
APTIM	Aptim Environmental & Infrastructure, LLC
AWOIS	Automated Wreck and Obstruction Information System
BAMM	Borrow Area Management and Monitoring
BICM	Barrier Island Comprehensive Monitoring
BISM	Barrier Island System Management
BOEM	Bureau of Ocean Energy Management
CIMS	Coastal Information Management System
CMAP	Council Monitoring and Assessment Program
CMECS	Coastal and Marine Ecological Classification Standard
CMP	Coastal Master Plan
CPRA	Coastal Protection and Restoration Authority
CRMS	Coastwide Reference Monitoring System
CY	Cubic Yards
DE	Data Element
EFH	Essential Fish Habitat
Esri	Environmental Systems Research Institute
FMP	Fisheries Management Plan
ft	feet/foot
GIS	Geographic Information System
GOM	Gulf of Mexico
HMS	Highly Migratory Species
LASAAP	Louisiana Sediment Availability and Allocation Program
LASARD	Louisiana Sand Resources Database
LASMP	Louisiana Sediment Management Plan
LDWF	Louisiana Department of Wildlife and Fisheries

LGS	Louisiana Geological Survey
LiDAR	Light Detection and Ranging
LORAN	Long Range Navigation
MCY	Million Cubic Yards
MMIS	Marine Minerals Information System
NAVD88	North American Vertical Datum of 1988
NCEI	National Centers for Environmental Information
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
POC	Point of Contact
SAV	Submerged Aquatic Vegetation
SEPM	Society for Sedimentary Geology
shoalMATE	Shoal Map Assessment Tool for EFH
SSD	Surficial Sediment Distribution
SWAMP	System Wide Assessment and Monitoring Program
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
YBP	Years Before Present

Executive Summary

Coastal restoration efforts, as envisioned in the 2023 Louisiana Coastal Master Plan (CMP), are projected to build and/or sustain up to 300 square miles of land estimated to cost at least $50 billion over the next 50 years. The success of the CMP restoration efforts depends on locating, managing and utilizing sediment in a cost-effective and sustainable manner.

Sediment is critical to the sustainability of coastal Louisiana, and being sediment-limited, proper management of sediment resources is important. Louisiana has developed a comprehensive Louisiana Sediment Management Plan (LASMP) to help manage sediment resources. It is a comprehensive sediment management plan that identifies and inventories sediment resources. It is also a tool and an opportunity to proactively identify and minimize conflicting uses for sediment, such that more sediment is made available efficiently and cost-effectively, through proper management. The Louisiana Sand Resources Database (LASARD), as well as monitoring, assessment and adaptive management programs like the System Wide Assessment and Monitoring Program (SWAMP), the Borrow Area Management and Monitoring (BAMM) program, Coastwide Reference Monitoring System (CRMS), and Barrier Island Comprehensive Monitoring (BICM) program and Barrier Island System Management (BISM) contribute to LASMP. These programs are major vehicles for data acquisition in coastal Louisiana besides project specific data acquisition.

The present endeavor was to identify areas with varying degrees of data-density and thereby identify areas where there are data gaps, especially for the geoscientific and related data. The gap assessment described in this report was conducted for a variety of reasons. It was initiated to aid in the development of a planning tool {Louisiana Sediment Availability and Allocation Program (LASAAP)} that identifies compatible sediment sources for restoration projects identified in the CMP. The tool links the compatible restoration – quality-sediment needs of the State's marsh, barrier island and ridge creation/restoration projects to the coast-wide sediment sources available from anticipated federal maintenance dredging and other sources including fluvial/offshore sediments. On a broader scale, the goal of the gap assessment is to evaluate availability of geoscientific data in coastal Louisiana to identify and delineate data density/data gaps and use this information to prioritize future data collection efforts to focus on areas where data are sparse or lacking.

During the gap assessment, existing data were reviewed to identify information gaps that exist in the compiled datasets and any spatial gaps where additional data would be necessary to describe and quantify potential sediment resources. Certain geoscientific data (e.g., elevation, sidescan sonar, magnetometer, sediment sample) have a shorter "shelf-life" than other data (e.g., sub-bottom). For this reason, the data were also reviewed temporally to assess the age of the data based on the date of acquisition. This gap assessment was used to identify areas that should be surveyed or undergo additional sampling efforts. Datasets within the Louisiana Sand Resources Database (LASARD) and other data sources were reviewed to determine how these data are attributed and where any inconsistencies exist. Datasets were reviewed to determine whether the data attribution would support future sediment resource identification and delineation.

The gap assessment described in this report encompasses offshore Louisiana within the limits of the existing Surficial Sediment Distribution (SSD) Maps (APTIM, 2022). Based on this gap assessment, we recommend that regional level (reconnaissance) hydrographic, geophysical and geotechnical data collection efforts be undertaken in the areas that lack data or contain data that were acquired a long time ago. Priority should be placed on collecting data around major sand shoals, buried paleochannnels, within potential paleovalleys, sand and sandy silt deposits identified by the Bureau of Ocean Energy Management (BOEM) and areas that have been delineated as potential or inferred sediment resources (sand and/or mixed sediment) in Louisiana's SSD Maps.

1.0 Introduction

The State of Louisiana developed the Coastal Master Plan (CMP) to address concerns related to coastal land loss and flooding. The CMP was first issued in 2007 and is updated every five to six years. The CMP has recommended several projects designed to build and maintain coastal land, reduce flood risk, and improve sustainability of the coast, while balancing short-term needs against long-term goals. The latest 2023 CMP includes 77 projects to build or maintain more than 300 mi^2 of land over the next 50 years by restoration/creation of marshes and ridges as well as the restoration of barrier islands and back barrier marshes on a regional scale (CPRA, 2023). The success of these projects and the CMP depend on locating, managing and utilizing sediments in a cost-effective manner. To effectively locate and manage sediment resources, the best available information is required to make informed decisions. Knowing what data exist and where data are being collected is key to meeting this goal.

Sediment management plays a vital role in implementing the CMP. The Louisiana Sediment Management Plan (LASMP) facilitates sediment management for restoration by providing an inventory of potential sediment resources and tracking sediment needs, both of which are crucial to the development of regional strategies for restoration. It is a tool and an opportunity to proactively identify and minimize conflicting uses for sediment, such that more sediment is made available efficiently and cost-effectively, through proper management. The Louisiana Sand Resources Database (LASARD), as well as monitoring, assessment and adaptive management programs like the System Wide Assessment and Monitoring Program (SWAMP), the Borrow Area Management and Monitoring (BAMM) program, Coastwide Reference Monitoring System (CRMS), and Barrier Island Comprehensive Monitoring (BICM) program and Barrier Island System Management (BISM) contribute to LASMP. These programs are major vehicles for data acquisition in coastal Louisiana e.g., under aegis of SWAMP over 6,963 nautical miles of geophysical and hydrographic data were collected between 2015 and 2021.

APTIM conducted a gap assessment with a focus on geoscientific data available through LASARD as well as other sources. This revision of the gap assessment was motivated by the recommendations of the Council Monitoring and Assessment Program (CMAP) (NOAA and USGS, 2020). To present results in a more user-friendly format, specific CMAP methods were adopted for sediment-data only. This was done as a pilot study to determine if these methods could be applied successfully to all other data types. All other data types were assessed using the same methods as used in the past.

1.1 Purpose and Scope

The gap assessment described in this report was conducted for a variety of reasons. Initially it was set up to aid in the development of a sediment management/planning tool {Louisiana Sediment Availability and Allocation Program (LASAAP)} that identifies compatible sediment sources for restoration projects identified in the CMP. The tool links the compatible sediment needs of the marsh, barrier island and ridge creation/restoration projects to the coast-wide sediment sources available from a variety of sources, mainly riverine and offshore sediments. However, on a broader scale, the goal of the gap assessment was to provide baseline data for the purpose of regional monitoring and identify areas where additional data should be collected. During the gap assessment, the quality of existing geotechnical and geophysical data were evaluated based on the categories below (NOAA and USGS, 2020).

Spatial Gaps: Spatial gaps are defined by a program or projects limited spatial coverage or inadequate number of samples, observation points/stations or survey tracklines.

Temporal Gaps: Temporal gaps are defined as a deficiency in the time frame or frequency of collection.

Informational Gaps: Informational gaps are assessed according to essential elements which may be lacking in descriptive metadata or documentation of collection and/or analysis procedures.

These factors help determine whether or not data are useful and how to prioritize future data collection efforts to focus on areas where data are inadequate, sparse or completely lacking.

1.2 Location

The gap assessment encompassed offshore Louisiana based on the limits of the existing Surficial Sediment Distribution (SSD) Maps (Figure 1) (APTIM, 2022; Khalil et al, 2018). It covered an area located between the Texas/Louisiana and Louisiana/Mississippi state borders. The assessment area extended inland to include major lakes and bays and approximately 17 miles offshore including nearshore coastal waters.

Figure 1. Boundaries of the data gap assessment.

2.0 Gap Assessment Framework and Method

2.1 Data Compilation

The first phase of the gap assessment was a data compilation effort. Geoscientific data were compiled from LASARD. Since the initial goal of this gap assessment was to identify and evaluate data to aid in the development of the LASAAP tool, additional data types not included in LASARD were also compiled. A brief description of the data sources is provided below.

2.1.1 Louisiana Sand Resources Database (LASARD)

The LASARD program was developed to manage geological, geophysical, geotechnical, and other data pertaining to offshore sand searches. It was designed to archive historical and current geoscientific data that could be queried by state, federal, and private entities for planning and executing restoration projects (Khalil et al, 2010). LASARD, which initially contained only data relevant to offshore sand searches, was expanded to include geoscientific data pertaining to the exploration of any sediment resource in coastal Louisiana and the Lower Mississippi River as well as monitoring data collected through various regional monitoring programs. The objective of LASARD is to centralize relevant data from various sources for better project coordination and to facilitate future planning for delineating and using sediment resources for restoration in coastal Louisiana.

CPRA archives all relevant data collected through the state's rapidly growing monitoring, assessment, and adaptive management programs in LASARD. These programs include the SWAMP, and BICM Programs. LASARD now includes over 3,000 datasets that were collected by private industry, universities, and federal and state agencies. The data consist predominantly of geophysical (e.g., sub-bottom, sidescan sonar, magnetometer, bathymetric) and geological (sediment obtained using vibracore, jet probe, and grab sampler) data. LASARD also includes oil and gas infrastructure data since it impacts the delineation of borrow areas and subsequent dredging. Data in LASARD are available through the CPRA Coastal Information Management System (CIMS) website at https://cims.coastal.louisiana.gov . Through this site, geoscientific information are easily accessible to all stakeholders, saving money, time, and avoiding duplication of data collection efforts.

2.1.2 Other Data Sources

Additional data sources were evaluated to make sure the gap assessment included data that may not have been incorporated into LASARD. Although some of these data types may exist in LASARD (e.g., sediment samples and geophysical data), the datasets identified and described below are not maintained in LASARD because they are large datasets, some covering North America, not just Louisiana. These datasets are typically maintained and updated regularly by other organizations.

2.1.2.1 usSEABED

usSEABED is the collaborative product of the U.S. Geological Survey (USGS), the University of Colorado, and other partners. It provides integrated data from marine research efforts by many entities including federal and state agencies, local authorities, universities, and private and public consortiums. usSEABED includes surficial and sub-bottom information on grain size and composition, and is held in comma-delimited files, useable in most Geographic Information System (GIS) programs. usSEABED is available at https://walrus.wr.usgs.gov/usseabed/index.html.

Currently, usSEABED includes georeferenced point data for more than 300,000 sites in U.S. waters from the beach to the deep sea, rivers, lakes, and estuaries. These data are predominantly grab samples with a few core borings. Data are sparse west of Caillou Bay, Louisiana. Data spacing ranges from about 0.3 miles to more than 7 miles. These data incorporate a wide variety of information including seafloor sediment texture, composition and color, biota and biological effects on the seafloor, rocky areas and seafloor hardness, seafloor features, seafloor acoustic properties, sediment geochemical analyses and sediment geotechnical analyses.

2.1.2.2 Automated Wreck and Obstruction Information System (AWOIS)

There are many types of marine cultural resources including shipwrecks, archaeological sites, artifacts and remains of historic structures. The management and protection of these resources is crucial. Depending on their significance, they must be avoided during dredging and restoration activities. Some of this information is included in LASARD. However, additional data can be found in the Coast Survey's AWOIS. These data are available at https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html.

2.1.2.3 Bureau of Ocean Energy Management (BOEM)

BOEM maintains Marine Mineral Program datasets through the Marine Minerals Information System (MMIS) viewer at https://mmis.doi.gov/BOEMMMIS/. The MMIS application is intended to aid ocean use planning and development of potential agreements for sand from the Outer Continental Shelf (OCS). The MMIS consolidates offshore data from multiple sources, notably BOEM funded work.

2.1.2.4 NOAA National Centers for Environmental Information (NCEI)

The National Oceanic and Atmospheric Administration (NOAA) NCEI Marine Trackline Geophysics database contains bathymetric, magnetic, gravity and sub-bottom navigation data collected during marine cruises from 1939 to the present. Because this is a federal database, the bulk of the data are within federal waters. The database is available at https://ncei.noaa.gov/maps/geophysics/.

2.2 Spatial Gap Evaluation

The spatial gap evaluation focused on assessing the spatial distribution of the geophysical, hydrographic, cultural resource and deposit/borrow area data. To facilitate visualization and analysis, coastal Louisiana was divided into geographic regions based on the coastal basins as shown in Figure 2. The spatial distribution of data was evaluated for each region.

Figure 2. Regions developed for the spatial gap evaluation.

2.3 Temporal Gap Evaluation

The temporal evaluation focused on an assessment of the timing of geophysical, hydrographic, cultural resource and deposit/borrow area data collection. Data were evaluated using the same schema used in the CMAP program (NOAA and USGS, 2020). Data were evaluated based on collection year (“prior to 1990”, “1990-2010”, “2011-2022”, and “unknown” if the collection date was unknown). These categories were used for ease of evaluation. It should be noted that age may not be an adequate indicator of data quality and selecting an appropriate cutoff age that applies to all situations is not possible. We can use these criteria for certain parameters/data like elevation especially in southeastern Louisiana with rapidly changing land/seascape. However, in other cases we can’t. For example, a grab sample that is over 10 years old may not be representative of current conditions. However, in areas which experience less geomorphic change, it may reflect current conditions.

2.4 Informational Gap Evaluation

Informational gaps were assessed based on essential elements that may be lacking in the geophysical, hydrographic, cultural resource and deposit/borrow area data. These included the items listed in Table 1 below.

Table 1. Elements incorporated into the informational gap evaluation.

Parameter	Gap Assessment Elements
Availability of metadata	Does metadata exist? Does metadata include a Point of Contact (POC)? Does metadata document collection and/or analysis procedures?
Availability of data	Are the data accessible (via web or upon request)? Are the data in a machine-readable or usable format?
Attribution	Data submitted to CPRA for incorporation into LASARD must include a specific set of attributes that vary depending on data type. Is this information complete?

CPRA has developed formatting standards, including specific attribution that contractors are required to follow when submitting geoscientific project deliverables. Full attribute specifications are available at https://cims.coastal.louisiana.gov/RecordDetail.aspx?Root=0&sid=12362. To be considered useful, all datasets should have some basic information including geospatial location (e.g., X and Y coordinates), date of collection and link to the actual data or, in the absence of actual data, the contact information for the contractor so the data can be requested. For each specific data type there are some additional pieces of information that should be evaluated when assessing informational gaps (Table 2).

A pilot study was conducted on the sediment sample data to explore CMAP methods of displaying the results of the spatial, temporal and informational gap assessment in a more user friendly and visually appealing manner. The pilot study is discussed in Section 4.0.

Table 2. Additional information used to evaluate informational gaps.

Data Type	Attribute	Description
Geophysical Tracklines	Line ID	Line identifier.
Cultural Resources	Resource Type	Cultural Resource Type.
Deposits/ Borrow Areas	Date Designed	Date designed (YYYYMMDD).
	Date Dredged	Date dredged (YYYYMMDD).
	Material Category	Sediment type. Sediment characteristics of the borrow area.
	Material Information	Detailed description of sediment in the borrow area (grain size, etc).
	Designed Volume (CY)	Estimated total volume of sediment in borrow area (units measured in cubic yards).
	Dredged Volume (CY)	Volume (units measured in CY) of sediment dredged from the borrow area.
Magnetic Anomalies	Target ID	Target identifier.
	Signal Strength (gam)	Peak gamma (gam) height.
	Signal Type	Signal characteristics (multi component, dipolar, monopolar, negative monopolar, or positive monopolar).
	Duration (ft)	Length of the duration of the anomaly signal (measured in feet).
Sidescan Sonar	Target ID	Target identifier.
	Feature Type	Type of feature represented by the sonar contact.

3.0 Gap Assessment Results

A summary of the results of the data gap assessment is provided below.

3.1 Data Compilation

The results of the data compilation effort are discussed below.

3.1.1 Louisiana Sand Resources Database (LASARD)

One of the tools used to assist in conducting a gap assessment is an inventory database along with web services. A copy of the current LASARD data catalog, which contains the bulk of the data used in this gap assessment is available at https://cims.coastal.louisiana.gov/RecordDetail.aspx?Root=0&sid=24235. The catalog is updated periodically. Table 3 and Figure 3 summarize the data that were compiled from LASARD.

Table 3. Data compiled from LASARD.

Data Type	No. of Datasets	No. of Features
Sediment Samples-Core Borings & Grab Samples	298	15,689
Geophysical Tracklines	102	10,942 (Sub-bottom) 3,348 (Sidescan Sonar) 3,057 (Magnetometer) 5,233 (Bathymetry/Topography)
Cultural Resources	6	420
Deposits/Borrow Areas	84	27 (unknown) 286 (Borrow Area) 25 (Investigation Area) 243 (Offshore Disposal Site/ Confined Disposal Facility) 21 (Potential Borrow Area) 321 (Potential Deposit) 12 (Rehandling Area)
Magnetic Anomalies	129	92,218
Sidescan Sonar	64	3,505

Note: The numbers shown in this table only represent data in LASARD that fall within the gap assessment boundary.

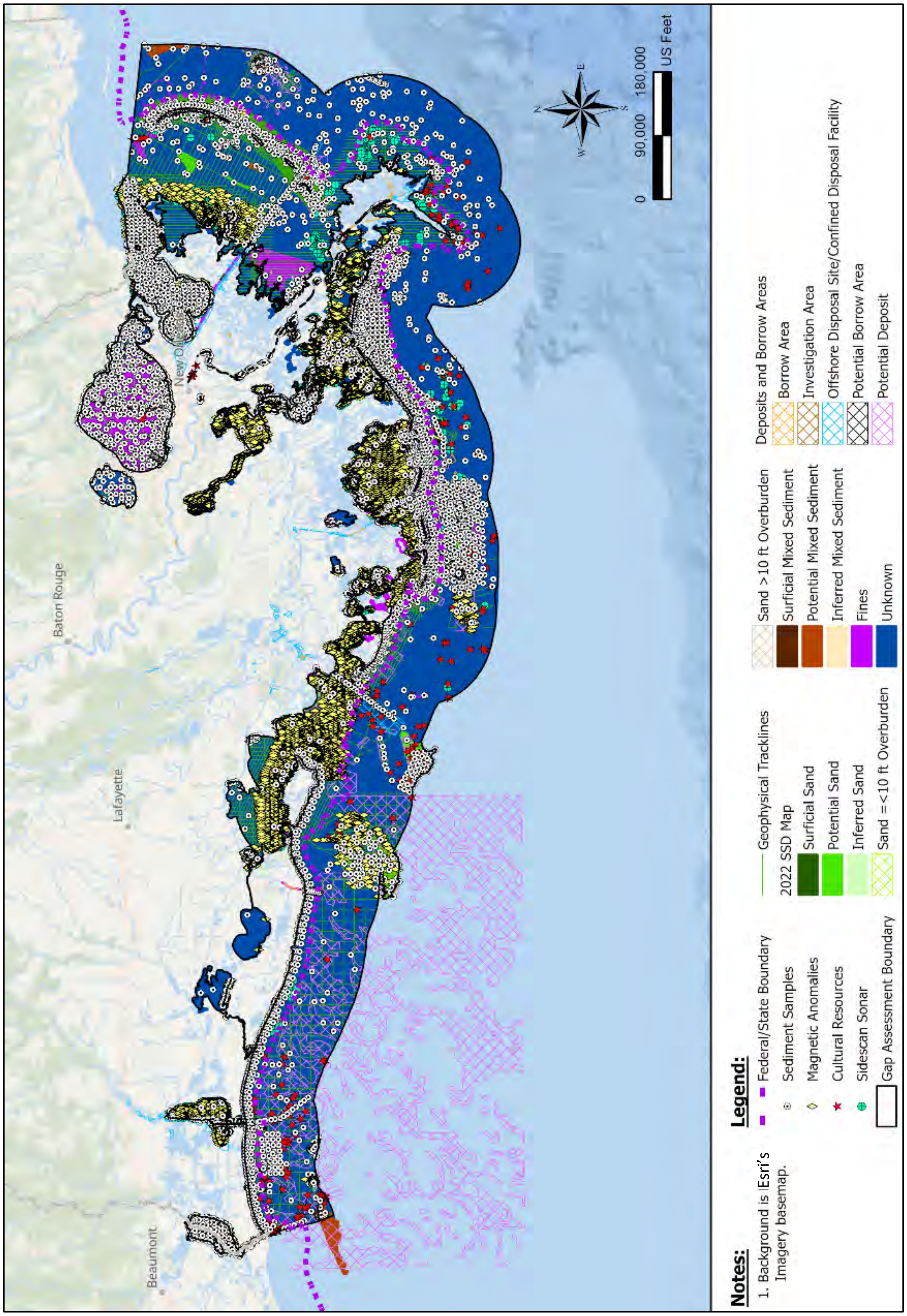

Figure 3. Datasets compiled from LASARD. Note: Deposit and borrow area definitions are provided in Table 9.

A total of 683 datasets were identified in LASARD. It is important to note that some of the datasets extend beyond the boundaries of this gap assessment. This gap assessment is limited to the boundaries shown in Figure 1. Any datasets that are not within this boundary are excluded. A total of 298 sediment sample datasets, representing approximately 9,052 grab samples, 6,391 core borings and 246 samples of unknown type were identified. These samples were collected using a variety of methods including dredges, augers, ponar grabs, vibracores, piston corers, box corers, etc. The samples were collected between 1951 and 2018 by a variety of consultants as well as agencies like the USGS, NOAA and the U.S. Army Corps of Engineers (USACE). A total of 102 geophysical trackline datasets, representing sub-bottom, sidescan sonar, magnetometer and hydrographic (bathymetric) data were identified. These surveys were conducted by a variety of private firms as well as state and federal agencies between 1963 and 2020. A total of 6 cultural resource datasets were also obtained from LASARD. A total of 84 deposit/borrow area datasets representing 935 borrow areas, potential deposits, rehandling areas and disposal sites were identified in LASARD. This includes the SSD Maps developed for CPRA. One hundred twenty-nine (129) datasets representing approximately 92,218 magnetic anomalies were also identified. These datasets include both significant and insignificant magnetic anomalies. Within LASARD, 64 sidescan sonar contact datasets collected between 2000 and 2019 were identified. These datasets represent 3,505 sidescan sonar contacts/targets. It should be noted that more recent data may have been collected but had not been incorporated into LASARD at the time of this gap assessment.

3.1.2 Other Data Sources

As discussed in Section 2.1.2 additional data sources were investigated. The results are summarized below.

3.1.2.1 usSEABED

Although usSEABED grab sample and core boring data have been included in LASARD, some additional sediment information, in the form of sediment composition maps, were located. Based on current LASARD standards, these maps are not suitable for incorporation into LASARD but may be useful in terms of identifying sediment resources (Figure 4). The first map shows the distribution of mud, sand, gravel and rock on the seabed and provides a summary of seabed physical properties in the Gulf of Mexico. It is a compilation of diverse datasets, describing the nature of seabed sediment. The data are categorized into percentages of mud, sand, gravel and rock. The second map provides an overview of the unconsolidated sediment types in the gulf and is a guide to their mobility under waves and currents, as well as to the physical factors for benthic animals. The third map provides a summary of bottom types in the Gulf of Mexico as determined by the percentage of mud in the sediment. These three maps were obtained from the Gulf of Mexico Data Atlas through the service found at https://gis.ngdc.noaa.gov/arcgis/services.

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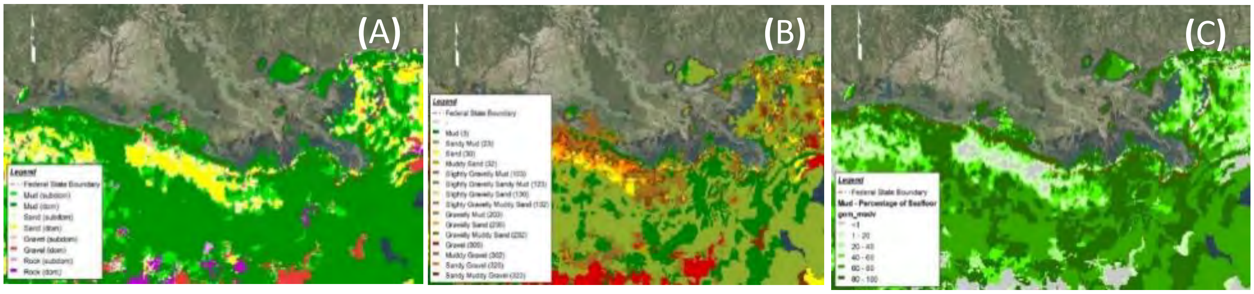

Figure 4. usSEABED maps. A) Dominant sediments. B) Unconsolidated sediments. C) Sediment composition.

3.1.2.2 Automated Wreck and Obstruction Information System (AWOIS)

A screen capture of the AWOIS web viewer is provided below in Figure 5. This system contains information on over 10,000 submerged wrecks and obstructions in the coastal waters of the United States. Information includes the latitude and longitude of each feature along with brief historic and descriptive details.

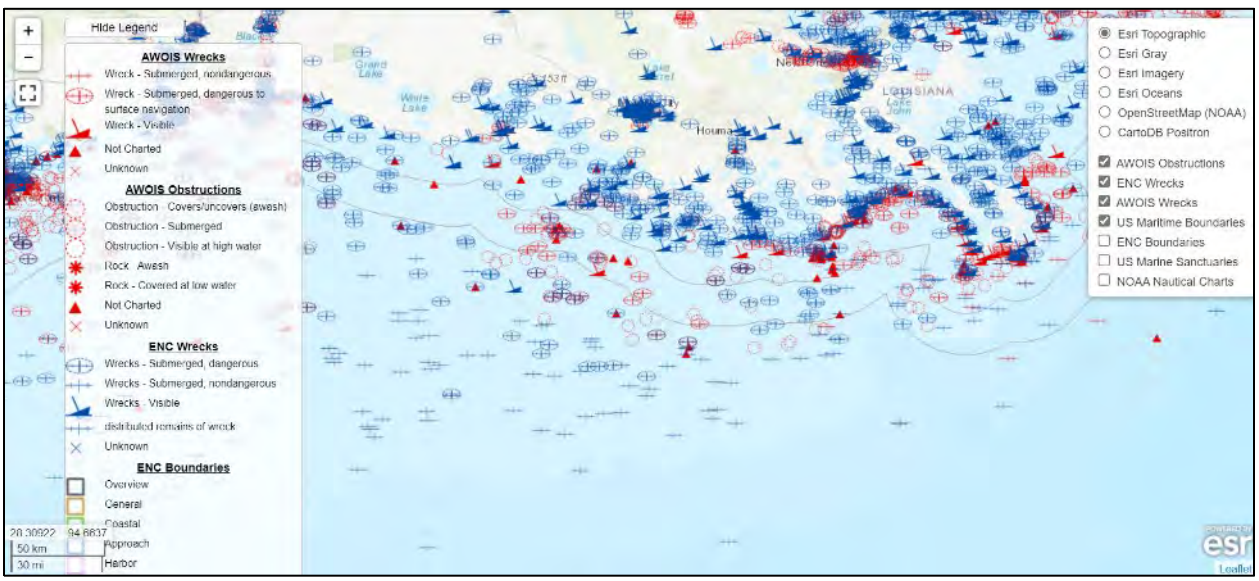

Figure 5. Screen capture of the AWOIS spatial data viewer.

It is important to note that AWOIS records are not comprehensive. There are wrecks in AWOIS that do not appear on the nautical charts and vice versa. Additionally, some wrecks are not reported due to confidentiality concerns. Recorded wrecks that have been salvaged or disproved by further investigation are also not included in the database. According to the NOAA website at https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html, which was last updated on June 8, 2018, the Office of the Coast stopped updating the AWOIS database in 2016.

3.1.2.3 Bureau of Ocean Energy Management (BOEM)

The MMIS includes sediment sample, geophysical (sub-bottom, magnetometer, sidescan sonar) and hydrographic (bathymetric) data. The MMIS covers the Gulf of Mexico and the U.S. Atlantic coast. Table 4 provides a summary of the number of data features found in offshore Louisiana. MMIS is a compilation of offshore data from a variety of sources, including CPRA. MMIS is linked to the LASARD data. Any data that overlapped data in LASARD were removed.

Table 4. Summary of data compiled from MMIS.

Data Type	*No. of Features*
Sediment Samples-Core Borings & Grab Samples	875
Geophysical Tracklines-Sub-bottom	2,380
Geophysical Tracklines-Sidescan Sonar	895
Geophysical Tracklines-Magnetometer	820
Geophysical Tracklines-Bathymetry	927
Surficial Sediment Maps (Sediment Deposits)	74

Coastal restoration, beach nourishment and levee reconstruction are crucial to mitigate future coastal erosion, land loss, flooding and storm damage in the Gulf of Mexico. The success of such long-term efforts depends on locating and securing significant quantities of Outer Continental Shelf (OCS) sediment resources that are compatible with the target environments being restored. Offshore sand resources, like upland sources, are extremely scarce where most needed. Additionally, sizable areas of these relatively small offshore sand resources are not extractable because of the presence of oil and gas infrastructure, archaeologically sensitive areas, and biologically/environmentally sensitive areas. Since the use of OCS sediment resources is authorized by BOEM, the bureau is implementing measures to help safeguard the most significant OCS sediment resources, reduce multiple use conflicts, and minimize interference with oil and gas operations under existing leases or rights-of-way. OCS sediment resources refer to the sediment deposit(s), including clay, silt, sand, and gravel size particles and shell, found on or below the surface of the seabed on the OCS, as defined in Section 2(a) of the OCS Lands Act (43 U.S.C. § 1331(a)). BOEM maintains an inventory of borrow areas within federal waters as shown in Figure 6. "Borrow Sites" delineates the surface location of significant OCS sediment resources that have been developed into borrow areas in the Gulf of Mexico. BOEM also maintains an inventory of the OCS blocks that contain significant sediment resources. These blocks are shown in Figure 6. Bottom-disturbing activities, including but not limited to surface or near-surface emplacement of platforms, wells, drilling rigs, pipelines, umbilicals, and cables should avoid, to the maximum extent practicable, significant OCS sediment resources.

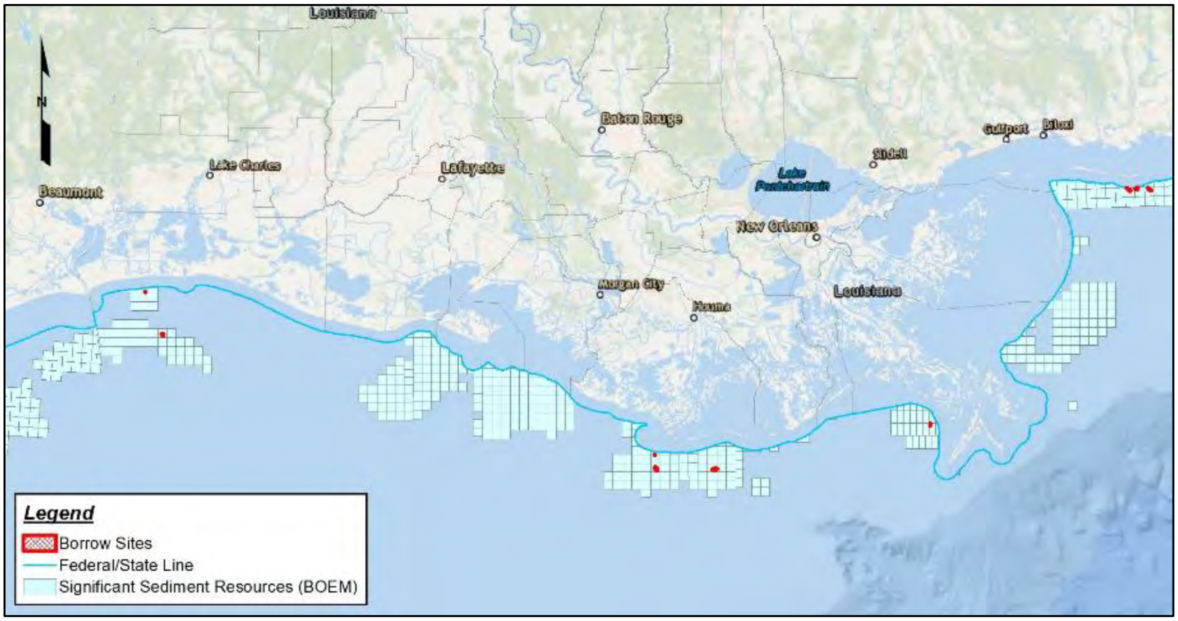

Figure 6. Inventory of borrow sites and OCS blocks designated as significant sediment resources. Because the borrow sites were obtained from MMIS, which is a compilation of data from other sources, some of the borrow sites were originally from CPRA. Note: background is Esri's Imagery Basemap.

3.1.2.4 NOAA National Centers for Environmental Information (NCEI)

The NCEI Marine Trackline Geophysics database contains bathymetric, magnetic, gravity and sub-bottom navigation data collected during marine cruises from 1939 to 2022 (Figure 7). This map service shows tracklines (both ship and airborne) for all geophysical surveys in the database, split into sub-layers by data type. Data associated with the tracklines are available by selecting specific tracklines.

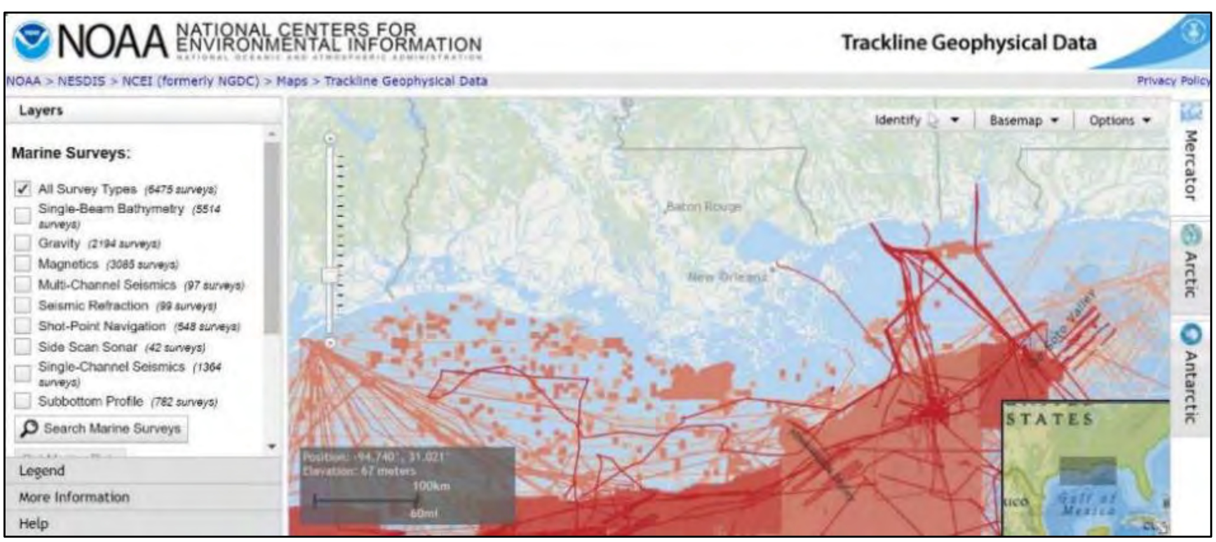

Figure 7. Screen capture of the NCEI Marine Trackline Geophysical database.

3.1.2.5 Additional Data Sources

Additional sediment deposit information was obtained from the following sources:

- Rodriguez, A.B., Anderson, J.B., Siringan, F.P. and Taviani, M., 1999. Sedimentary Facies and Genesis of Holocene Sand Banks on the East Texas Inner Continental Shelf, SEPM (Society for Sedimentary Geology) ISBN 1-56576-057-3 p.165-178.
- Thomas, M.A. and Anderson, J.B., 1994. Sea-Level Controls on the Facies Architecture of the Trinity/Sabine Incised Valley System, Texas Continental Shelf, SEPM (Society for Sedimentary Geology) ISBN 1-56576-901-58 p.63-82.
- Shoal Map Assessment Tool for EFH (shoalMATE) which can be found at https://mmis.doi.gov/arcgis/services/shoalMATE-Public/Shoals

3.1.3 Additional Data Types Not Included in LASARD

Upon review of the compiled datasets discussed in section 2.1, it was determined that additional data types such as waterways, critical habitat and infrastructure may be needed to facilitate a comprehensive LASAAP, which was the initial purpose of this gap assessment. Additional data were compiled that included the datasets described below. These data are briefly described below but were not included in the gap assessment.

3.1.3.1 Navigation and Waterways

Several datasets related to inland waterways were located (Figure 8). These datasets were obtained from the Gulf of Mexico Data Atlas, which is available through https://gis.ngdc.noaa.gov/arcgis/rest/services/GulfDataAtlas/USACE_NatlWaterWayNetwork/MapServer.

USACE National Waterway Network- This dataset is part of the National Transportation Atlas Database and was created on behalf of the USACE Navigation Data Center to enable assessments of waterway infrastructure, national and international movement of commodities, and other geospatial analyses. The waterway line features in the database may represent actual shipping lanes or hypothetical routes between points where no shipping lanes exist. U.S. waterway types are classified as harbors and bays, intracoastal waterways, sea lanes with and without separation zones, open water routes, rivers, creeks, thoroughfares, lakes, estuaries, channels, canals, Great Lakes direct and indirect links and Corps of Engineers locks. Waterways can also be identified by their functional class: deep or shallow draft waterways, or both, special vessel waterways (fishing, pleasure craft, etc.) and non-traffic or non-navigable waterways.

Shipping and Navigation- This dataset depicts the shipping fairways, submarine cables and wrecks and obstructions in the Gulf of Mexico. This data source is not as comprehensive as the AWOIS.

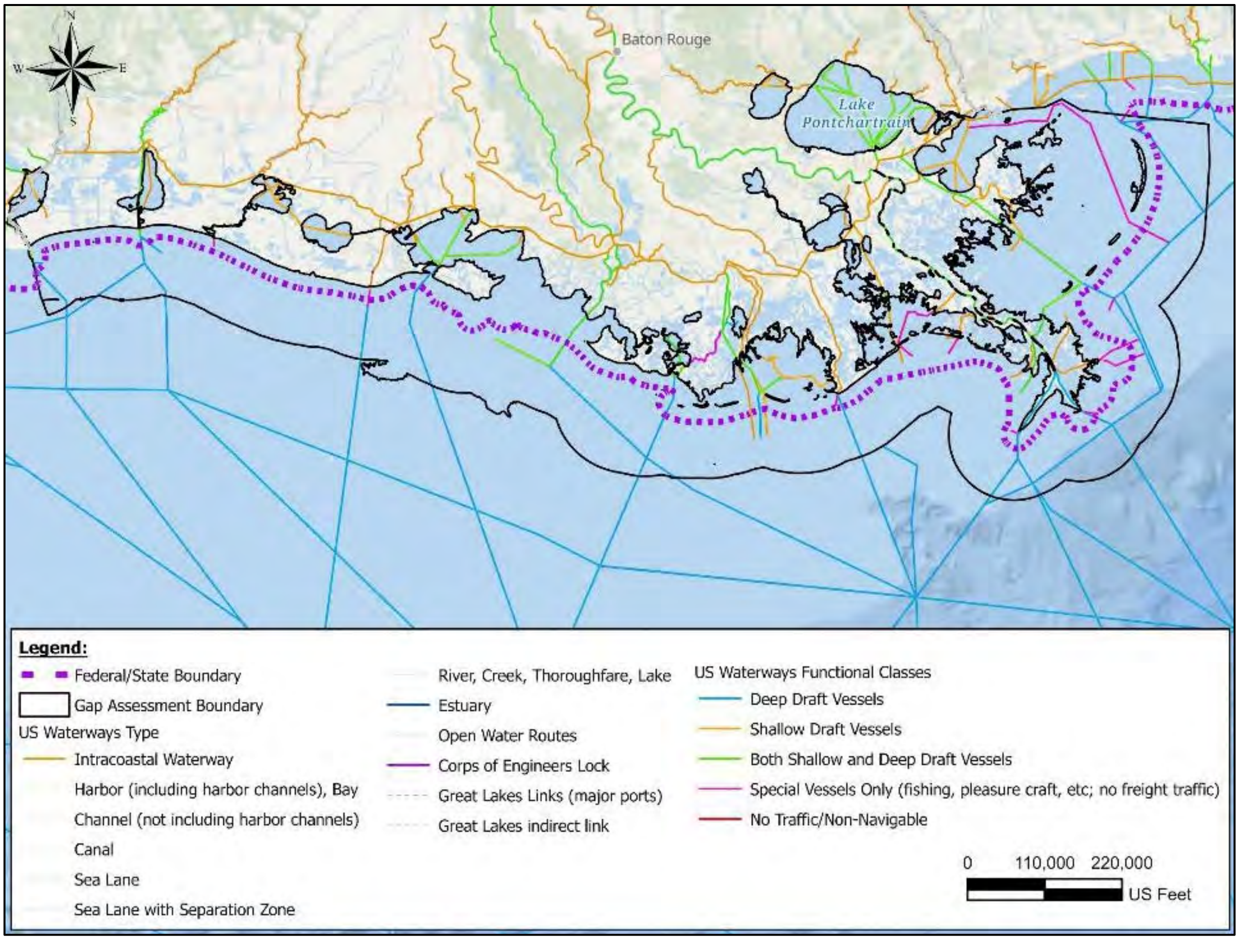

Figure 8. Navigation and waterway data. Note: background is Esri's Imagery Basemap.

3.1.3.2 Oil and Gas Infrastructure

Louisiana ranks among the top 10 states in both crude oil reserves and annual crude oil production. As a result of this, Louisiana has an extensive pipeline network with thousands of miles of pipeline in the state, serving all facets of the industry as well as consumers. There are approximately 125,000 miles of pipelines crisscrossing Louisiana. There are an estimated 87,764 miles of pipelines onshore Louisiana (land and within state waters) and 37,000 miles of pipelines in Louisiana OCS waters. These pipelines obstruct access and thereby reduce available sediment volume for restoration significantly. They also impact the delineation of borrow areas and subsequent dredging. Pipeline data are only included in LASARD if the data represent verified locations of pipelines. For this reason, oil and gas infrastructure data available through LASARD are very limited. However, there are numerous other sources for this data, including BOEM. It is important to note that there is no single comprehensive source for pipeline data and there is little consistency between pipeline databases. The two datasets described below were provided by BOEM and are shown in Figure 9.

Oil and Gas Pipelines- This dataset shows the locations of pipelines in the Gulf of Mexico which include oil, gas and H_2S (hydrogen sulfide). This includes proposed, active and out of service pipelines as of July 2011.

Drilling Platforms- This dataset contains the locations of offshore oil and gas structures. Offshore oil and gas structures are commonly referred to as "rigs" or "platforms." These terms actually refer to the drilling rigs used to drill wells and the large structures that serve as production platforms at producing well sites.

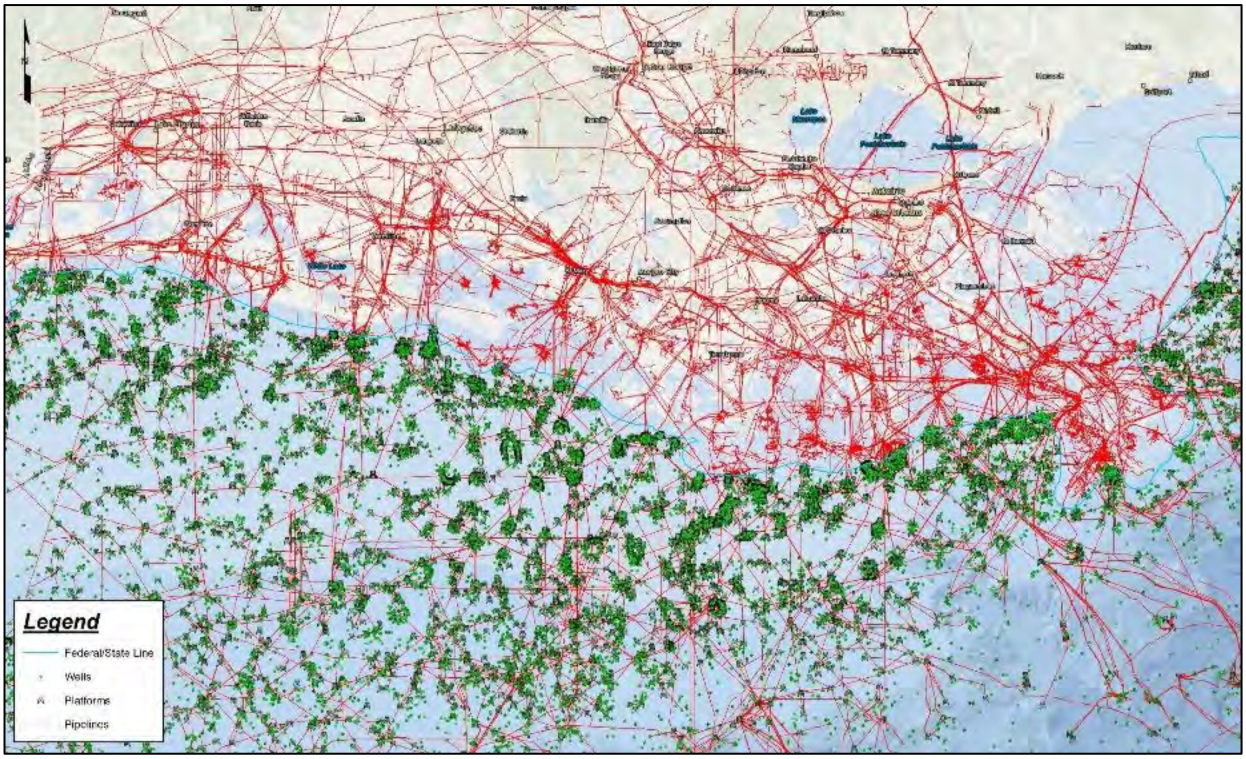

Figure 9. Oil and gas infrastructure datasets. Note: background is Esri's Imagery Basemap.

3.1.3.3 Environmental and Critical Habitat Areas

A critical component of LASAAP will be the ability to identify and avoid areas of environmental concern and critical habitat areas. Several datasets have been identified that may be incorporated into the program (Figure 10). They represent areas that need to be avoided or have special permitting requirements. Unless otherwise indicated, these datasets were obtained from the Gulf of Mexico Data Atlas at https://gis.ngdc.noaa.gov/arcgis/services/GulfDataAtlas/.

Submerged Aquatic Vegetation (SAV)- This dataset delineates the locations of seagrass habitat in the Gulf of Mexico.

Gulf of Mexico (GOM) Oysters- This dataset represents the locations of oyster beds in the Gulf of Mexico and state waters. This dataset is organized by state.

Bluefin Tuna Essential Fish Habitat- This dataset is a spatial representation of Amendment 1 of the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. This amendment constitutes the results of the comprehensive review and update of Essential Fish Habitat (EFH) for all Highly Migratory Species (HMS) that began with the Consolidated HMS Fisheries Management Plan (FMP). New information, including information on the biology, distribution, habitat requirements, life history characteristics, migratory patterns, spawning, pupping, and nursery areas of GOM were taken into consideration when updating EFH in this amendment.

Essential Fish Habitats- EFHs are defined in the Magnuson-Stevens Act as "...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The rules promulgated by the National Marine Fisheries Service (NMFS) in 1997 and 2002 further clarify EFH with the following definitions: waters - aquatic areas and their associated physical, chemical and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate - sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary - the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and spawning, breeding, feeding or growth to maturity - stages representing a species' full life cycle. The area defined includes Gulf of Mexico waters and substrates extending from the US/Mexico border to the boundary between the areas covered by the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council from estuarine waters out to depths of over 600 ft.

Critical Habitats- Critical habitat identifies specific areas that are essential to the conservation of a listed species, and that may require special management considerations or protection. Section 7(a)(2) of the Endangered Species Act of 1973 requires that each Federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of critical habitat. This dataset represents critical habitat areas in the Gulf of Mexico for Gulf Sturgeon.

Active Oyster Leases- According to the LDWF, as of October 2018, Louisiana had in place about 8,027 oyster leases covering approximately 403,000 acres. The average lease covers 50 acres, but more than half of the leases are smaller than 25 acres. The locations of active oyster leases were obtained from https://gis.wlf.la.gov/oystermap/map.html.

Artificial Reefs - The Louisiana Artificial Reef Program was established in 1986 to take advantage of obsolete oil and gas platforms which were recognized as providing habitat important to many of Louisiana's coastal fish. Federal law and international treaty require these platforms to be removed one year after production ceases. The removal of these platforms results in a loss of reef habitat.

Since the program's inception in 1986, 71 oil and gas related companies have participated in the program and donated the jackets of oil and gas structures. In addition to the material, companies also donate one half their realized savings over a traditional onshore removal to Louisiana's Artificial Reef Trust Fund. In 1999, the Louisiana Artificial Reef Program created the world's largest artificial reef. This reef was created off Grand Isle, Louisiana from the Freeport Sulphur mine. This reef is composed of more than 29 structures. It is in 42 to 50 ft of water and has 27 ft of clearance. For safety of navigation it is marked by five lighted buoys. Forty armored personnel carriers (APC's) and one offshore tug were also deployed within two other offshore artificial reefs.

The Louisiana Artificial Reef program has also developed 30 inshore reefs in Louisiana's state waters. These reefs are primarily low-profile reefs composed of shell or limestone. Eight inshore artificial reefs have been constructed using reef balls. Recycled concrete from the decommissioning of the old I-10 Twin Span bridges and other concrete sources have been used to develop new inshore reefs. Seven inshore reefs were constructed by Louisiana Department of Wildlife and Fisheries (LDWF) and 23 others were constructed in partnership with public conservation, private groups and other governmental entities.

This dataset shows the locations of artificial reefs and was obtained from http://www.wlf.louisiana.gov/fishing/artificial-reef-program.

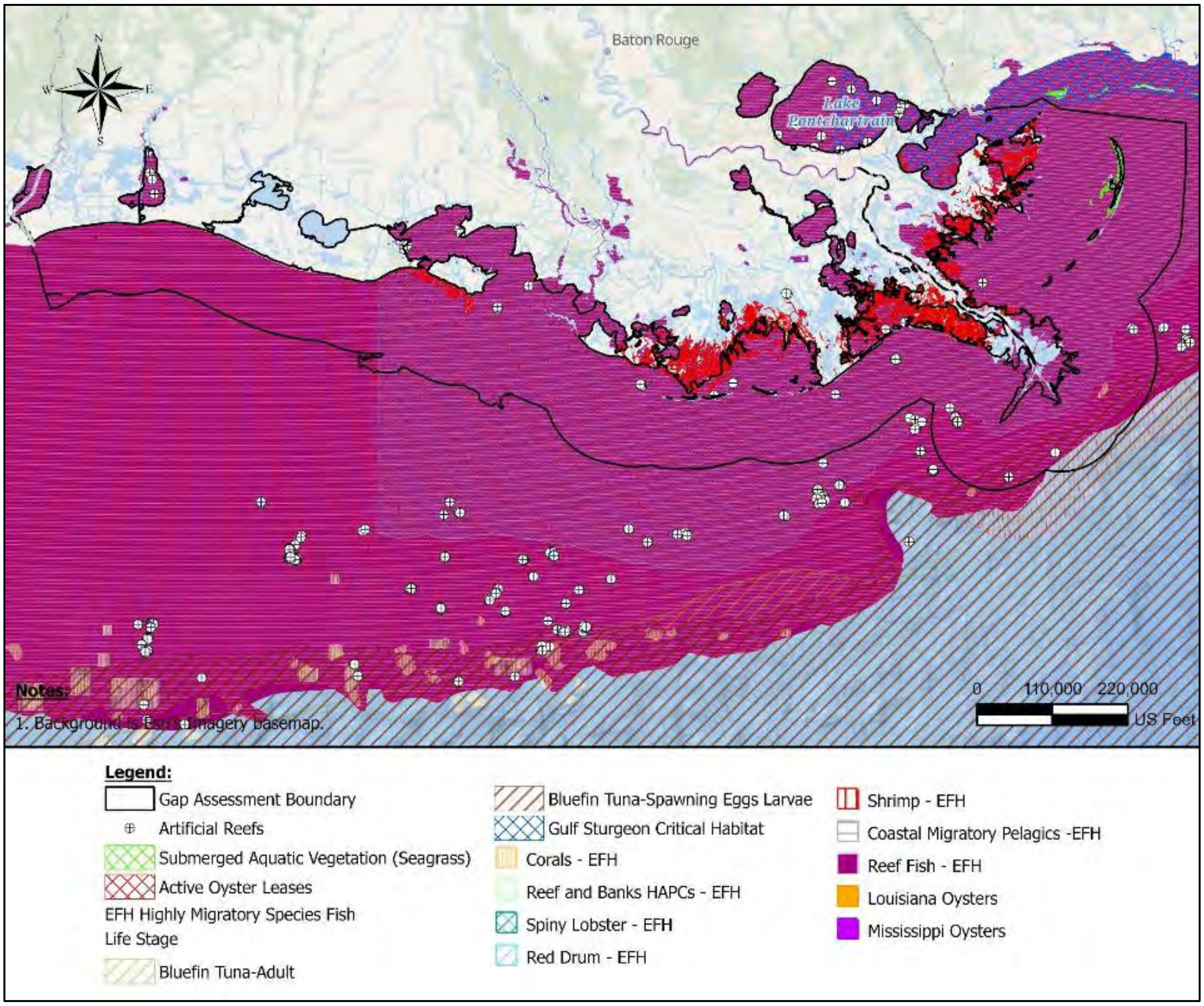

Figure 10. Environmental and critical habitat datasets.

3.2 Spatial Gap Evaluation

The geophysical, hydrographic, cultural resource and deposit/borrow area data that were compiled from LASARD, MMIS and NCEI were first reviewed to evaluate spatial coverage. The results of this review are described below.

3.2.1 Geophysical and Hydrographic Data

Geophysical data were compiled from LASARD and MMIS. Both tracklines and data were compiled. A trackline represents the path of the survey vessel towing various sensors/instrumentation. The tracklines represent the location of lines along which sub-bottom, sidescan sonar, magnetometer and bathymetric data (or any combination of the above) were collected. To provide an accurate representation of existing data, all of the figures below (Figures 11 through 14) also include NOAA's tracklines from the NCEI database. It is important to note that although LASARD contains information about magnetic anomalies, sidescan sonar contacts, bathymetric points and contours and sub-bottom reflection data, the tracklines associated with these data may not be included in

LASARD if they were not available. The opposite may be true as well, with tracklines residing in LASARD but no associated data. This is mostly seen in very old datasets. Tracklines without the associated data have very limited usefulness and are not a good indicator of the presence or absence of spatial data gaps.

3.2.1.1 Sub-bottom Data

Figure 11 shows the location of tracklines along which sub-bottom data were collected. The majority of sub-bottom tracklines in LASARD were run between Vermilion Bay and Sandy Point. Sub-bottom surveys have also been conducted along the Chandeleur Islands and in Lakes Borgne and Pontchartrain. Several inland lakes, including Lac Des Allemands, Lake Salvador, Bayou Perot, Bayou Rigolets and Little Lake, Calcasieu Lake and Sabine Lake have also been extensively surveyed. The bulk of the sub-bottom survey data archived in LASARD were collected in state waters. Very little sub-bottom data has been collected west of Vermilion Bay. The bulk of the NCEI surveys, on the other hand, were conducted in federal waters with the exception of a survey in state waters near Cameron and near Southwest Pass. Trackline spacing varies from 3,000 ft to 4 miles. As shown in Table 5, the mileage of sub-bottom data collected in each basin ranged from 67 miles in the Pearl River Basin to 20,398 miles in the offshore zone. The Offshore, Pontchartrain, Barataria and Terrebonne Basins have the most sub-bottom data.

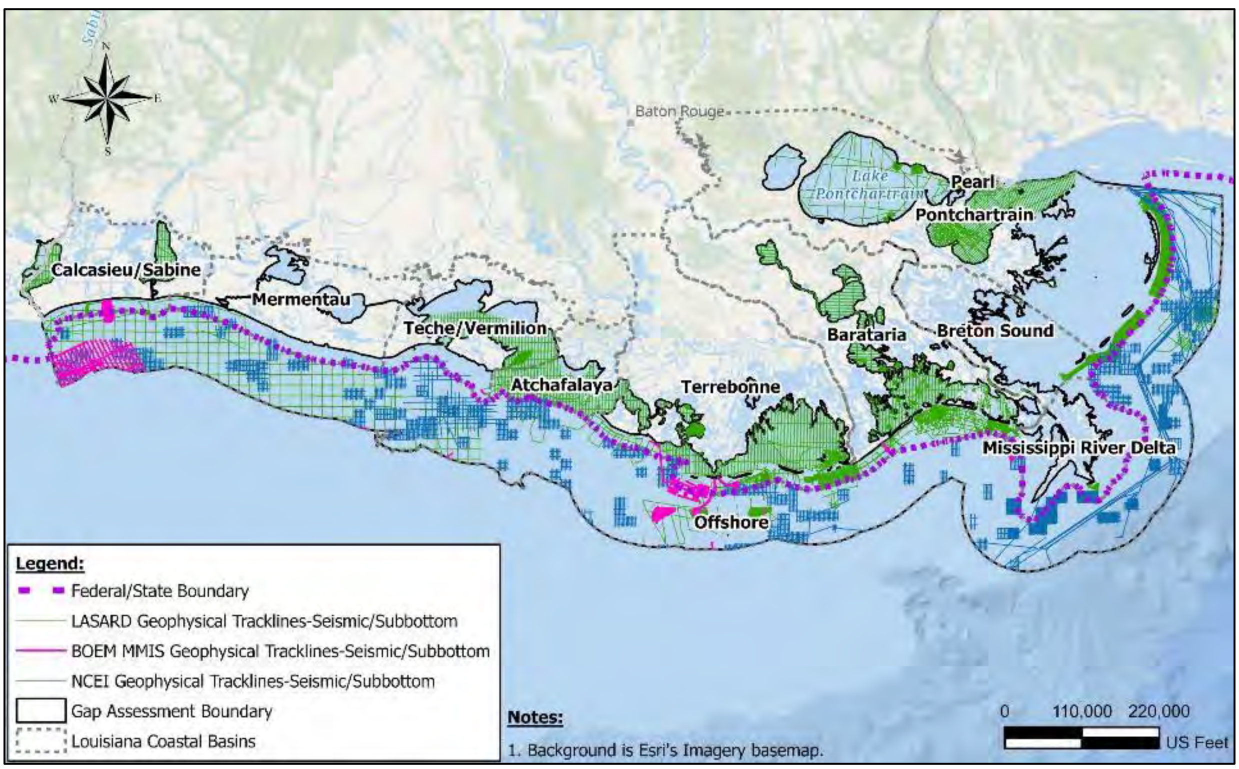

Figure 11. Compilation of sub-bottom tracklines.

Table 5. Sub-bottom trackline mileage within each coastal basin.

Coastal Basin	Area (square miles)[1]	No. of Tracklines[2]	Trackline Coverage (miles)[2]
Atchafalaya	450	224	794
Barataria	1,063	4,705	4,836
Breton Sound	745	641	325
Calcasieu	363	407	755
Mermentau	508	27	286
Mississippi River	735	1,977	737
Pontchartrain	3,180	2,040	5,902
Pearl River	17	32	67
Terrebonne	1,160	1,265	3,447
Teche/Vermilion	833	284	782
Offshore	8,953	2,408	20,398

[1]Only considers the portion of each basin that falls within the gap analysis boundary.
[2]Only tracklines that fall within the gap analysis boundary were included in this count.

3.2.1.2 Sidescan Sonar Data

Between 1970 and 2021 sidescan sonar data were collected along the tracklines shown in Figure 12. The majority of the tracklines in LASARD were run in state waters in Sabine Lake, Calcasieu Lake, Vermilion Bay, East and West Cote Blanche Bays, Terrebonne/Timbalier Bay, Barataria Bay, Lake Borgne, Little Lake and in Chandeleur Sound. However, being a federal database, tracklines from the NCEI database are predominantly in federal waters. The MMIS data are also in federal waters in the vicinity of Ship Shoal and the St. Bernard Shoals.

A total of 64 sidescan sonar contact datasets were identified in LASARD during the data compilation phase. These include both significant and non-significant contacts. These datasets represent approximately 3,505 sidescan sonar contacts, which are shown in Figure 12. The majority of the sidescan sonar contacts are on Sabine Bank, Ship Shoal, Vermilion Bay, East and West Cote Blanche Bays, Barataria Bay, Terrebonne Bay, Lake Borgne and part of Chandeleur Sound. Very few sidescan sonar contacts are within federal waters.

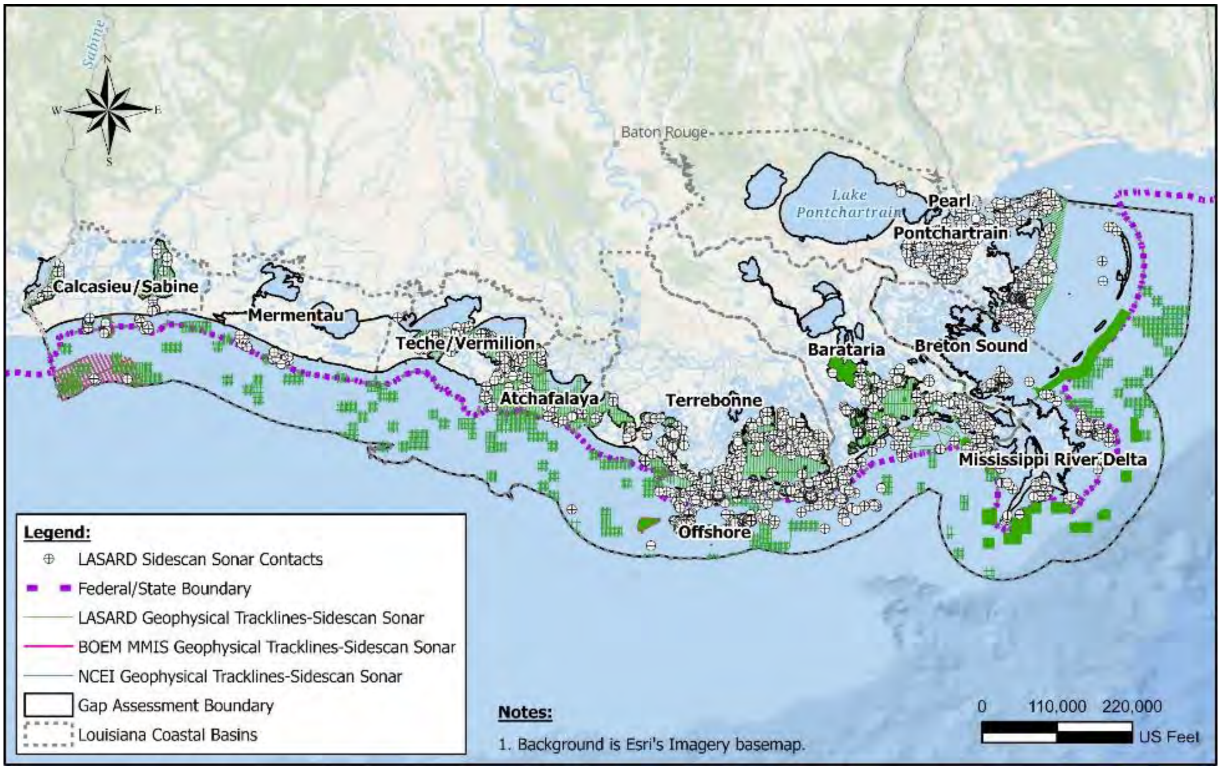

Figure 12. Compilation of sidescan sonar tracklines and contacts.

As shown in Table 6, the mileage of sidescan sonar data collected in each basin ranged from 0 miles in the Pearl River Basin to 6,058 miles in the offshore zone. The Offshore, Pontchartrain, Barataria and Terrebonne Basins have the most sidescan sonar data (tracklines and sidescan sonar contacts). It is important to note that some of the contacts are associated with tracklines while others are not.

Table 6. Sidescan sonar trackline mileage and contact coverage within each coastal basin.

Coastal Basin	Area (square miles)[1]	No. of Sidescan Sonar Contacts[2]	No. of Tracklines[2]	Trackline Coverage (miles)[2]
Atchafalaya	450	33	201	700
Barataria	1,063	371	1,792	2,719
Breton Sound	745	59	172	335
Calcasieu	363	108	130	364
Mermentau	508	17	3	94
Mississippi River	735	187	13	253
Pontchartrain	3,180	1,030	379	1,229
Pearl River	17	20	0	0
Terrebonne	1,160	1,108	804	1,936
Teche/Vermilion	833	135	194	611
Offshore	8,953	415	793	6,058

[1]Only considers the portion of each basin that falls within the gap analysis boundary.
[2]Only tracklines and data that fall within the gap analysis boundary were included in this count.

3.2.1.3 Magnetometer Data

Figure 13 shows the location of tracklines along which magnetometer data were collected as well as magnetic anomalies. A total of 129 magnetic anomaly datasets were identified in LASARD during the data compilation phase. These datasets represent 92,218 individual magnetic anomalies. These include both significant and insignificant magnetic anomalies. The majority of the tracklines and anomalies fall within Lakes Calcasieu and Sabine, Vermilion Bay, East and West Cote Blanche, Terrebonne/Timbalier Basin, Barataria Basin, Lake Borgne and inland lakes. All of the magnetometer surveys from the NCEI database were conducted in federal waters, with surveys extending from approximately 6 miles to more than 60 miles offshore.

As shown in Table 7, the mileage of magnetometer data collected in each basin ranged from 0 miles in the Mermentau and Pearl River Basins to 2,606 miles in the Barataria Basin. The Offshore, Pontchartrain, Barataria and Terrebonne Basins have the most magnetometer data (tracklines and magnetic anomalies). It is important to note that some of the anomalies are associated with tracklines while others are not.

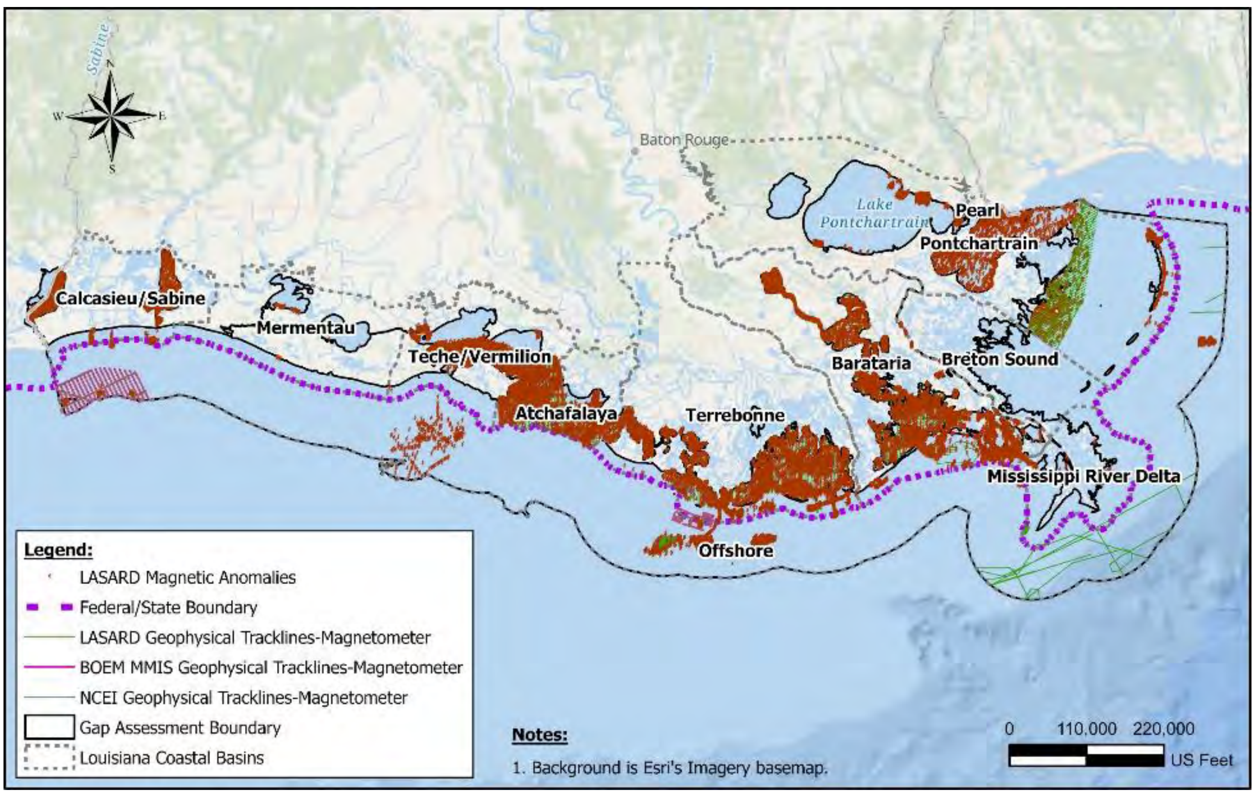

Figure 13. Compilation of magnetometer tracklines and magnetic anomalies.

Table 7. Magnetometer trackline mileage and anomaly coverage within each coastal basin.

Coastal Basin	Area (square miles)[1]	No. of Magnetic Anomalies[2]	No. of Tracklines[2]	Trackline Coverage (miles)[2]
Atchafalaya	450	2,889	200	682
Barataria	1,063	15,983	1,815	2,606
Breton Sound	745	171	37	21
Calcasieu	363	3,368	91	300
Mermentau	508	151	0	0
Mississippi River	735	230	3	73
Pontchartrain	3,180	22,290	167	561
Pearl River	17	134	0	0
Terrebonne	1,160	9,752	858	1,655
Teche/Vermilion	833	5,649	192	603
Offshore	8,953	31,504	652	1,315

[1]*Only considers the portion of each basin that falls within the gap analysis boundary.*
[2]*Only tracklines and data that fall within the gap analysis boundary were included in this count.*

3.2.1.4 Bathymetric/Topographic Data

Figure 14 shows the location of tracklines along which bathymetric and/or topographic data were collected. Light Detection and Ranging (LiDAR) tracklines are included in Figure 14. The majority of tracklines were run in state waters between Vermilion Bay and the Mississippi State line. Several inland lakes, including Sabine Lake, Calcasieu Lake, Lost Lake, Lake Mechant, Caillou Lake and portions of Little Lake and the Rigolets have also been surveyed. Surveys have also been conducted in Lake Pontchartrain, Lake Borgne and Chandeleur Sound. LiDAR data have been collected between Vermilion Bay and Lake Borgne but are not shown. The data obtained from the NCEI database fall predominantly within federal waters from Texas to Mississippi. The tracklines from MMIS were run across Ship Shoal.

As shown in Table 8, the total line miles of bathymetric data collected in each basin ranged from 15 miles in the Pearl River Basin to 10,680 miles in the offshore zone. The Offshore, Barataria, Terrebonne and Pontchartrain Basins have the most bathymetric data.

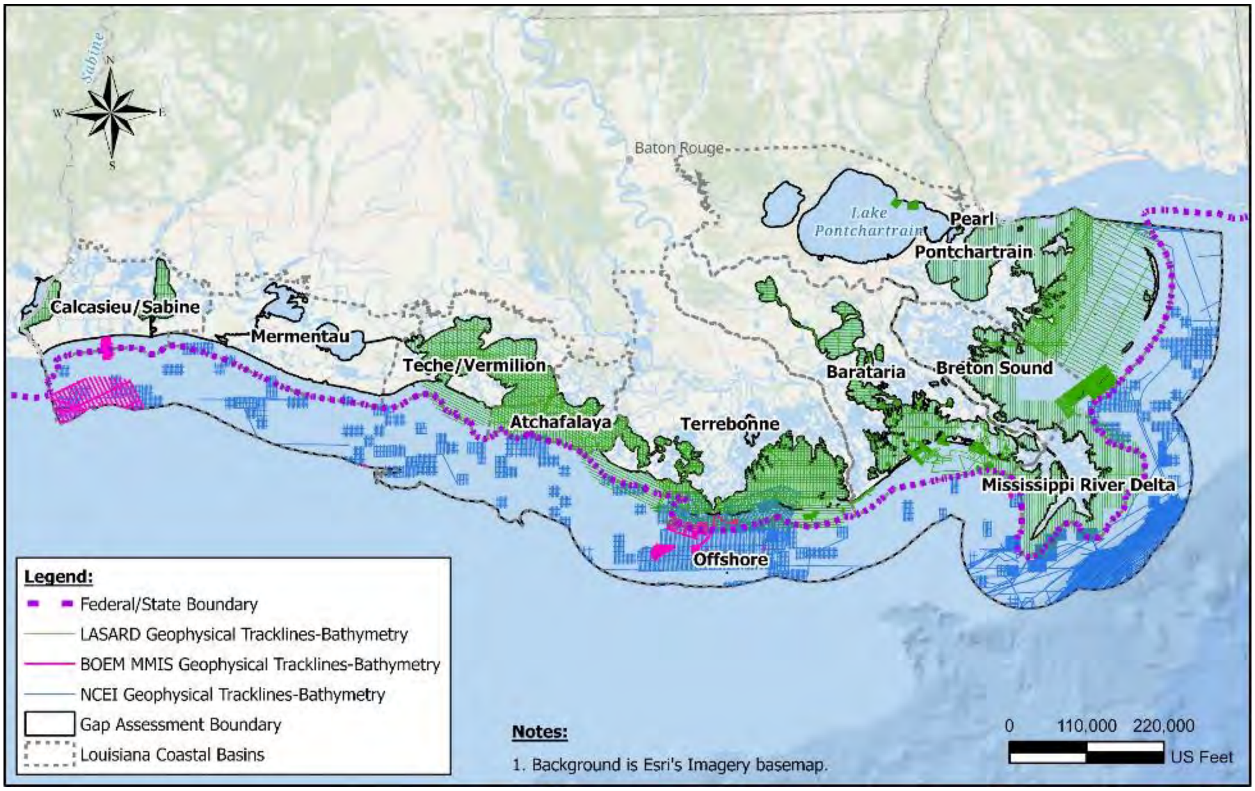

Figure 14. Compilation of bathymetric tracklines.

Table 8. Bathymetric trackline mileage within each coastal basin.

Coastal Basin	Area (square miles)[1]	No. of Tracklines[2]	Trackline Coverage (miles)[2]
Atchafalaya	450	296	1,185
Barataria	1,063	2,899	3,229
Breton Sound	745	513	1,114
Calcasieu	363	112	341
Mermantau	508	3	94
Mississippi River	735	64	1,003
Pontchartrain	3,180	744	3,359
Pearl River	17	15	15
Terrebonne	1,160	923	3,820
Teche/Vermilion	833	288	1,560
Offshore	8,953	853	10,680

[1]Only considers the portion of each basin that falls within the gap analysis boundary.
[2]Only tracklines and data that fall within the gap analysis boundary were included in this count.

While having multiple bathymetric surveys is useful for large scale studies of specific regions, incorporating a continuous bathymetric surface for the state is a useful baseline reference for program managers. It aids with survey planning and allows researchers to identify bathymetric highs (developed from change surfaces by comparing bathymetric surfaces of two time periods) which may represent potential sediment resources that would be good candidates for further investigation. APTIM developed a continuous bathymetric/topographic surface for Louisiana. This surface is shown in Figure 15. It represents a compilation of bathymetric data and topographic LiDAR data. LiDAR data collected by the USGS were downloaded from the National Map Viewer. Bathymetric data were collected during the SWAMP Phase I, II, III and IV surveys that were conducted between 2015 and 2019. BICM program data were collected between 2006 and 2017. Breton Sound data were collected by NOAA in 2011. LiDAR data were downloaded at 1 m grids. SWAMP data were gridded at 10 ft. BICM and Breton Sound data were gridded at 10 m. All surfaces were converted to UTM Zone 15 North, NAVD88 feet and upsampled/downsampled to 10 m. The final surface had the following hierarchy, with the first surface at the top: SWAMP, Breton Sound, BICM, USGS, NOAA, NCEI. This surface is updated on a regular basis as additional data are available. The most recent update was completed in April of 2020 as shown in Figure 15. Applied Coastal Research & Engineering (ACRE, 2020) developed an Operational Sediment Budget by developing bathymetric change surfaces. This is a key element in sediment management in general and LASMP in particular.

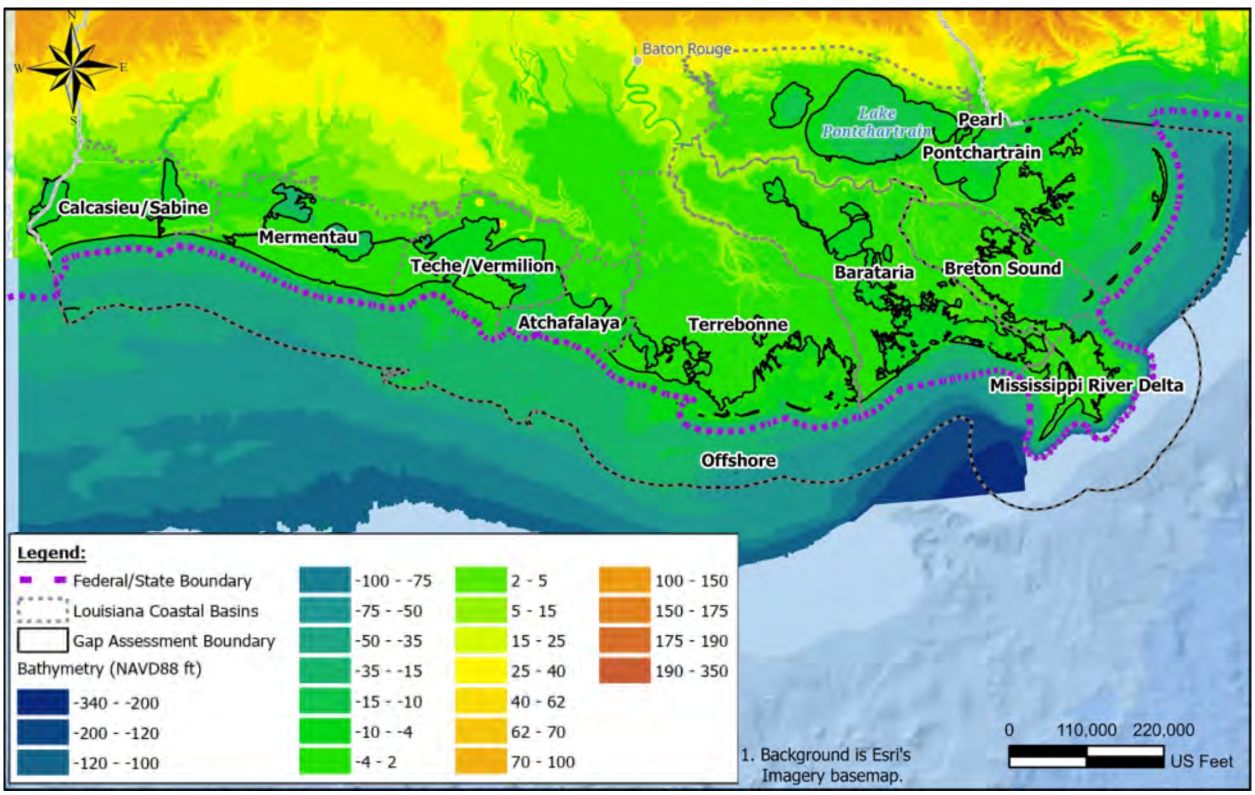

Figure 15. Bathymetric and topographic surface created based on existing bathymetric data in LASARD.

3.2.2 Cultural Resources

Cultural resource data are not typically included in LASARD since these data are available through various services and websites, where they are updated frequently. However, LASARD does include 6 datasets that represent over 1,000 archaeological sites and unknown obstructions. 420 of these features fall within the boundaries of the gap assessment (Figure 16). Data coverage is most dense in state waters off Calcasieu Lake, at Southwest Pass and Barataria Bay. There are some data within the Mississippi River, at the mouth of the river and within Lakes Pontchartrain and Borgne. Additional cultural resource data are available in AWOIS, which are also shown in Figure 16 below. However, as previously noted, AWOIS has not been updated since 2016. Cultural resources were not part of this gap assessment because they are available elsewhere and because cultural resource investigations are a requirement of all bottom disturbing activities including borrow area development, offshore oil and gas infrastructure development, pipeline/conveyance corridors etc.

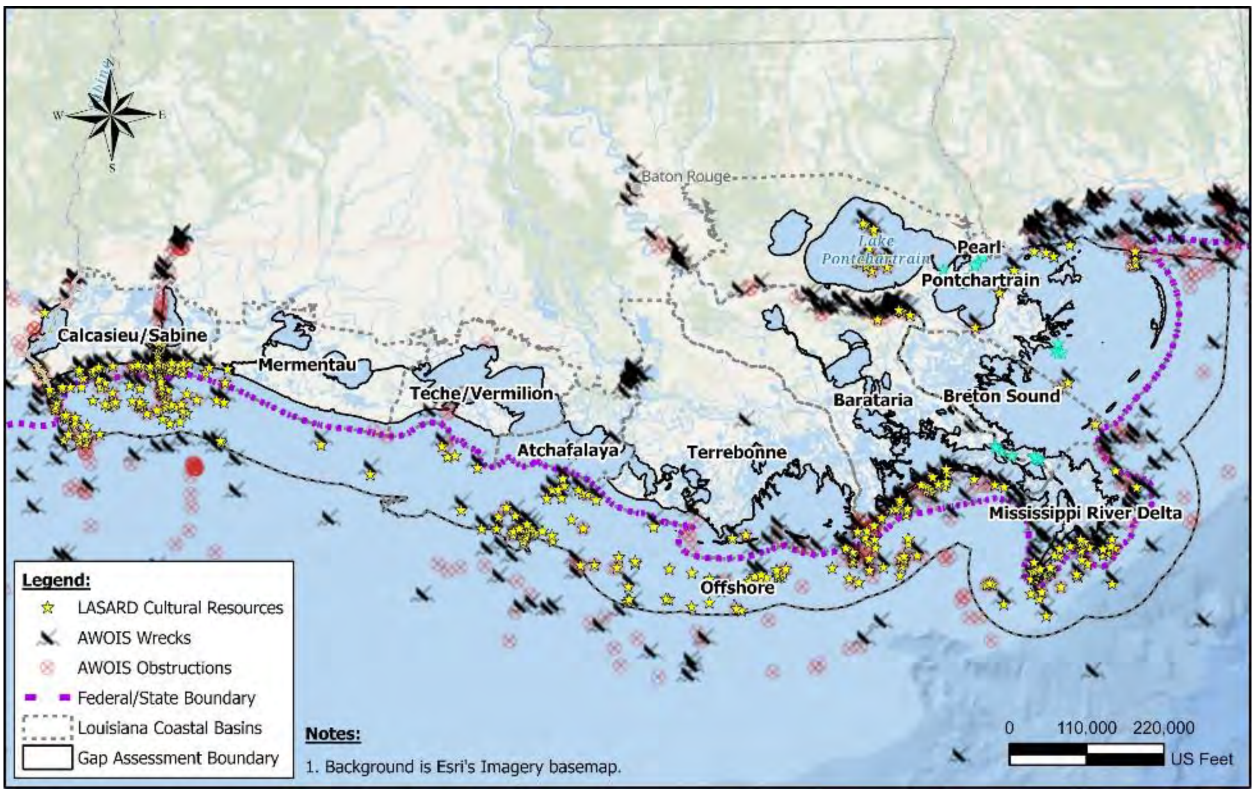

Figure 16. Compilation of cultural resource data.

3.2.3 Deposits/Borrow Areas

Datasets representing borrow areas (permitted and potential), investigation areas, offshore and confined disposal sites, potential deposit areas and rehandling areas were identified. Definitions for each of these types are provided in Table 9 below. These borrow areas were identified and delineated between 1990 and 2020. As shown in Figure 17, they cover the majority of coastal Louisiana with the exception of Lake Borgne, Chandeleur Sound and Breton Sound. The deposits/borrow areas found in MMIS overlapped those found in LASARD. It is important to note that many of these borrow areas and deposits were classified based on very limited information. As a result, their classification may not be accurate. It is also worth noting that borrow area history is not consistently tracked. Often there are no records of whether a designed borrow area was actually permitted or dredged.

Table 9. Definitions of deposit types.

Type of Deposit	Description
Borrow Area	A well-defined area from which sediment is could be dredged for placement at a project site. To be designated as a borrow area, the area must have been delineated on the basis of detailed/engineering scale survey and have undergone cultural resource and environmental clearance.
Sediment Deposit	Source of sediment (sand and mixed sediment) identified on the basis of high level/reconnaissance level survey followed by appropriate sedimentological investigation and analyses
Potential Sediment Deposit	A sediment source identified and delineated on the basis of limited data (viz. acoustic remote sensing). In most cases there are no geotechnical information about the sediment characteristic. Most of the Potential Deposits shown in Figure 17 represent potential buried paleochannels identified in the literature.
Investigation Area	An area identified as a sediment resource on the basis of limited existing/historic data. This area is the focus of additional engineering level detailed surveys during an investigation for sediment.
Offshore Disposal Site/Confined Disposal Facility	Sites used for the offshore disposal of sediment excavated or otherwise removed from the bottom of navigable waterways.
Rehandling Area	A designated area on the seabed where a hopper dredge dumps sediment from a distant borrow area. Another dredge then transfers the sediment to the project fill site.
Unknown	This term only applies to legacy data where a polygon was available but there were no additional data indicating what the site was used for or what it should be categorized as.

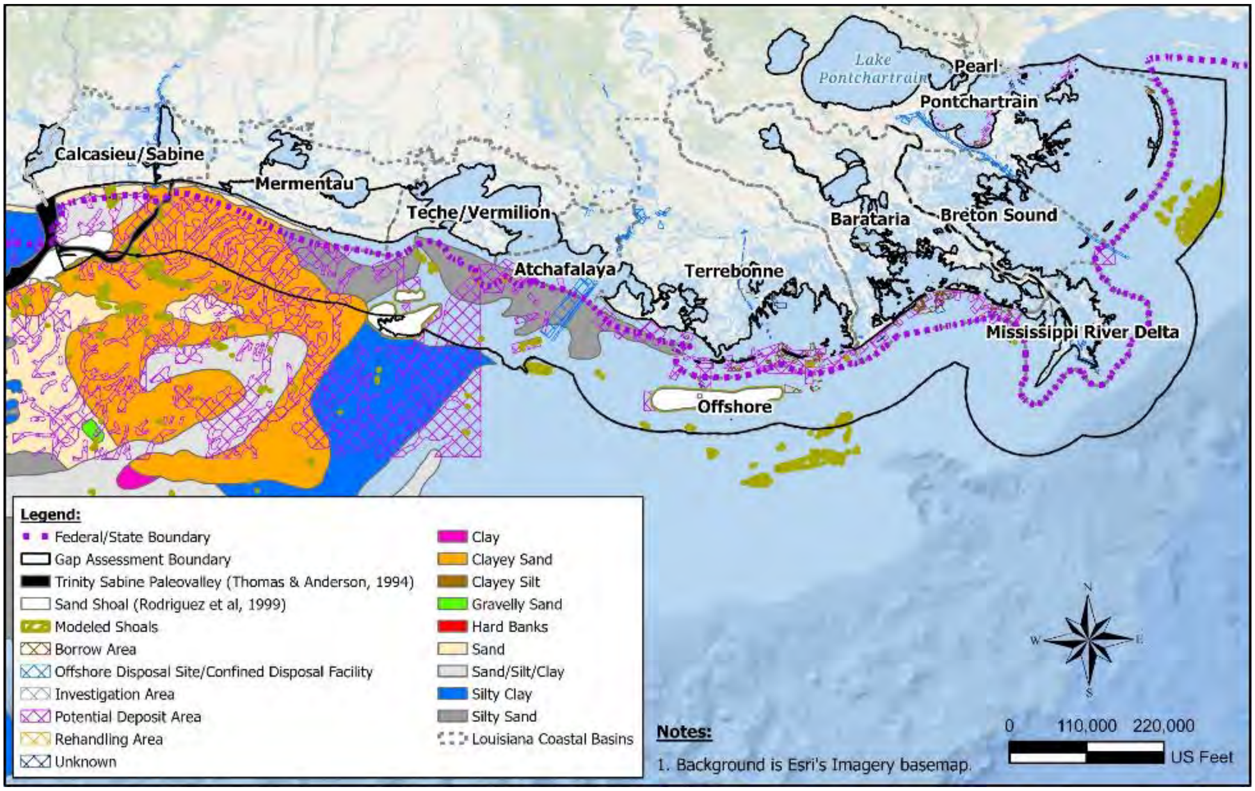

Figure 17. Compilation of borrow areas and deposits.

3.3 Temporal Evaluation

The coast is a dynamic environment. As a result, seafloor bathymetry changes over time. Magnetic anomaly and sidescan sonar data may also change as the seafloor shifts and features on the seafloor shift in response. The data that were compiled were categorized based on collection date. Table 10 provides a summary of the relative ages of the various data.

The majority of the sub-bottom tracklines and magnetic anomalies are more than 10 years old or have an unknown age. However, the age of these data is not as critical as the age of bathymetric data. The surface of the seafloor is a dynamic environment, so current bathymetric data is critical to identify and quantify surficial deposits that can be used as sediment resources. There are many uncertainties in older bathymetric data, but they are often the only source of information available.

Table 10. Summary of temporal data review of data compiled from LASARD, MMIS and NCEI.

Dataset Type	***Relative Age***	***Basin***										
		Offshore	***Atchafalaya***	***Barataria***	***Breton Sound***	***Calcasieu***	***Mermentau***	***Mississippi River***	***Pearl River***	***Pontchartrain***	***Teche/ Vermilion***	***Terrebonne***
Geophysical Tracklines-Sub-bottom	Prior to 1990	206	24	58	5	16	18	15	0	36	11	129
	1990-2010	1,189	0	1,586	86	41	9	17	10	1,339	40	420
	2011-2022	769	200	2,651	68	350	0	0	22	413	233	716
	Unknown Age	244	0	410	482	0	0	1,945	0	252	0	0
Geophysical Tracklines-Sidescan Sonar	Prior to 1990	4	1	0	1	0	3	4	0	1	2	4
	1990-2010	145	0	435	134	21	0	9	0	264	0	149
	2011-2022	644	200	1,357	37	109	0	0	0	114	192	651
	Unknown Age	0	0	0	0	0	0	0	0	0	0	0
Geophysical Tracklines-Magnetometer	Prior to 1990	7	0	0	0	0	0	2	0	0	0	0
	1990-2010	79	0	308	0	0	0	1	0	0	0	121
	2011-2022	566	200	1,507	37	91	0	0	0	167	192	737
	Unknown Age	0	0	0	0	0	0	0	0	0	0	0
Geophysical Tracklines-Bathymetry/Topography	Prior to 1990	34	1	0	2	0	3	7	0	2	2	14
	1990-2010	89	0	308	0	21	0	0	0	1	0	121
	2011-2022	730	295	2,591	511	91	0	57	15	681	286	788
	Unknown Age	0	0	0	0	0	0	0	0	60	0	0
Magnetic Anomalies	Prior to 1990	0	0	0	0	0	0	0	0	133	0	0
	1990-2010	2,284	1	2,405	82	333	137	230	0	1,059	979	1,344
	2011-2022	1,370	2,888	12,479	89	3,035	14	0	134	5,277	4,574	8,408
	Unknown Age	27,850	0	1,099	8	0	0	0	0	15,821	96	0
Sidescan Sonar Contacts	Prior to 1990	0	0	0	0	0	0	0	0	0	0	0
	1990-2010	124	9	128	7	10	17	85	13	147	0	271
	2011-2022	261	24	239	0	98	0	0	7	880	135	765
	Unknown Age	30	0	4	52	0	0	102	0	3	0	72

Note: the numbers provided in the table above represent numbers of features (e.g., tracklines, magnetic anomalies or sidescan sonar contacts).

3.3.1 Geophysical and Hydrographic Data

Geophysical surveys were conducted between 1968 and 2020. These surveys are described below.

3.3.1.1 Sub-bottom Data

Figure 18 shows the distribution of data categorized based on relative age as shown in Table 10 above. Recent data is considered anything collected within the last decade. If a sample did not have a collection date the date was marked unknown. Coastwide, sub-bottom data were collected between 1968 and 2020.

As shown in Figure 18 and Table 10, most of the sub-bottom tracklines were collected between the 2011 and 2022 time interval. The bulk of the tracklines in the Breton Sound and Mississippi River Basins had unknown collection dates. Most of the tracklines in the Mermantau Basin were collected prior to 1990. The bulk of the tracklines in the Offshore and Pontchartrain Basins were run between 1990 and 2010. The majority of tracklines in the Atchafalaya, Barataria, Calcasieu, Pearl River, Teche/Vermilion and Terrebonne Basins were collected between 2011 and 2022.

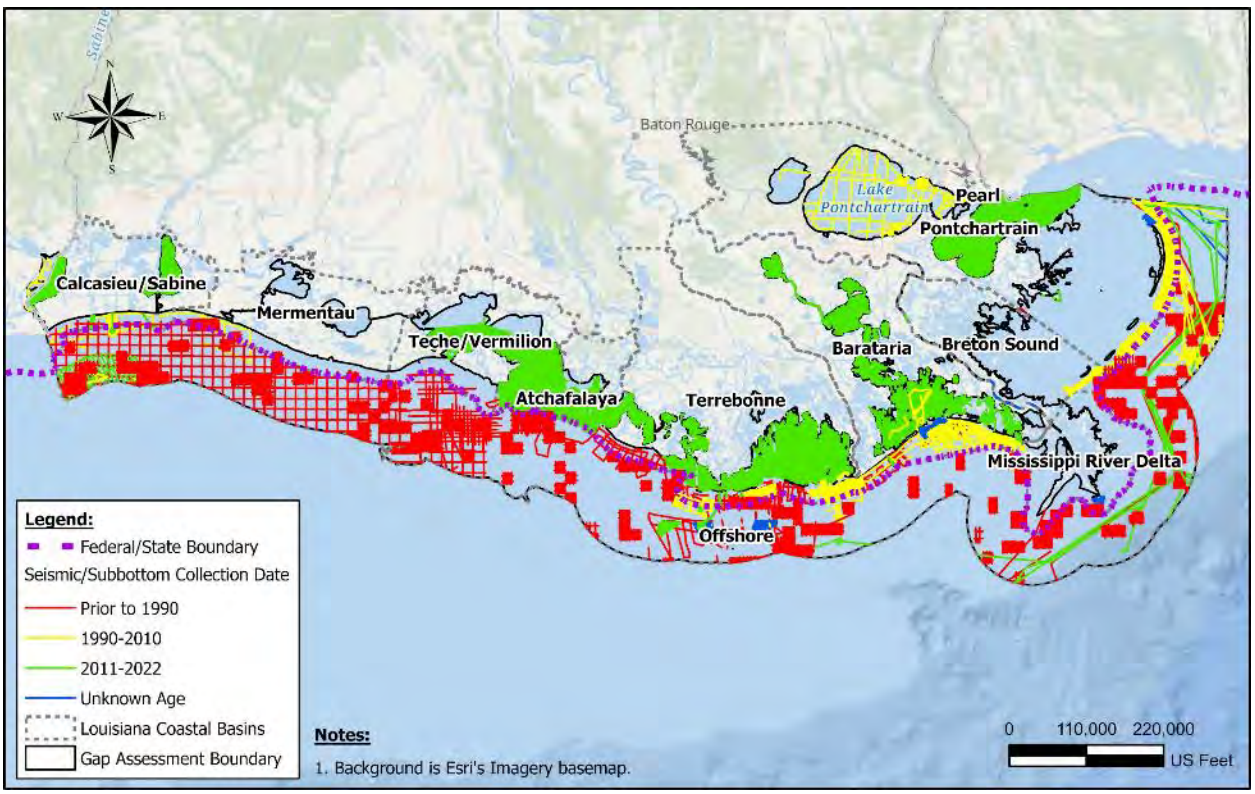

Figure 18. Categorization of sub-bottom tracklines based on collection date.

3.3.1.2 Sidescan Sonar Data

Figure 19 shows the distribution of data categorized based on relative age as shown in Table 10 above. Recent data is considered anything collected within the last decade. If a sample did not have a collection date the date was marked unknown. Coastwide, sidescan sonar data were collected between 1978 and 2019.

As shown in Figure 19 and Table 10, most of the tracklines along which sidescan sonar data were collected were collected between 2011 and 2022. The bulk of these tracklines in the Mermantau Basin were collected prior to 1990. Most of the tracklines in the Breton Sound, Mississippi River and Pontchartrain Basins were run between 1990 and 2010. The majority of tracklines in the Offshore, Atchafalaya, Barataria, Calcasieu, Teche/Vermilion and Terrebonne Basins were collected between 2011 and 2022. Most of the sidescan sonar contacts were collected between 2011 and 2022.

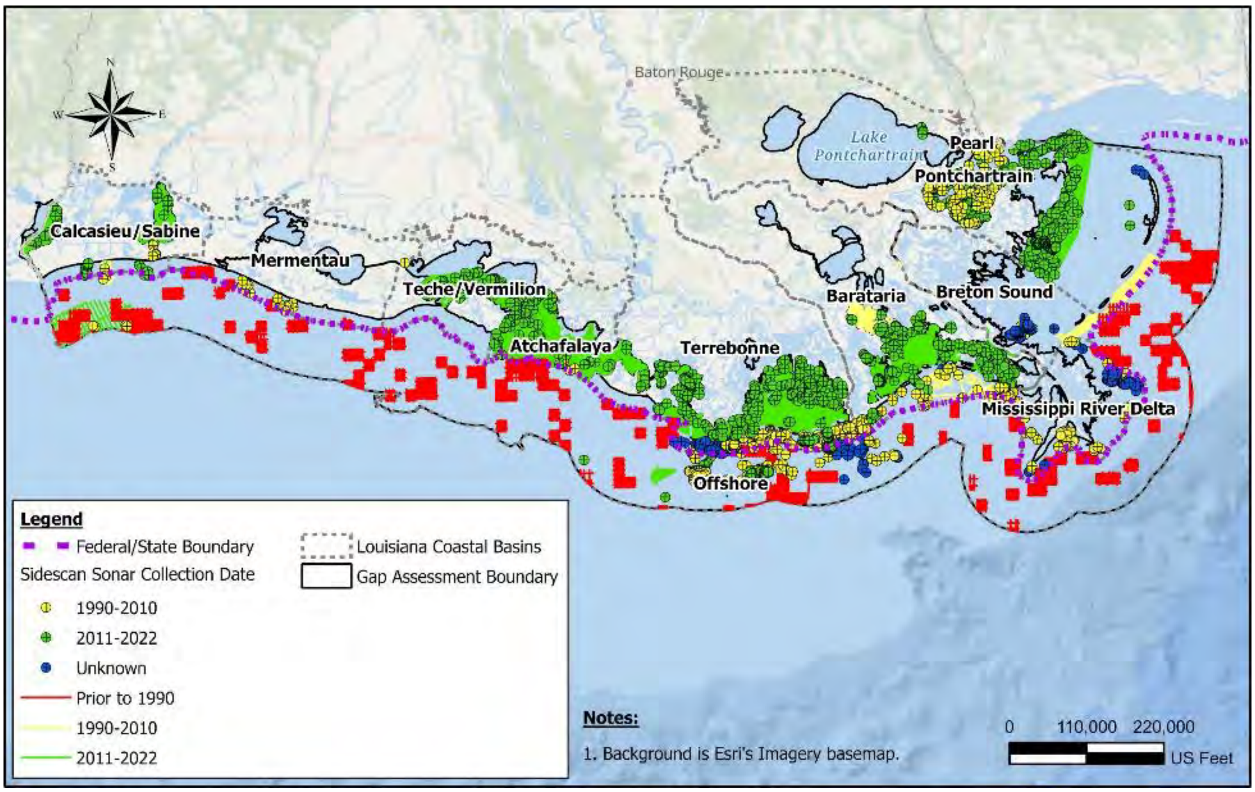

Figure 19. Categorization of tracklines along which sidescan sonar data were collected and sidescan sonar contacts based on collection date.

3.3.1.3 Magnetometer Data

Between 1950 and 2020 magnetic anomaly data were collected along the tracklines included in the NCEI database, MMIS and in LASARD. As shown in Figure 20 and Table 10, most of the magnetometer data were collected between 2011 and 2022. Most of the tracklines in the Offshore, Atchafalaya, Barataria, Breton Sound, Calcasieu, Pontchartrain, Teche Vermilion and Terrebonne Basins were run between 2011 and 2022. The majority of tracklines in the Mississippi River Basin were run prior to 1990. There are no tracklines in the Mermantau and Pearl River Basins. Most of the magnetic anomalies were collected in an unknown year.

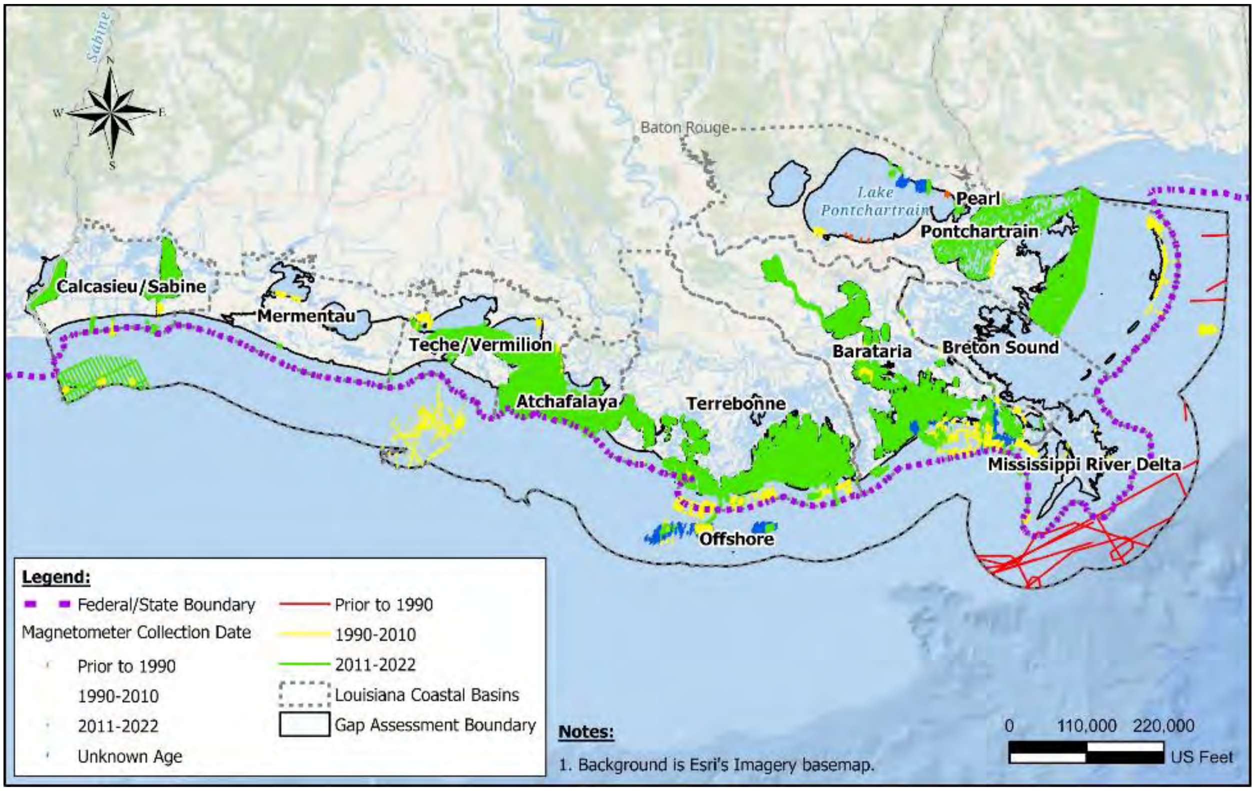

Figure 20. Categorization of magnetometer tracklines and magnetic anomalies based on collection date.

3.3.1.4 Bathymetric/Topographic Data

Between 1968 and 2019 bathymetric and topographic data were collected along the tracklines included in the NCEI database, MMIS, and LASARD. As shown in Figure 21 and Table 10, most of the bathymetry tracklines fall within the 2011 to 2022 time interval.

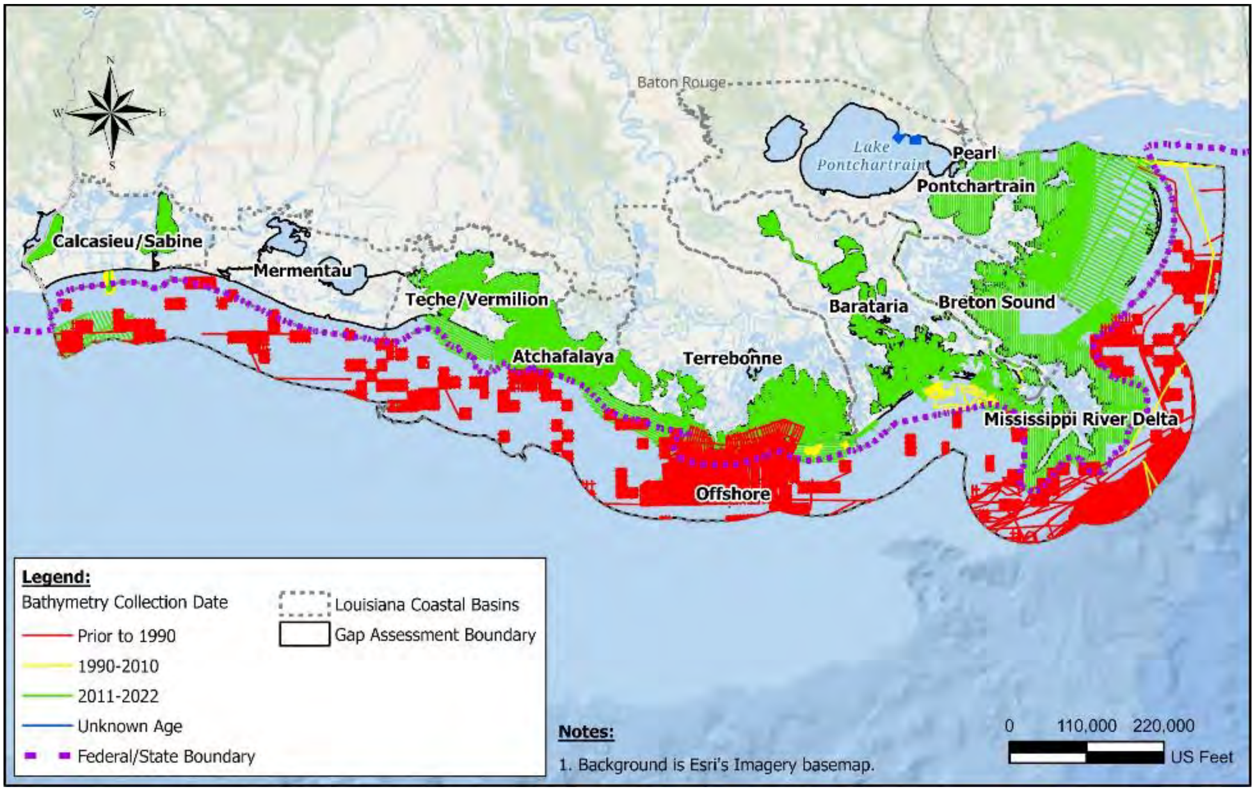

Figure 21. Categorization of bathymetric tracklines based on collection date.

3.3.2 Cultural Resources

The knowledge of where cultural resources are located is more important than when the cultural resource was identified. It is also important to note that during the permitting process for a borrow area, a cultural resource survey will likely be required. For this reason, the cultural resource datasets were not evaluated based on age of the data.

3.3.3 Deposits/Borrow Areas

A knowledge of where historic and existing borrow areas are located is important, regardless of the age of the borrow areas. It helps guide future investigations for sediment resources. The age of a borrow area does not significantly impact sediment resource delineation. Although older borrow areas are likely to have infilled more than recently dredged ones. It also depends on their location along the coast. Deposit/Borrow Area datasets were not evaluated based on their age.

3.4 Informational Gap Evaluation

The quality of the data compiled during this gap assessment is highly variable. Data standards have evolved over time. Therefore, datasets compiled and formatted during the early phases of LASARD may have fewer details than data submitted during the most current phase of LASARD. The data that have been compiled were reviewed to quantify the percentage of datasets lacking the necessary information.

Table 11 provides a summary of the number of datasets containing adequate attributes that could be considered sufficient and the number of datasets that contain less information. Percentages in brackets refer to the percentage relative to the total number of features. A discussion of what is considered an adequate attribute and what isn't for each data type, is provided in the sections below.

3.4.1 Geophysical and Hydrographic Data

Current LASARD formatting standards require specific attributes to be provided when submitting geophysical tracklines to CPRA. The most important of these are listed in Table 2. Geophysical tracklines are the lines along which an acoustic geophysical sensor is towed by vessel of opportunity along which sub-bottom, magnetometer, sidescan sonar and/or bathymetric data were collected. For a geophysical trackline dataset to be considered useful it needs to include a line ID and any associated sub-bottom reflection profiles, sidescan sonar mosaics, magnetic anomaly data or bathymetric/topographic data. Tracklines with no associated data are simply lines and are of little use.

Of the 13,348 sub-bottom tracklines in LASARD, MMIS, and NCEI, the majority (10,968) had a point of contact provided. Approximately 25% of the tracklines had line IDs and sub-bottom profiles available (or readily obtainable), while the remaining tracklines had locations only with no associated data. The majority of the 4,133 sidescan sonar tracklines, had associated data. Most of the magnetic anomaly tracklines have associated magnetometer data available and sufficient metadata. The majority of the 5,895 datasets representing bathymetric tracklines, sufficient attribution and had associated bathymetric data.

Sub-bottom, sidescan sonar, magnetic anomaly and bathymetric data are also available through the BOEM's MMIS and through the NCEI database. Attribution for the tracklines from MMIS includes cruise and track IDs, the type of data collected, equipment used, and links to the data imagery. The data from the NCEI database includes navigation data collected during marine cruises from 1939 to the present. The information provided with each trackline dataset includes the survey ID and type, the platform name, the survey start and end year, the institution responsible for data collection, the project name, the name of the chief scientist and the date that the tracklines were added to the database. In some cases, the data associated with the tracklines are available as scanned microfilm. The data, if available, can be requested through the data viewer at https://www.ncei.noaa.gov/maps/trackline-geophysics/.

3.4.2 Magnetic Anomaly Data

To be considered useful a dataset should include a target ID, locational information and signal information (strength, duration, and type). Approximately 98% of the 92,218 magnetic anomalies, included the information above. Just over 50% of the datasets included contractor/point of contact information

It is important to note that even if there is existing magnetic anomaly data within an investigation area, to develop and utilize a borrow area, a full cultural resource investigation will be required for cultural resource clearance. This will likely be required regardless of existing data.

3.4.3 Sidescan Sonar Contact Data

To be considered useful a dataset should include a target ID, feature type and locational information. All of the sidescan sonar contact datasets have at least some of the attributes listed above. None of the datasets are completely lacking information. All of the datasets have contractor information.

3.4.4 Cultural Resources

For a cultural resource dataset to be considered useful it needs to include, at a minimum, location information and the type of cultural resource. LASARD is not a repository for cultural resource information since such databases already exist. All of the cultural resources in LASARD have location information. However, less than 5% have contact information and information regarding location as well as the resource type (e.g., obstruction, wreck, etc.). Due to the sensitive nature of these data, they are not made publicly available. Additional data are available through AWOIS. These data contain information on the location of the wreck, the depth of the wreck, its history and the ID of the navigation chart on which it appears.

3.4.5 Deposits/Borrow Areas

To be considered adequate, a dataset needs to include dates of design and dredging, information on the type of sediment within the borrow area, borrow area elevations (designed and dredged) as well as design and post dredge volumes. If datasets contain this information, they can be used to provide more accurate estimates of sediment volumes within surficial sediment deposits. Of the LASARD datasets none contained all of this information. However, all of the LASARD datasets included contact information, so these missing details could likely be requested. The borrow area/deposits provided by BOEM contain location information only.

Table 11. Attribution review summary for the gap assessment data.

Data Type	***Total No. of Features***	***Metadata Exists***	***Point of Contact is Provided***	***Metadata Documents collection/ analysis methods***	***Data are accessible (web or on request)***	***Data are in a useable format***	***IDs are provided that correspond to raw data***
Geophysical Tracklines-Sub-bottom	13,348	3,381 (25%)	10,968 (82%)	3,381 (25%)	3,385 (25%)	3,385 (25%)	3,223 (24%)
Geophysical Tracklines-Sidescan Sonar	4,247	4,235 (99%)	3,660 (86%)	3,648 (86%)	4,200 (99%)	4,180 (98%)	4,215 (99%)
Geophysical Tracklines-Magnetometer	3,885	3,030 (78%)	3,065 (79%)	3,030 (78%	3,065 (79%)	3,065 (79%)	3,885 (100%)
Geophysical Tracklines-Bathymetry	6,199	6,199 (100%)	6,199 (100%)	6,199 (100%)	5,272 (85%)	4,877 (79%)	4,793 (77%)
Cultural Resources	420	22 (5%)	22 (5%)	22 (5%)	11 (3%)	11 (3%)	11 (3%)
Deposits/Borrow Areas	935	698 (75%)	877 (94%)	698 (75%)	935 (100%)	935 (100%)	935 (100%)
Magnetic Anomalies	92,218	48,289 (52%)	49,877 (54%)	48,289 (52%)	64,456 (70%)	90,260 (98%)	90,754 (98%)
Sidescan Sonar Contacts	3,505	3,505 (100%)	3,505 (100%)	3,505 (100%)	3,505 (100%)	3,505 (100%)	3,505 (100%)

**Evaluation of Cultural Resources and Deposits/Borrow Areas only includes LASARD. It does not include data from other sources, like the other data types do.*

4.0 Sediment Sample Pilot Assessment

In an attempt to assess patterns and trends in data availability and data quality and present the results in a more user-friendly, easily understandable format, APTIM applied CMAP methods to the assessment of the sediment sample data only. This was a pilot study to determine if these methods could be applied successfully. If successful, these methods could be modified and applied to the other data types in future gap assessment updates.

As described in CMAP (2020), a critical decision in any gap assessment is determining the spatial unit of analysis. Because the area being assessed covers the entire coast of Louisiana, a 2-mile square grid was developed and clipped to the gap assessment footprint. The areas made inaccessible due to oil and gas infrastructure safety buffers (1,000 ft for pipelines, 500 ft for wells and platforms) have been excluded from the grid since sediment within these buffers is not available for use (Figure 22).

4.1 Spatial Evaluation

In previous versions of the gap assessment, qualitative and quantitative assessments of the spatial distribution of sediment samples and grab samples were done. The spatial distribution of core borings and grab samples was evaluated visually. The qualitative assessment was done by plotting all of the samples on a map and visually assessing their distribution. The quantitative evaluation was performed by calculating the area of each basin that falls within the gap analysis boundary, applying a buffer (250 ft for grab samples and 1,000 ft for core borings) to each sample based on the accepted current industry standards and calculating the area in square miles covered by the buffered samples in each basin. A percentage representing the area of each basin covered by samples was then calculated.

During this current effort, methods were revised to more closely follow CMAP. To assess the spatial distribution of the core borings, grab samples and unknown sample types, for each individual grid cell a count of individual samples was determined. Grid cells were then color coded based on the density of data within each grid (Figures 23, 24 and 25). This is an effective way of visualizing the spatial density of data.

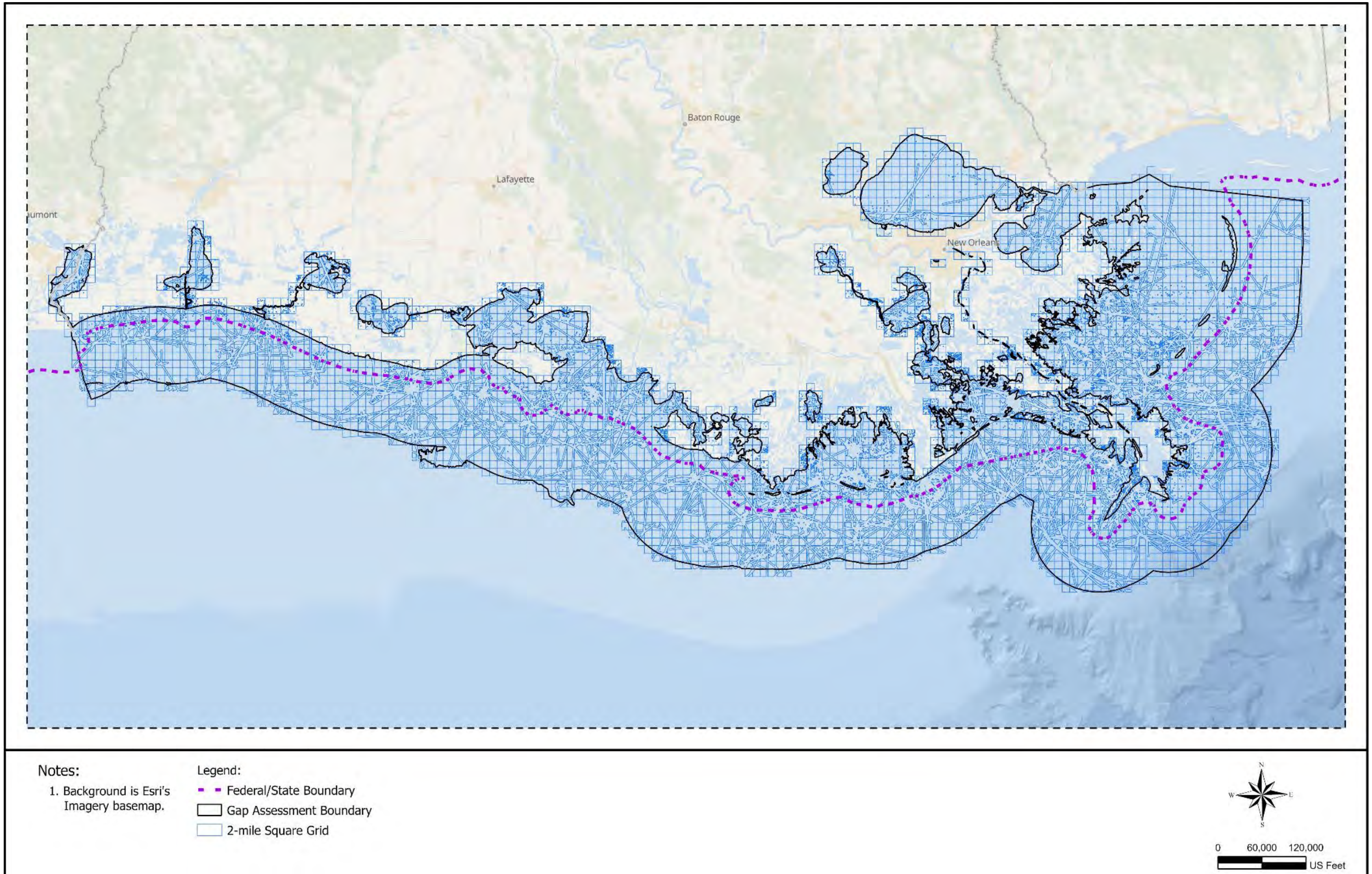

Figure 22. Grid developed for pilot study gap assessment of sediment sample data.

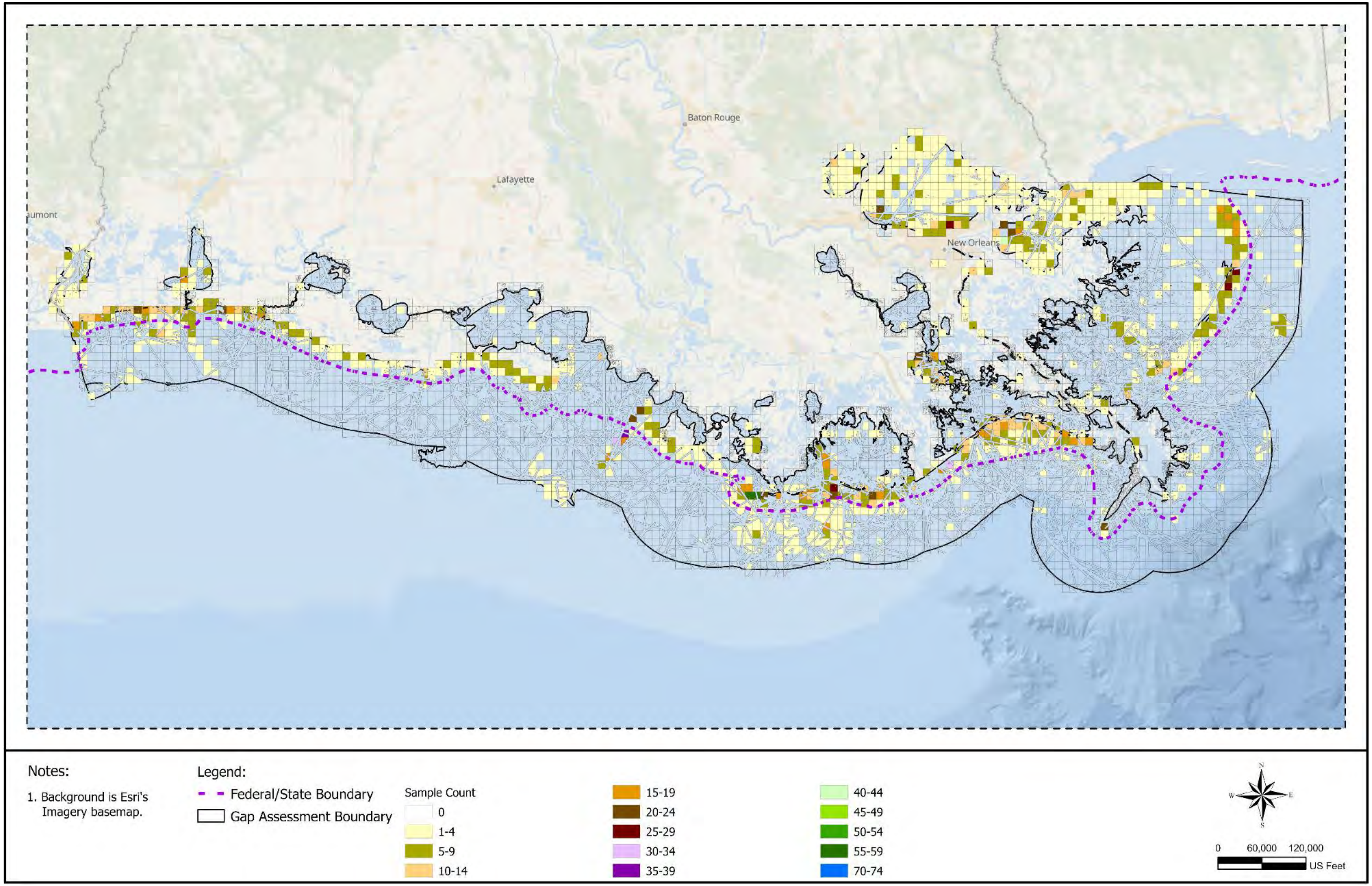

Figure 23. Spatial evaluation of grab samples.

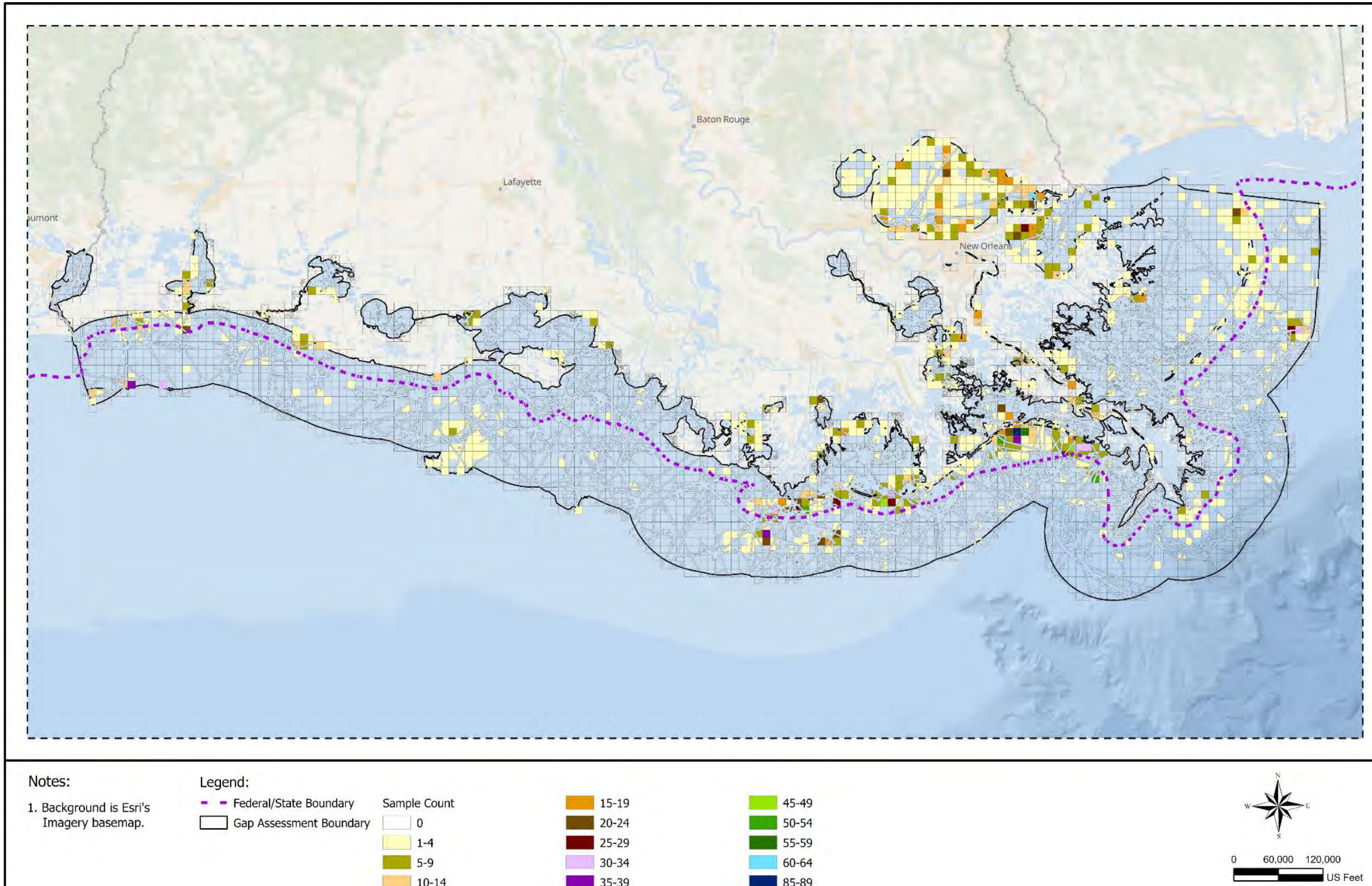

Figure 24. Spatial evaluation of core borings.

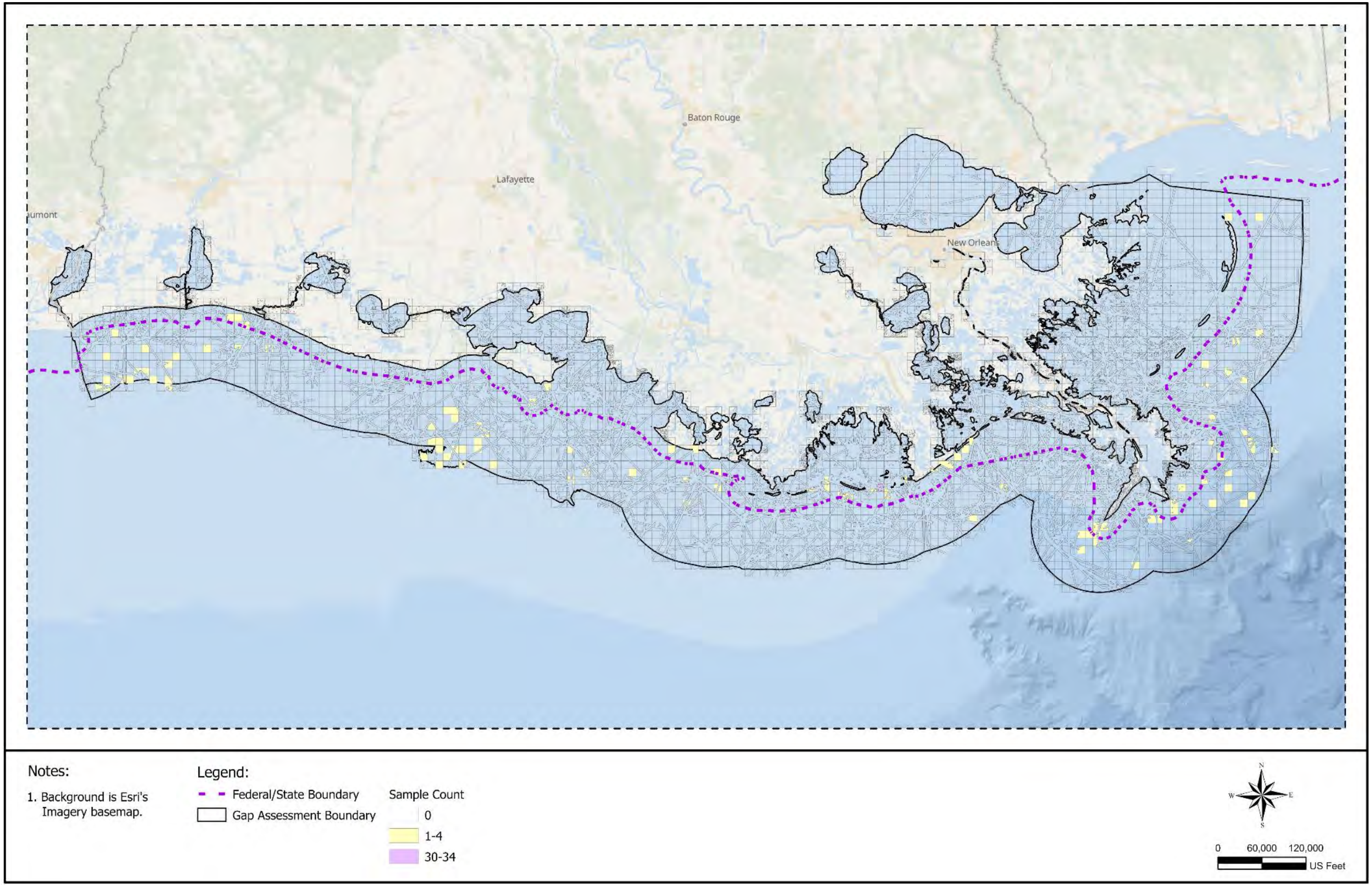

Figure 25. Spatial evaluation of unknown samples.

4.2 Informational Gap Evaluation

Based on CMAP, informational gaps were assessed according to essential elements which may be lacking in each dataset. Current LASARD formatting standards require specific attributes to be provided when submitting sediment sample data to CPRA. The most important of these attributes were identified. The core borings and grab samples were then evaluated based on whether or not they had sufficient attribution, sufficient metadata and whether they had data associated with them (e.g., boring logs, grain size data, photographs etc). Nine "Data Elements" (DEs) that indicate the level of quality of the data were identified and include the following:

1. Does metadata exist?
2. Is there a "Point of Contact"?
3. Does metadata document collection and/or analysis procedures?
4. Are the data accessible (web or sent upon request)?
5. Are the data in a machine readable or usable format?
6. In the attribute table, is "Fines Thickness (ft)" filled out?
7. In the attribute table, is "Mixed Sediment Thickness (ft)" filled out?
8. In the attribute table, is "Sand Thickness (ft)" filled out?
9. In the attribute table, is "Grab Sample Percentage (%) of Sand" filled out?

Eight of the questions above apply to core borings (questions 1-8), 6 apply to grab samples (questions 1-5, 9) and all apply to unknown sample types (questions 1-9). Using these criteria, informational gaps were assessed for each sediment sample record. A standardized value was calculated for each sample within each grid cell which indicates the percent of DE's that were answered in the affirmative. Each question has a "Yes" (1 point) or "No" (0 points) answer. Based on this, each sample was assigned a value between 0 and 100%. The values for the samples within each block were averaged to assign each block a value between 0 and 100% (Figures 26, 27 and 28).

4.3 Temporal Evaluation

As previously stated, the coast is a dynamic environment. Grab samples are only relevant for a small window of time before the sediment on the seafloor are redistributed and the nature of the surficial sediment changes. The core boring and grab sample data that were compiled were categorized based on collection date, color coded and visually assessed in the same way the geophysical, hydrographic, cultural resource and deposit/borrow area data were assessed (Figures 29, 30 and 31).

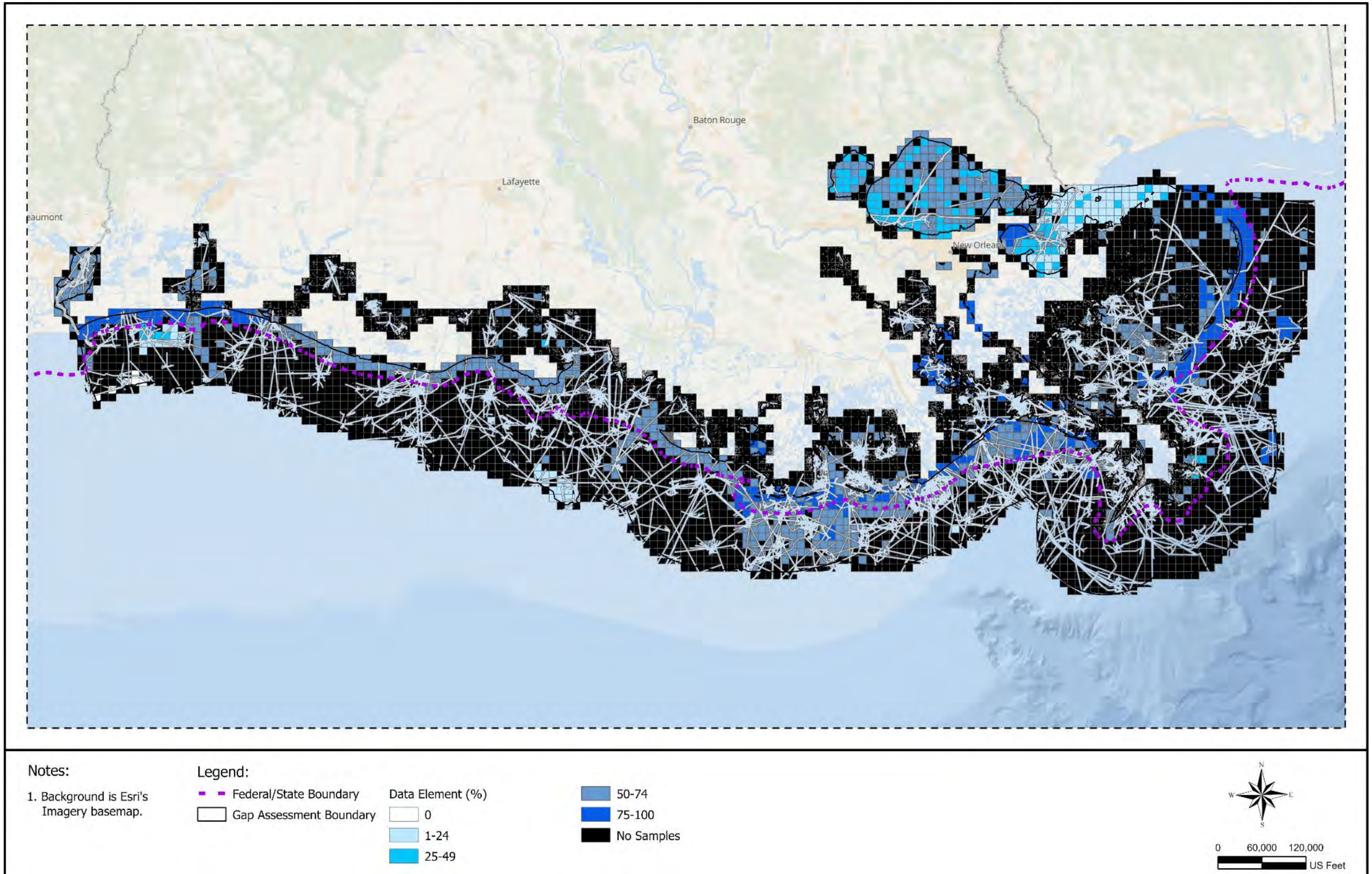

Figure 26. Informational gap assessment of grab samples.

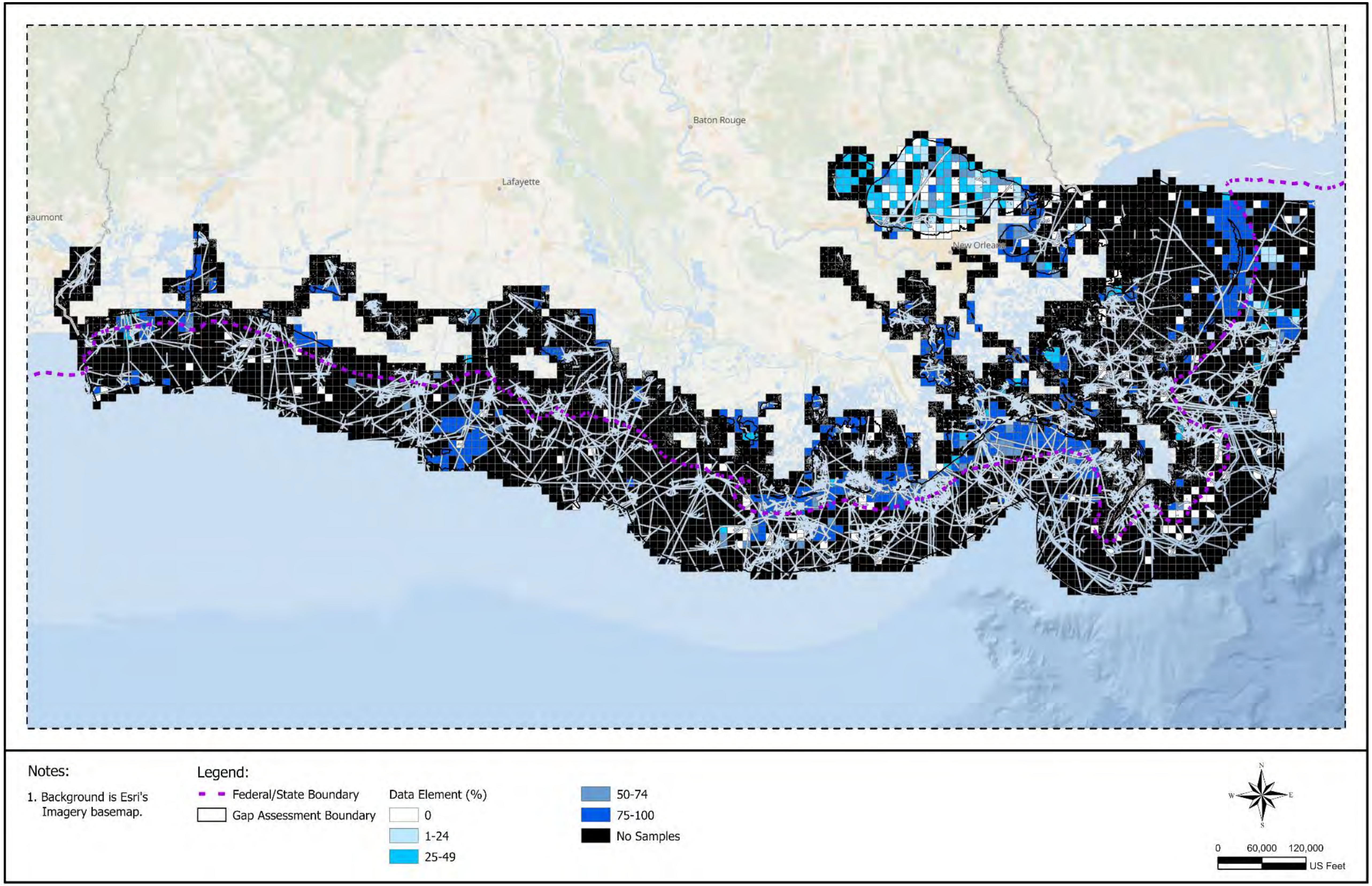

Figure 27. Informational gap assessment of core borings.

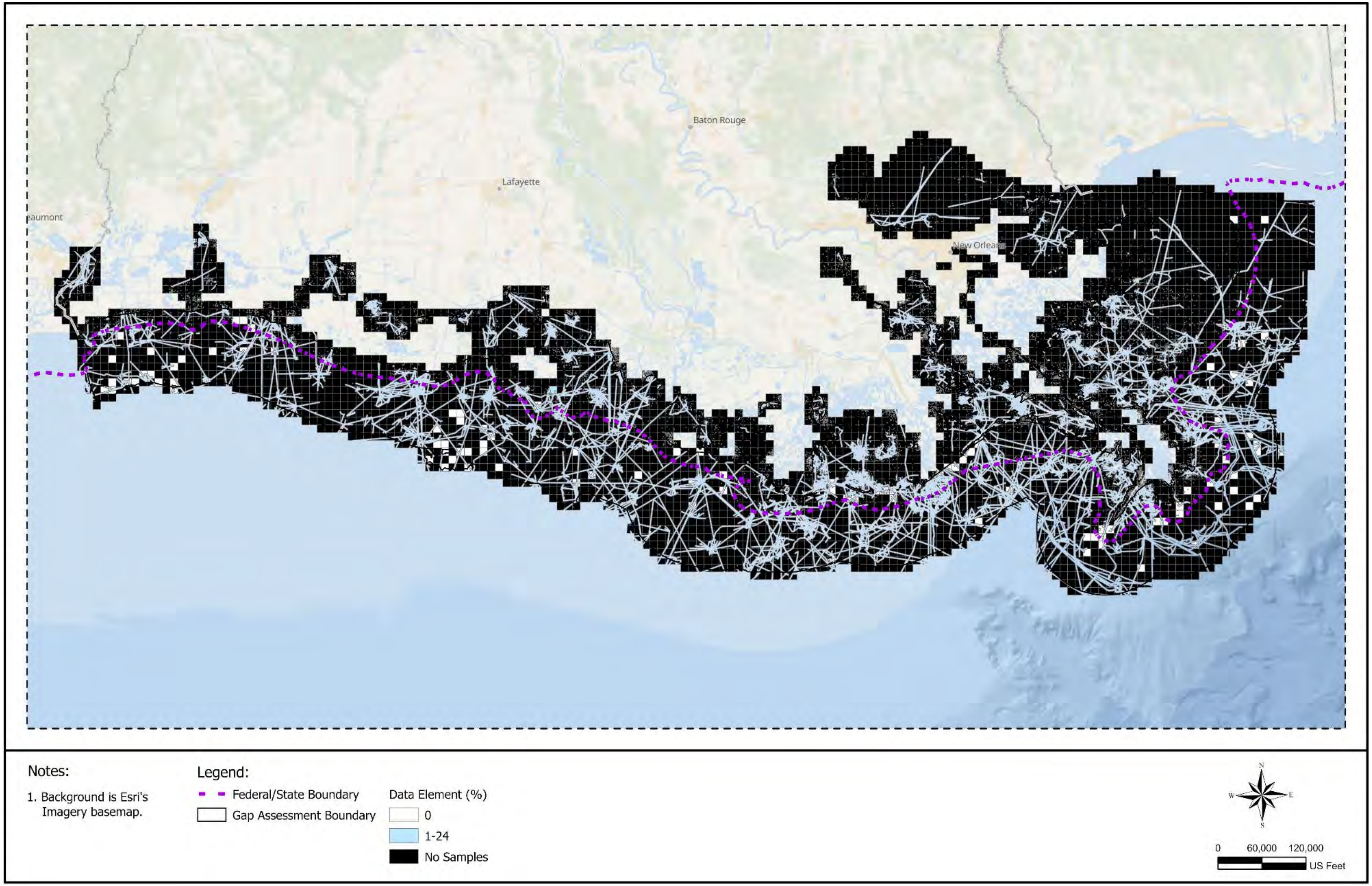

Figure 28. Informational gap assessment of unknown samples.

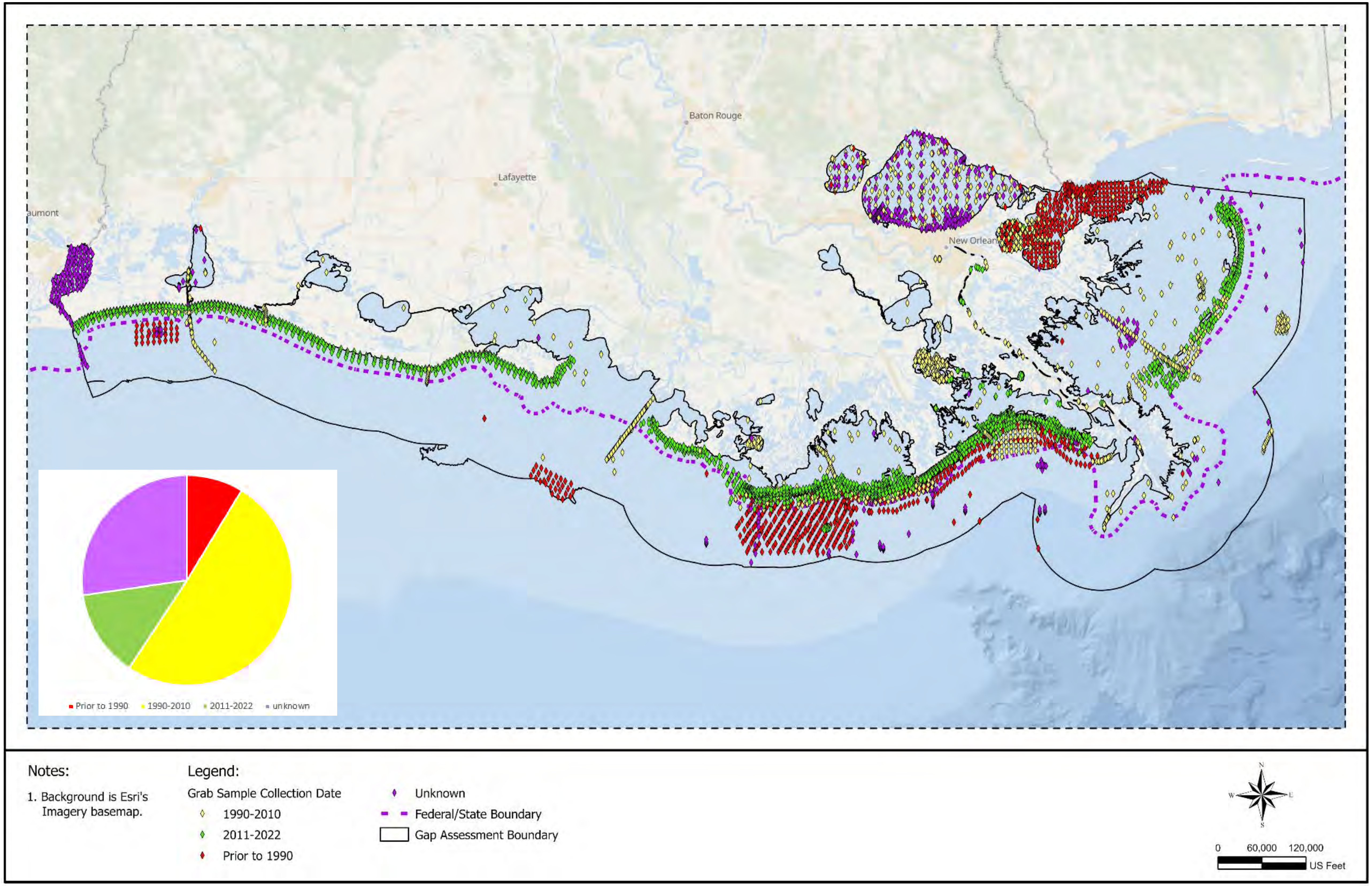

Figure 29. Temporal gap assessment of grab samples. Inset shows the temporal distribution of grab samples.

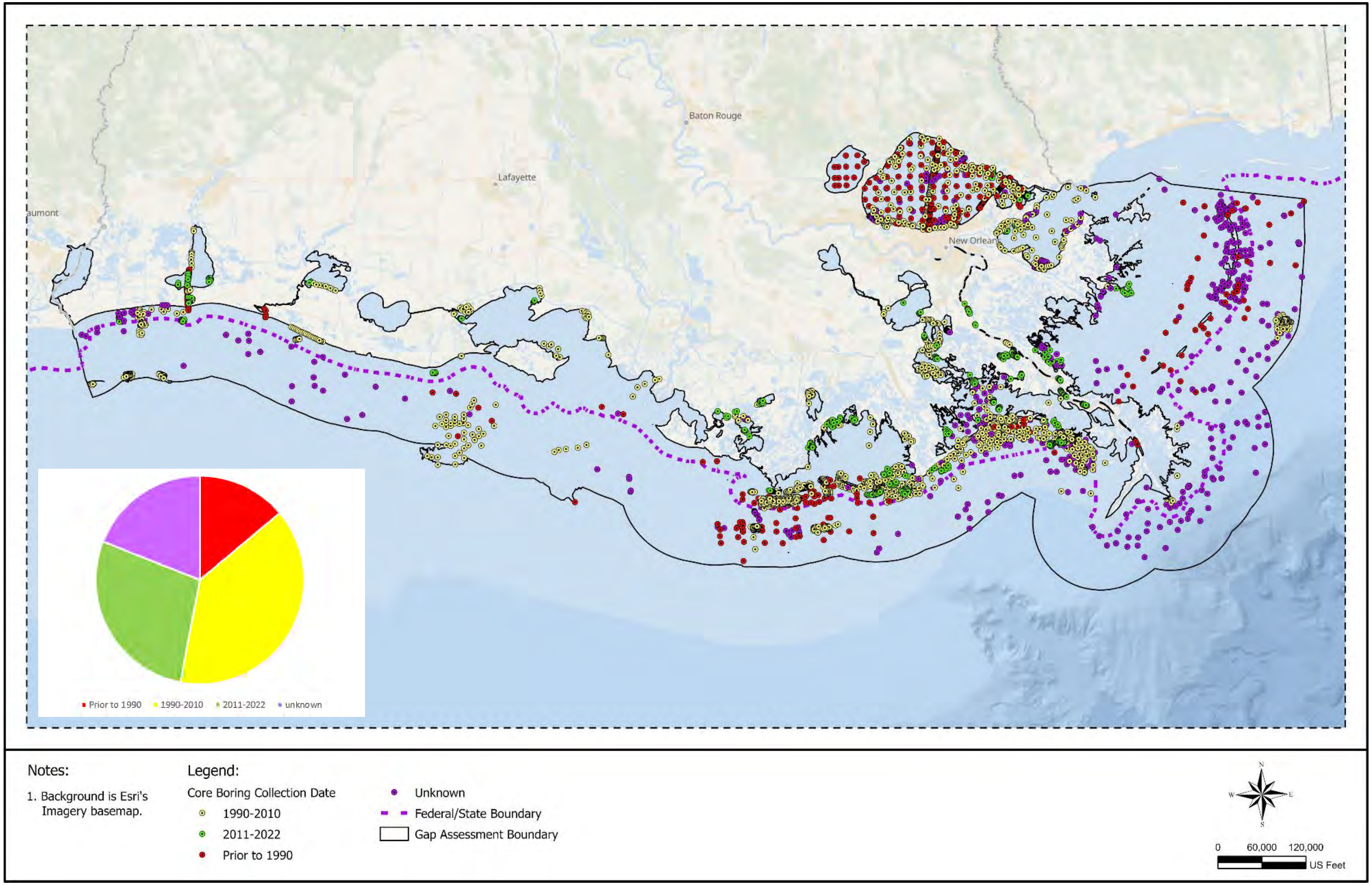

Figure 30. Temporal gap assessment of core borings. Inset shows the temporal distribution of core borings.

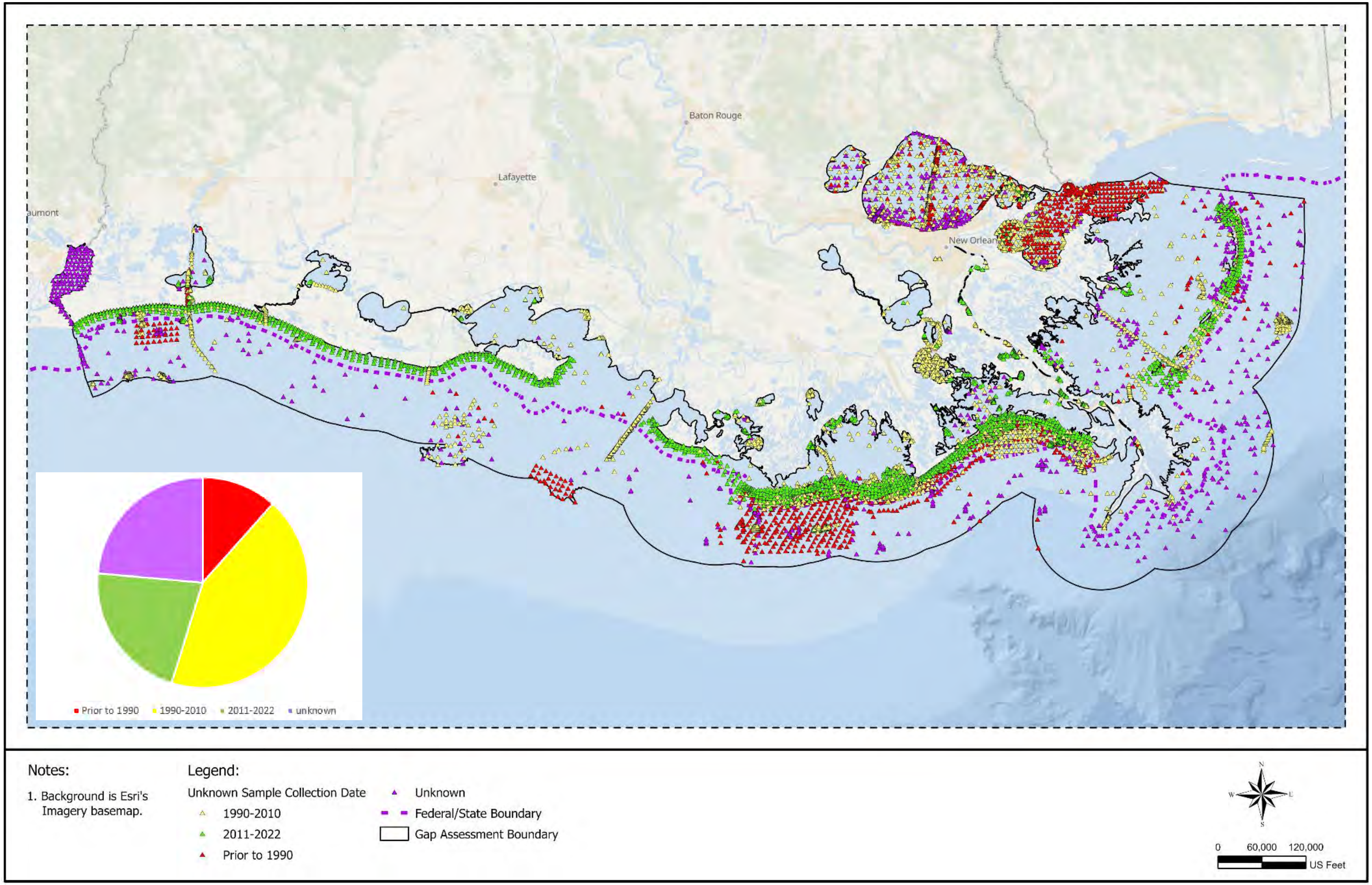

Figure 31. Temporal gap assessment of unknown samples. Inset shows the temporal distribution of unknown samples.

5.0 Identification of Data Gaps

Based on the spatial, temporal and attribution reviews of the data compiled from LASARD, MMIS and other sources, several data gaps were identified. The highest priority gaps were identified based on their location relative to the following features:

- **Trinity/Sabine Paleovalley:** The Trinity River paleovalley is an offshore stratigraphic structure located on the inner continental shelf of the Gulf of Mexico offshore Galveston, Texas (Thomas and Anderson, 1994). Its formation is linked to the paleo-Trinity system as it existed across the continental shelf during the last glacial period.
- **MMIS modeled shoals feature class ("Modeled Shoals"):** The modeled shoals feature class in MMIS is a collection of sediment resource features that were modeled by NOAA for the Shoal Map Assessment Tool for EFH (ShoalMATE). Information relating to the process used for modeling can be found in Pickens et al. (2019).
- **SSD Maps:** the SSD Maps developed from data from LASARD (APTIM, 2022). These maps are updated on an annual basis. The highest priority resources based on the needs of the State of Louisiana are Surficial and Potential sand and mixed sediment.
- **MMIS Surficial sediment feature class:** The Sediment Component feature class contains polygons representing areas of differing seabed lithology, or sediment grain size that are classified according to the dominant grain size using the Coastal and Marine Ecological Classification Standard (CMECS) classification. The data in this layer were collected as part of multiple research projects focused on the OCS, which were fully or partially funded by BOEM. The intent is to build upon the dataset as new reports and data become available. Data from pre-existing reports will be added to the dataset as time permits. Attribution consists of original sediment descriptions, the classification method (e.g., Folk, Shepard, Wentworth), CMECS version of the classification, and identification properties associated with each study.

These identified areas may potentially contain sediment (sand or mixed sediment) that could be used in future restoration efforts. The State can use this information to develop a plan to target areas based on future restoration project needs. It should also be noted that when funds permit, additional sampling should be done in the areas delineated as "unknown" in the SSD Maps.

5.1 Sedimentological Data

Grab sample coverage in state waters is generally good along the coast from the Texas/Louisiana border, east to Marsh Island. Coverage is also good between Point Au Fer Island and Pelican Island. Coverage is also good in Lake Pontchartrain, the western lobe of Lake Borgne and in the vicinity of the Chandeleur Islands. A very systematic approach to grab sediment sampling was undertaken by the BICM Program. The program was established in 2006. The first phase was completed in 2012. Phase II started in 2015 and was completed in 2020. Many of the grab samples identified in this assessment were collected under the BICM program. Under this program, grab samples were collected in 2008 and then repeat samples were taken again in 2015/2016. With the exception of samples collected on Sabine Bank, Ship Shoal, Tiger and Trinity

Shoals and St. Bernard Shoals, grab sample coverage is sparse in federal waters. Grab sample spacing typically ranges from approximately 90 ft in Lake Borgne to over 11,000 ft. on Ship Shoal. As previously discussed, all grab samples were color coded by age (prior to 1990, 1990-2010, 2011-2022 and unknown) based on sample collection date. Because of the uncertainty of basing a review on age alone, data quality, in terms of the available supporting data (e.g., grain size information etc.) was also taken into consideration. Grab samples that had no data associated with them were considered poor quality and color coded white (Figure 26). Because of the uncertainties associated with an age-based assessment, only data quality was considered when evaluating where additional samples should be collected. Grab sample ages need to be considered on a case-by-case basis. The most obvious data gaps are in West Cote Blanche Bay, Vermilion Bay, Timbalier/Terrebonne Bay, the Mississippi River Delta, Breton Sound, Chandeleur Sound and all Federal waters.

The coverage of core borings is similar to the grab samples. Coverage is good in Lake Pontchartrain, the western lobe of Lake Borgne and in the vicinity of the Chandeleur Islands. Coverage is also good around the barrier islands rimming Timbalier/Terrebonne Bay and Barataria Bay. Coverage is sparse in state waters between the Texas/Louisiana border and West Belle Pass in the East. With the exception of core borings collected on Ship Shoal, Tiger and Trinity Shoals and Sabine Bank, coverage is sparse in federal waters. The majority of the cores are over 10 years old or are lacking data (e.g., sieve data, core logs etc.). As with the grab samples, to provide a regional overview of the surficial sediment distribution, reconnaissance level (widely spaced) sampling is recommended in state waters from Calcasieu Lake east to West Belle Pass (including West Cote Blanche Bay and Vermilion Bay), Timbalier/Terrebonne Bay, Breton Sound, Chandeleur Sound and Lake Borgne.

5.2 Geophysical and Hydrographic Data

5.2.1 Sub-bottom Data

Sub-bottom survey tracklines were evaluated to determine where additional reconnaissance level geophysical surveys should be conducted. Because sub-bottom data can be useful regardless of age, data older than 10 years were included in the evaluation. However, it should be noted that the biggest issue impacting sub-bottom accuracy is positioning. For example, if the data from the 1990s and the positioning is based off Long Range Navigation (LORAN) or something older, the data positioning quality decreases. The bulk of the sub-bottom data have been collected in West Cote Blanche Bay, Vermilion Bay, Atchafalaya Bay, Terrebonne/Timbalier Bay, Barataria Bay (and the inland lakes to the north), Lake Pontchartrain and Lake Borgne. Sub-bottom data are sparse in Breton Sound and Chandeleur Sound as well as around the mouth of the Mississippi River. Data are also sparse in state waters between Sabine Lake and Marsh Island.

5.2.2 Sidescan Sonar Data

Although LASARD contains information about sidescan sonar contacts, the tracklines along which the contact information was collected may not be available. The opposite is true as well, there may be tracklines but no associated sidescan sonar data. For this reason, sidescan sonar tracklines alone may not be a good indicator of the presence or absence of data gaps. To address this, sidescan sonar contacts and survey tracklines were evaluated together to determine where additional reconnaissance level surveys should be conducted. The bulk of the sidescan sonar data have been collected in West Cote Blanche Bay, Vermilion Bay, Atchafalaya Bay, Terrebonne/Timbalier Bay, Barataria Bay (and the inland lakes to the north), and Lake Borgne. Sidescan sonar data are sparse in Breton Sound, Lake Pontchartrain, Chandeleur Sound and in state waters between Sabine Lake and Marsh Island.

5.2.3 Magnetometer Data

As previously noted, although LASARD contains information about magnetic anomalies, the tracklines associated with these data may not be included in LASARD. Similarly, tracklines may be available in LASARD, MMIS and NCEI but there may not be any associated magnetic data. For this reason, geophysical tracklines alone may not be a good indicator of the presence or absence of spatial data gaps. Therefore, magnetic anomalies and survey tracklines were combined and evaluated together to assess data gaps. Because the age of a magnetometer survey is not critical, data older than 10 years were included in the evaluation. As with the sub-bottom data, it should be noted that biggest issue impacting accuracy is positioning.

The majority of magnetometer data have been collected in Sabine and Calcasieu Lakes, West and East Cote Blanche Bays, Vermilion Bay, Atchafalaya Bay, Timbalier/Terrebonne Bay, Barataria Bay (including the inland lakes to the north), Lake Borgne and the western portion of Chandeleur Sound. Surveys have also been conducted on the Tiger and Trinity Shoals and portions of Ship Shoal. With the exception of Sabine Lake east to Marsh Island, Breton Sound, Lake Pontchartrain and the eastern portion of Chandeleur Sound, data coverage in state waters is good. Coverage in federal waters is not as good. In federal waters data collection was focused on Tiger/Trinity Shoal, Ship Shoal and St. Bernard Shoal.

5.2.4 Bathymetric/Topographic Data

Figure 14 shows the distribution of bathymetric survey tracklines from LASARD, the NCEI database and BOEM's MMIS. The seafloor and its surficial sediments are constantly shifting. For this reason, bathymetry is time sensitive. Areas covered by surveys older than 10 years are recommended for additional data collection, in addition to areas where bathymetric data are sparse or lacking.

The majority of bathymetric data have been collected in Sabine and Calcasieu Lakes, West and East Cote Blanche Bays, Vermilion Bay, Atchafalaya Bay, Timbalier/Terrebonne Bay, Barataria Bay (including the inland lakes to the north), Lake Borgne and the western portion of Chandeleur Sound. Surveys have also been conducted on the Tiger and Trinity Shoals and Ship Shoal. With the exception of Sabine Lake east to Marsh Island coverage in state waters is good. Coverage in federal waters is not as good. In federal waters data collection was focused on Tiger/Trinity Shoal and Ship Shoal.

5.3 Cultural Resources

Between the data currently in LASARD and the additional data available through various websites and the Environmental Systems Research Institute (Esri) REST services, there are adequate cultural resource data. It is important to note that any restoration project utilizing a borrow area will likely be required to conduct a full cultural resource investigation to obtain cultural resource clearance, regardless of existing data. The results of these cultural resource surveys should be added to LASARD where data are publicly available and there are no confidentiality issues.

5.4 Deposits/Borrow Areas

Pleistocene glaciation repeatedly lowered global sea level. This resulted in the creation of incised valleys on the exposed shelf. Fluvial sediment infilling these paleovalleys may provide potential sources of sand for coastal restoration projects. There are numerous paleovalleys and paleochannels offshore Louisiana that may have the potential to contain sand or mixed sediment. Several studies have undertaken the mapping of paleovalleys on the continental shelf. However, most of these studies have focused on western Louisiana.

Between 1982 and 1986, the Louisiana Geological Survey (LGS) conducted a nearshore sand resource inventory in support of barrier island restoration and beach nourishment (Suter et al, 1991). Over 4,660 miles of sub-bottom profiles and 152 vibracores were collected. The data were used to define 55 nearshore sand resources between Sabine Lake and Sandy Point (Figure 32). The estimated volumes of these deposits ranged from 2.6 million CY to 2.1 billion CY. As part of this work, distributary channel patterns were mapped along the Plaquemines Delta shoreline using the sub-bottom profiles (Figure 32).

Milliken et al. (2008) mapped the Holocene-Pleistocene exposure surface that defines the incised Sabine-Neches river paleovalley. Her mapping extended into western Louisiana as shown in Figure 32 and included the Trinity/Sabine Paleovalley.

The submerged paleodrainage system of the early Balize Delta complex that extended onto the inner continental shelf at 1500 years before present (YBP) has not been completely studied in great detail. Mester (2011) interprets the environmental deltaic facies of the Balize Delta, in the Sandy Point region offshore the southeastern Louisiana coast from 75 miles of sub-bottom data and 48 vibracores. The stratigraphic and environmental units established in this study provide a geological framework for this area. Overlying Holocene deposits interpreted to be muds of prodelta and lower delta front origin were interpreted as having been deposited from the retreating delta atop a transgressive surface, indicated by the top lapping seismic reflectors and the ravinement surface. The deltaic facies below the ravinement surface are of regressive origin, an inner shelf delta with widespread delta front sheet sands from a dense group of many distributaries.

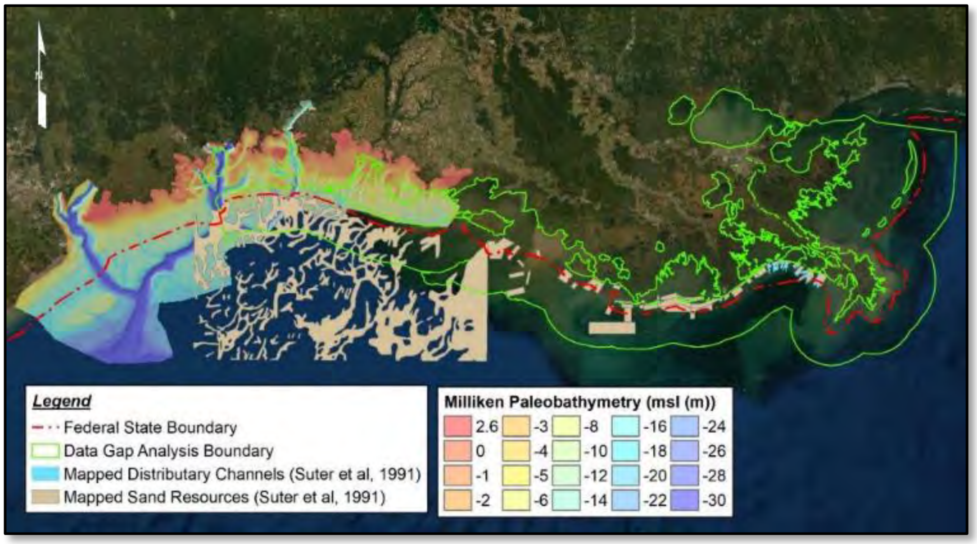

Figure 32. Mapped sand resources, distributary channels and paleobathymetry.

In 2013/2014, Paulsell et al. (2014) undertook a project mapping late Quaternary paleovalleys in southwest Louisiana. Figure 33 shows their study area and a couple of examples of their mapping results.

It would be beneficial to conduct a detailed sub-bottom and vibracore survey to map the paleovalleys offshore coastal Louisiana as these may provide an unexplored sediment resource for restoration projects. These potential sand deposits and paleochannels should be sampled (core borings and grab samples) to assess their potential for containing sand or mixed sediment.

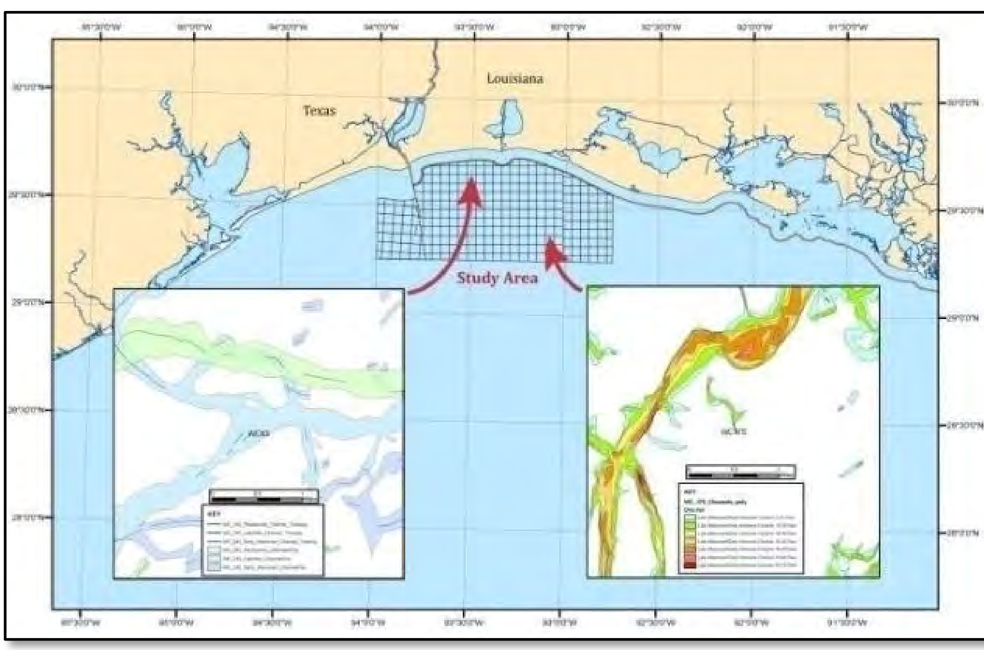

Figure 33. Distributary channels mapped by Paulsell et al, 2014.

6.0 Geospatial Analysis of Potential Sediment Sources

LASMP was developed to help manage sediment resources and is a comprehensive sediment management plan which identifies and inventories all proven and potential sediment resources and is being implemented by usage of various sediment management tools. These tools help proactively identify and minimize conflicting uses for sediment, such that more sediment is made available efficiently and cost-effectively, through proper management (Khalil and Freeman, 2014). The SSD Maps for offshore coastal Louisiana and the Lower Mississippi River are one of the tools LASMP uses to manage sediment resources. SSD Maps were compiled using geoscientific data residing in LASARD. The initial SSD Maps were compiled in 2011 to assist in planning coastal restoration projects for the 2012 CMP. The maps are regularly updated when additional LASARD data are available. The SSD Maps have been updated recently to help in development of the 2023 CMP. The goal of the mapping was to identify the existing and potential sediment deposits that could be further investigated for future borrow area development (CPRA, 2017).

To create the SSD Maps, existing core log and sedimentological data (mostly grain size) were reviewed, classified, and color-coded according to sediment type. Using the same classification system and color-coding scheme, sub-bottom data were also reviewed, classified, and color-coded. The classified and color-coded data were displayed in ArcGIS, and clusters of sample/sub-bottom data with the same classification were identified and preliminary boundaries drawn around each cluster. If data classified as the same type were spaced less than 1 mile apart, the cluster was designated as a sediment deposit of that type. If data classified, as the same type, were spaced more than 1 mile apart, the cluster was designated as a "potential" sediment deposit of that type because of the decreased level of confidence. Based on sediment type, the deposits were classified as surficial or potential surficial sand (predominantly sand (70-100%) with <30% silt/clay), surficial or potential surficial mixed sediment (mixture of 30-70% sand with the remaining fraction made up of fines (silt/clay)), and surficial or potential surficial fines (comprised predominantly of fines (silt/clay) with <30% sand). Areas where no data were available were labeled as "unknown". Detailed explanations of the mapping methodology can be found in APTIM (2022).

A geospatial gap assessment was performed on the existing surficial sediment distribution map to identify areas where additional data would help refine potential sediment resources that could be used for future nourishment projects. As shown in Figure 34, a large portion of coastal Louisiana is classified as "Unknown". This is because there was not sufficient data in these areas to map them. A large number of the delineated deposits are classified as "Potential" for the same reason. Although data were available, they were sparse or too widely spaced to map with a high level of confidence. Additional sub-bottom and sediment sample data should be collected in the areas shown in dark blue ("Unknown") and in deposits delineated as potential sand/mixed sediment and inferred sand/mixed sediment in Figure 34 to refine the mapping in these areas where the data coverage is poor or completely lacking.

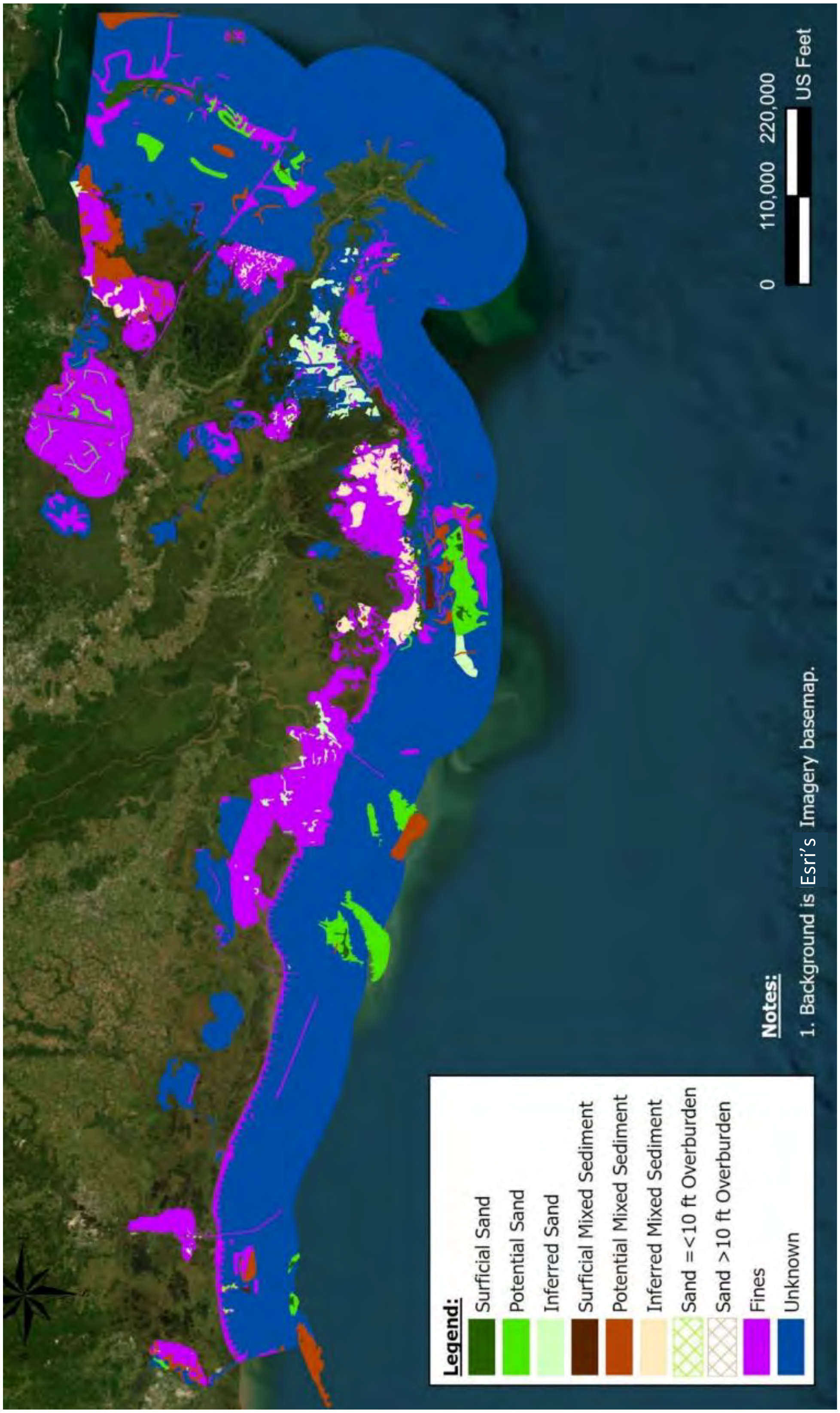

Figure 34. Offshore Louisiana sediment distribution map (APTIM, 2022).

7.0 Recommendations

Based on this gap assessment, we recommend that regional level (reconnaissance) geophysical and geotechnical data collection efforts be undertaken in the areas identified as data gaps. These additional data will help identify potential sediment resources that could be used for future restoration projects and help the state further its sediment management efforts. We recommend that priority should be placed on those areas that fall within potential sand resources (e.g., paleovalleys, modeled shoals, areas identified by MMIS), followed by areas mapped as potential or inferred sediment resources followed by those that fall within areas mapped as unknown. These areas may be re-prioritized by CPRA based on their needs and priorities. The following are recommendations for future data collection activities to fill in spatial and temporal gaps in the existing data:

- The most prominent grab sample data gaps are in West Cote Blanche Bay, Vermilion Bay, Timbalier/Terrebonne Bay, the Mississippi River Delta, Breton Sound, Chandeleur Sound and all Federal waters.

- With the exception of core borings collected on Ship Shoal, Tiger and Trinity Shoals and Sabine Bank, coverage is sparse in federal waters. The largest data gaps are in state waters from Calcasieu Lake east to West Belle Pass (including West Cote Blanche Bay and Vermilion Bay), Timbalier/Terrebonne Bay, Breton Sound, Chandeleur Sound and Lake Borgne.

- It is important to note that since grab samples only represent the uppermost few inches of sediment, their usefulness in delineating potential sediment deposits is limited. The collection of additional core borings should take priority over the collection of additional grab samples.

- Sub-bottom data are sparse in Breton Sound and Chandeleur Sound as well as around the mouth of the Mississippi River. Data are also sparse in state waters between Sabine Lake and Marsh Island. However, data efforts are currently being undertaken to collect sub-bottom data between Sabine Lake and Calcasieu Lake.

- Sidescan sonar data are sparse in Breton Sound, Lake Pontchartrain, Chandeleur Sound and in state waters between Sabine Lake and Marsh Island.

- Magnetometer coverage and bathymetric coverage in federal waters is not as good as in state waters. In federal waters data collection was focused on Tiger/Trinity Shoal, Ship Shoal and St. Bernard Shoal. Future data collection efforts should be focused on the areas in state waters between Sabine Lake and Marsh Island, the mouth of the Mississippi River, Breton Sound, Chandeleur Sound and Lake Pontchartrain. The collection of magnetic data should be considered low priority because regardless of whether data exist or not, additional magnetic data collection will likely be required as part of any sediment search investigation.

- Between the data currently in LASARD and the additional data available through various websites and Esri REST services, there are adequate cultural resource data. It is important to note that any restoration project utilizing a borrow area will likely be required to conduct a full cultural resource investigation to obtain cultural resource clearance, regardless of existing data.

- Generally, additional data collection is recommended within the Trinity/Sabine Paleovalley to better characterize the sediment infilling the paleovalley and determine if it would be suitable for restoration use. Sampling is also recommended on several of the "Modeled Shoals" as well as areas identified by MMIS as potential sand.

- New sediment sample and sub-bottom data would help refine the current SSD Map and fill in some of the areas that are not currently mapped or are mapped with a low confidence (potential/inferred deposits). This in turn would provide additional useful data for the LASAAP tool and would also help facilitate consistency reviews (for decommissioned pipeline removal as well as for pipeline placement). Future data collection efforts should be prioritized to focus on the areas that are labelled as potential sediment resources (with potential sand and mixed sediment as the highest priorities) and inferred sediment resources (with inferred sand and mixed sediment as the highest priorities). Additional sub-bottom and sediment sample data should also be collected in the areas classified as "unknown" in the SSD Map to refine the mapping in these areas where the data coverage is poor or completely lacking. With additional data, some of these areas may be mapped with more confidence and could be reclassified as surficial deposits.

- The most efficient way to collect data to fill in the gaps would be through a regional/reconnaissance level investigation. The first step should be to obtain and reprocess additional historic sub-bottom data to identify potential sediment resources that have not been previously identified. This first step should also include a detailed gap assessment. Based on this, additional reconnaissance level sub-bottom data and bathymetric data are recommended. Reconnaissance level vibracores should then be collected to ground-truth the newly collected geophysical data. A regional approach to the data collection will help build the dataset that CPRA needs and will facilitate a refinement of the existing surficial sediment distribution maps.

- Although we recommend collecting sub-bottom and bathymetric data, there is added value in conducting a full geophysical survey rather than just collecting bathymetric and sub-bottom data. If a full survey (bathymetric, sub-bottom, sidescan sonar and magnetometer) is conducted, all data types can be conducted together under the same mobilization. This results in a cost savings.

- Although general recommendations have been made in this report, the priority will be driven by the state and current/future project needs.

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