Texas General Land Office Lower Coast Outer Continental Shelf, Central and Upper Outer Continental Shelf Data Gap Areas Offshore Sand Source Survey

November 2025

U.S. Department of the Interior
Bureau of Ocean Energy Management
Headquarters, Sterling, VA

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List of Abbreviations and Acronyms

%	percent
~	approximately
AEZ	Acoustic Exclusion Zone
AGC	Automatic Gain Control
APTIM	Aptim Environmental and Infrastructure, LLC
APTIM-CPE	APTIM (formerly known as Coastal Planning & Engineering, Inc.)
BOEM	Bureau of Ocean Energy Management
CEPRA	Coastal Erosion Planning and Response Act
CORS	National Geodetic Survey Continually Operating Reference Stations
EGN	Empirical Gain Normalization
ft	feet (foot)
GLO	General Land Office
GNSS	Global Navigation Satellite System
HRG	High Resolution Geophysical
Hz	hertz
kHz	kilohertz
km	kilometer
m	meter
m/ms	meter per millisecond
MCY	million cubic yards
mm/yr.	millimeter per year
MFS	maximum flooding surface
MIS	Marine Isotope Stage
MMIS	Marine Minerals Information System
MMP	Marine Minerals Program
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
nT	nanotesla
OCS	Outer Continental Shelf
P-P	Peak to Peak
PAM	Passive Acoustic Monitoring
PPK	Post-Processing Kinematic
PSO	Protected Species Observer
Q1	Quaternary 1
QMA	Qualified Marine Archaeologist
SVP	Sound Velocity Profiler
TBC	Trimble Business Center
TVG	Time-Varying Gain
TWI	The Water Institute
UGC	User-Defined Gain Control

Executive Summary

Through a grant awarded by the Bureau of Ocean Energy Management (BOEM), the Texas General Land Office (GLO) contracted Aptim Environmental and Infrastructure, LLC (APTIM), with The Water Institute (TWI) as a team member, to conduct geophysical surveys to assist the GLO and BOEM with identifying and delineating sediment resources along the Texas Lower Coast Outer Continental Shelf (OCS) as well as additional areas in the Upper and Central OCS. The APTIM team conducted an extensive review of existing geophysical and geotechnical data to ensure no duplication of data occurred. Marine hazard and resource data were also acquired and compiled, reviewed, and incorporated to further develop the geophysical survey plan. APTIM reviewed the existing data to assess seafloor depth, seafloor hazards, base of overburden, top of sand, base of sand, channels/paleochannels, and ravinement surfaces. Based on this evaluation, the APTIM team developed a survey plan that made the most efficient use of existing data while avoiding the collection of duplicate data.

An initial survey plan was developed consisting of 1,790 nautical miles (nm) (3,315 kilometers [km]) of full suite geophysical and single-beam bathymetry data. The plan included three investigation areas spanning from Sabine Bank to the U.S.-Mexico border. These three investigation areas are split between Lower OCS (offshore GLO Region 4), and data gap areas within the Central OCS (offshore GLO Regions 2 and 3) and Upper OCS (offshore GLO Region 1). Data collection efforts along the Lower OCS Investigation Area consisted of acquiring chirp sub-bottom, sidescan sonar, magnetometer, and single-beam fathometer in a 3.5 x 3.5 nm (6.5 x 6.5 km) grid pattern with additional lines down-spacing the grid over specific identified features. Geophysical data acquisition efforts within the Central and Upper OCS Data Gap Investigation Area consisted of the same instrumentation and were intended to expand previously acquired datasets or fill in data gaps in order to augment the understanding of the geology of the region, as well as identify and connect identified resources. Within the Central OCS Data Gap Investigation Area, survey tracklines had variable spacing, with shore parallel lines ranging between 1.5 nm (2.7 km) and 2.3 nm (4.2 km) and shore perpendicular lines ranging between 3.5 nm (6.5 km) and 17.6 nm (32.6 km) in order to expand the findings of the 2022 Central Coast OCS investigation (APTIM and TWI 2024a). Along the Upper OCS Data Gap Investigation Area, APTIM collected geophysical data in a 3 x 6 nm (5.5 x 11 km) grid in order to connect the 2021 GLO Region 1 investigation (APTIM and TWI 2021) to the 2022 Sabine, Heald, and adjacent banks OCS investigation (APTIM and TWI 2022). Between February 8 and March 16, 2024, APTIM collected a total of 1,843.9 nm (3,414.9 km) of full suite geophysical (sub-bottom, sidescan sonar, magnetometer, and single beam bathymetry) data along the Texas Lower, Central, and Upper OCS offshore the GLO Regions 1, 2, 3, and 4 (Area Code PS, PN, MU, MI, BA, GA, and HI) within the delineated investigations in support of the GLO Sediment Management Plan Surveys of the Federal OCS. At the time of this report, no new geological data has been collected.

Interpretation of the reconnaissance geophysical survey were used to identify major regional stratigraphic features located within the Lower OCS, Central and Upper OCS Data Gap regions to correlate to results from previous and concurrent state waters investigation, as well as develop a regional geologic framework of major depositional systems that have the potential to contain accessible sand resources. An additional seven large-scale regional geologic features are likely to contain sand resources out of the sixteen features identified in the Lower OCS and Central OCS and Upper Data Gap Investigation Areas.

This investigation expanded the Texas Mud Blanket delineation, a regional feature found in GLO Region 2 and 3 and the Central Coast OCS, extending to Region 4 and the Lower OCS. This feature has been extensively researched in prior studies (see Weight et al. 2011). Its seismic character includes draping, horizontally laminated, to slightly wavy, laterally continuous reflectors of varying amplitudes. The reflector sets downlap seaward and onlap landward. The unit thickens seaward and to the southwest, up to

100 feet (30.48 meters) thick. This muddy, to sandy mud unit does not represent a potential sand resource but understanding its distribution was critical to identifying the limiting overburden that may constrain the utility of any underlying potential sand-bearing sediment resources.

In addition to the large regional units, smaller, isolated features were also identified during data processing. These localized features are observed throughout the OCS, and many are potentially sand-bearing deposits but are not observed on adjacent geophysical lines, making characterization and quantification of potential sand resources impossible at this resolution. These smaller features are normally isolated channels or sediment pockets, which are indicative of sand or mixed sediments.

The features identified in this investigation are not exhaustive or inclusive of all potential sand-bearing stratigraphy within the region, but rather represent systems that are sufficiently regionally extensive and contiguous to be confidently interpreted across the reconnaissance spaced survey grid. The major geologic systems observed represent a cumulative gross volume of ~9.2 billion cubic yards (~7 billion cubic meters) of sand and mixed sediments. The precise composition of these deposits is likely highly variable and requires more detailed geological investigation. Some of these large, depositional systems have never been previously observed and help to constrain areas of fluvial-deltaic activity of the Texas coastal rivers and reorganization by coastal processes throughout the Pleistocene and Holocene.

1 Introduction

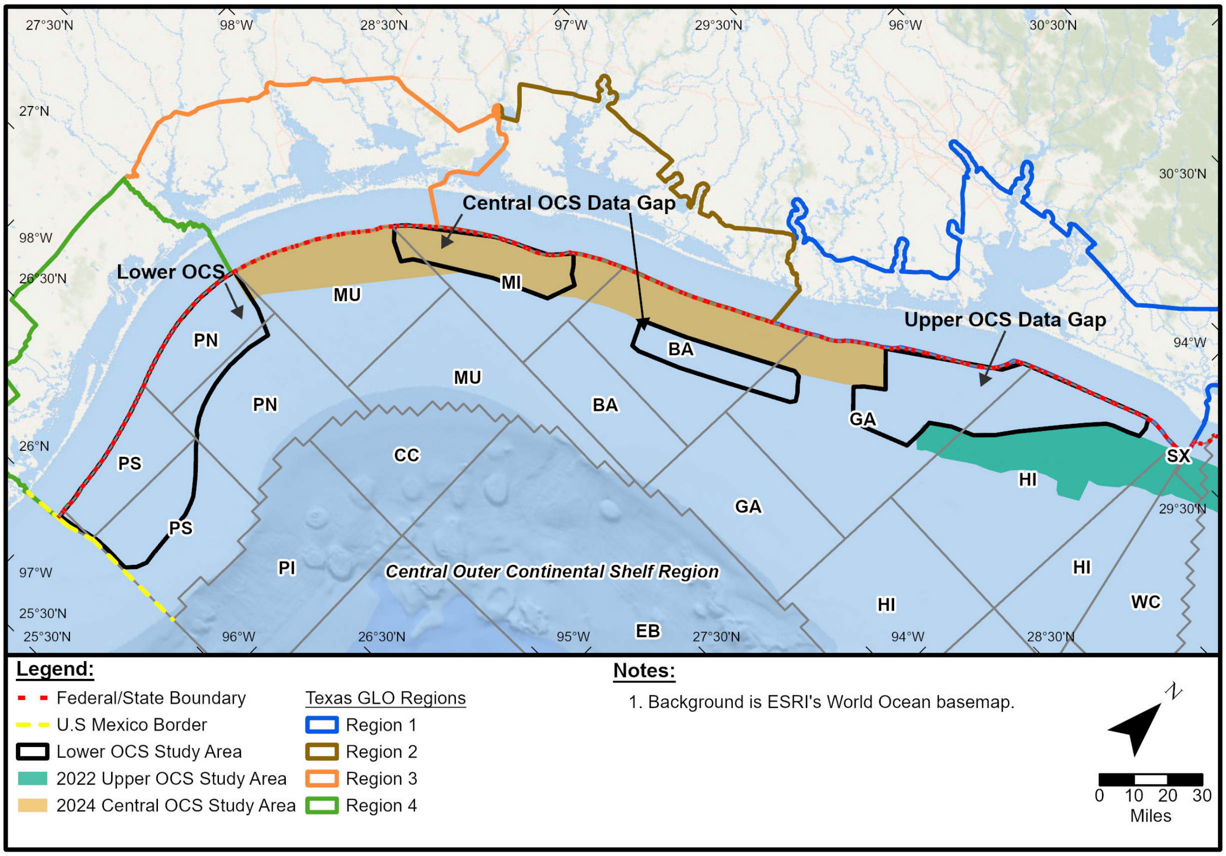
The Texas General Land Office (GLO) and the Bureau of Ocean Energy Management (BOEM) contracted Aptim Environmental & Infrastructure, LLC (APTIM) with team member The Water Institute (TWI) to conduct geophysical surveys to assist the GLO and BOEM with identifying and delineating sediment resources along the Texas Lower Coast Outer Continental Shelf (OCS) as well as additional data gap areas in the Upper and Central OCS (Figure 1). This work will contribute to the development of policies and inventories for coastal restoration, maintaining ports and navigation channels (dredging), determining appropriate sediment disposal sites, and determining the location of sediment deposits for restoration efforts to mitigate beach erosion caused by storms and currents. A secondary goal of the project was to provide the GLO with a dataset that correlated recent state-side geophysical data (collected December 11, 2023, through February 2, 2024; the location of surveys collected in GLO Region 4 is shown in Figure 1) with OCS data for a more comprehensive understanding and mapping of geologic features in the area.

To efficiently coordinate this investigation, the GLO, BOEM, APTIM, and TWI developed a two-phase project approach. The first phase consisted of a desktop study, submitted in June 2024, followed by a second phase which consisted of reconnaissance-level geophysical data collection (chirp sub-bottom, sidescan sonar, magnetometer, and single-beam fathometer), data processing, and interpretation to delineate potential sand deposits along the Lower OCS as well as additional data gap areas in the Upper and Central OCS that were not covered during previous APTIM investigations.

The Task 1 desktop study consisted of historical data compilation followed by a review of the data to provide a comprehensive understanding of existing data coverage and geological framework research. APTIM compiled bathymetric and sub-bottom data, as well as geotechnical information (vibracores and grab samples when available) and scientific reports to help in the identification of potential sand resources, which resulted in the development of a survey plan. Information on the compiled data, resources used, and data types used in Task 1 that supported the survey plan are described in Section 2. After the desktop study was completed, APTIM began work on the Task 2 geophysical survey data collection and processing activities for this project.

Between February 8 and March 16, 2024, APTIM collected a total of 1,843.9 nautical miles (nm) (3,414.9 kilometers [km]) of geophysical data in federal waters in the South Padre Island, North Padre Island, Mustang Island, Brazos, Galveston, and High Island areas (Area Code PS, PN, MU, MI, BA, GA, and HI) offshore Cameron, Willacy, Kenedy, Kleberg, Nueces, Aransas, Calhoun, Matagorda, Brazoria, Galveston, Chambers, and Jefferson counties. Upon completion of the geophysical data collection, APTIM began processing and interpreting the data. Sidescan sonar and magnetometer data were reviewed for any potential hazards, areas of avoidance, and to characterize the composition of the seafloor. A review of the reconnaissance-level geophysical survey data by APTIM's qualified marine archaeologist (QMA) did not result in any recommendations for new archaeological avoidance buffers. The seismic sub-bottom data were used to delineate any shoals and channel deposits within the investigation area and estimate a potential gross volume of sediments that could be available for coastal restoration efforts. Moreover, the seismic data were reviewed for any features/structures that refine the overall geologic framework from what was previously synthesized during the desktop study portion of the investigation.

Figure 1: Overview of Lower OCS and Upper and Central OCS Data Gap Investigation Areas.



2 Task 1 Historic Data Review/Survey Plan Development

The Task 1 desktop study involved compiling existing datasets, reviewing their relevance to the GLO Sediment Management Plan objectives, identifying prominent data coverage gaps, and synthesizing geologic framework research through a targeted literature review to identify potential sand resources for investigation. As part of this effort, APTIM compiled bathymetric and sub-bottom data as well as geotechnical information (vibracores and grab samples) and analyzed previously delineated sediment deposits from various academic research, public state and federal databases, and prior sand search investigations (see the Desktop study report for more details: *Lower Coast OCS offshore sand source survey: Historic data review and survey plan development;* 2024a) These data were correlated with scientific reports to aid in the identification of potential sand resources and construct preliminary hypotheses of resource occurrence within the Lower OCS Investigation Area. Task 1 resulted in the development of a roughly 3.5 x 3.5 nm (6.5 x 6.5 km) survey grid, totaling 800 nm (1481.6 km) of geophysical data collection, with an additional 5% of base mileage (88 nm; 163 km) allocated in the field down-spacing the survey grid. Along the Central OCS Data Gap Investigation Area, APTIM, TWI, the GLO, and BOEM reviewed the geophysical data collected by APTIM and TWI in 2020 and 2022 (2021; 2024b; 2024c) and identified specific areas where additional data collection would improve understanding of the geologic framework and help constrain potential sand resources. Based on existing datasets, three areas were selected for the collection of 353 nm (653.8 km) of data to further delineate previously identified features such as channel systems and other potential sand deposits. Within the Upper OCS Data Gap Investigation Area, a data gap existed between the Region 1 Investigation Area (2021) and the Sand Banks OCS Investigation Area (2021), and as a result, 549 nm (1,014.9 km) of geophysical data were collected to fill in this gap area, which allowed for a better understanding and integration of the two datasets. Information on the compiled data, resources, and data types used for Task 1 that support the survey plan are described below.

2.1 Geologic Approach to Sediment Resource Prospecting

Within Task 1, the APTIM team developed an initial geologic framework to aid in the accurate identification and quantification of potential sediment resources, as well as the prediction of further occurrence. Coastal systems and continental shelves may have very localized processes and geologic history, but a region-specific synthesis of this evolution allows for high grading of the most promising areas and the potential processes responsible for deposition and preservation of sediment resources. In turn, this allows for economically efficient targeted data collection and science-based assessment of geotechnical properties of identified geologic resource deposits. This investigation employed a source-to-sink approach to develop a geologic model that predicts sand resource occurrence and quantifies sand resource estimates at a reconnaissance scale to inform future detailed exploration. In simple terms, the source-to-sink approach considers the Texas coastal system and associated continental shelf holistically throughout its evolution with a focus on coarse-grained sediment delivery to the coast from upland fluvial sources via the fluvial channel belts and potential subsequent reworking and concentration of sands by coastal processes. This source-to-sink approach involves creation of a regional framework geology based on an understanding of the processes and drivers of sediment erosion, transport, and deposition in the fluvial to marine transition zone over various timescales. In this way, areas of sediment production (e.g., fluvial inputs, erosional sources, etc.) are linked to sediment transfer or dispersal corridors (fluvial channel belts, deltaic distributary channels, tidal channels, and shorelines) and ultimately locations of restoration-quality sediment deposition and preservation (Figure 2). Key to the regional geologic models built here is the incorporation of foundational, depositional, and erosional processes associated with specific landforms and environments; how they interact over time, and what the overall pattern of resulting sedimentary deposits are likely to be. Fluvial systems that built the Texas shelf consist of vastly different drainage basins, climates, and therefore sediment delivery to the coast as sea level positions changed throughout geologic time. Importantly, the approach employed here allows for prediction of potential deposit occurrence (e.g., where sandy deposits are located on the shelf) with constraints to their potential geotechnical variability and relation to surrounding subsurface stratigraphy (Figure 3). An accurate understanding of the relative history and formational processes of each specific region is required to explain the patterns of occurrence for sand resource deposits.

Figure 2: General illustration of source-to-sink concepts. The Texas Coastal Plain is located within the transfer and deposition domains.

Note: Synoptic views of rivers and delta systems emphasize the predictability of changes in sedimentary processes and potential deposits as a function of location along the axis of the total system. Key to recognition and effective use of sediment resources is placing observed sediments within a broader process context that aids in the prediction of deposit size, continuity, geotechnical properties, and compatibility with restoration projects. From Hajek and Straub (2017).

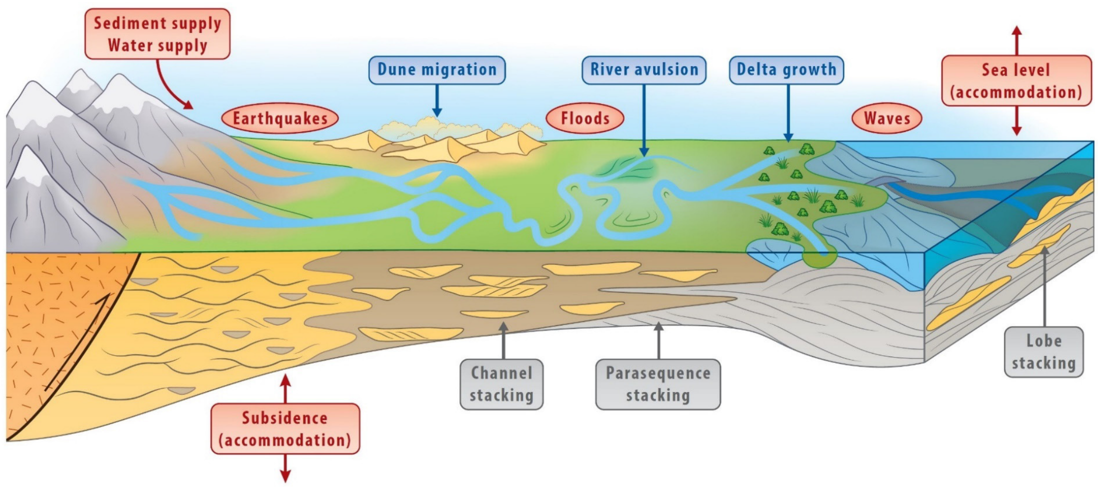
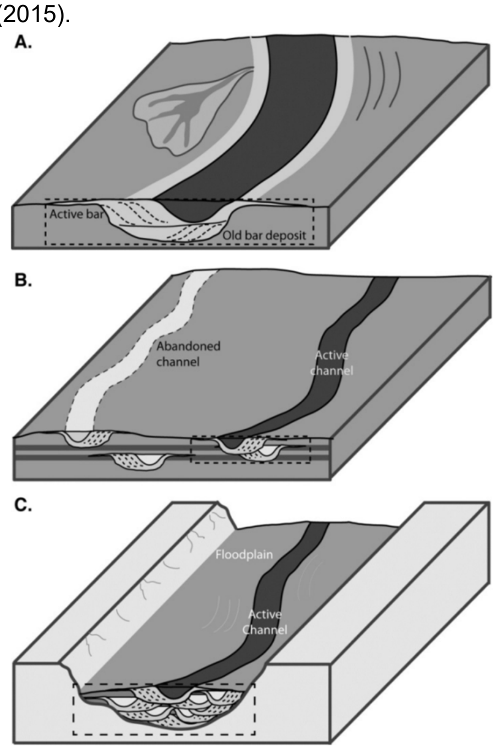


Figure 3: Conceptual block diagrams of the hierarchy and relationship of sand-rich deposits formed by an ancient river relative to the surrounding floodplain.

Note: A) Lateral migration of a meandering river creates complex stratigraphy but potentially high net to gross sand deposits. B) Avulsive river systems can create discrete sand-rich channel belts within a larger mud-dominated floodplain system, requiring dense data coverage to accurately quantify position and volumes of restoration-quality sediment. C) River erosion can lead to formation of an incised valley, which constrains the lateral extent of an ancient river. From Chamberlin and Hajek (2015).



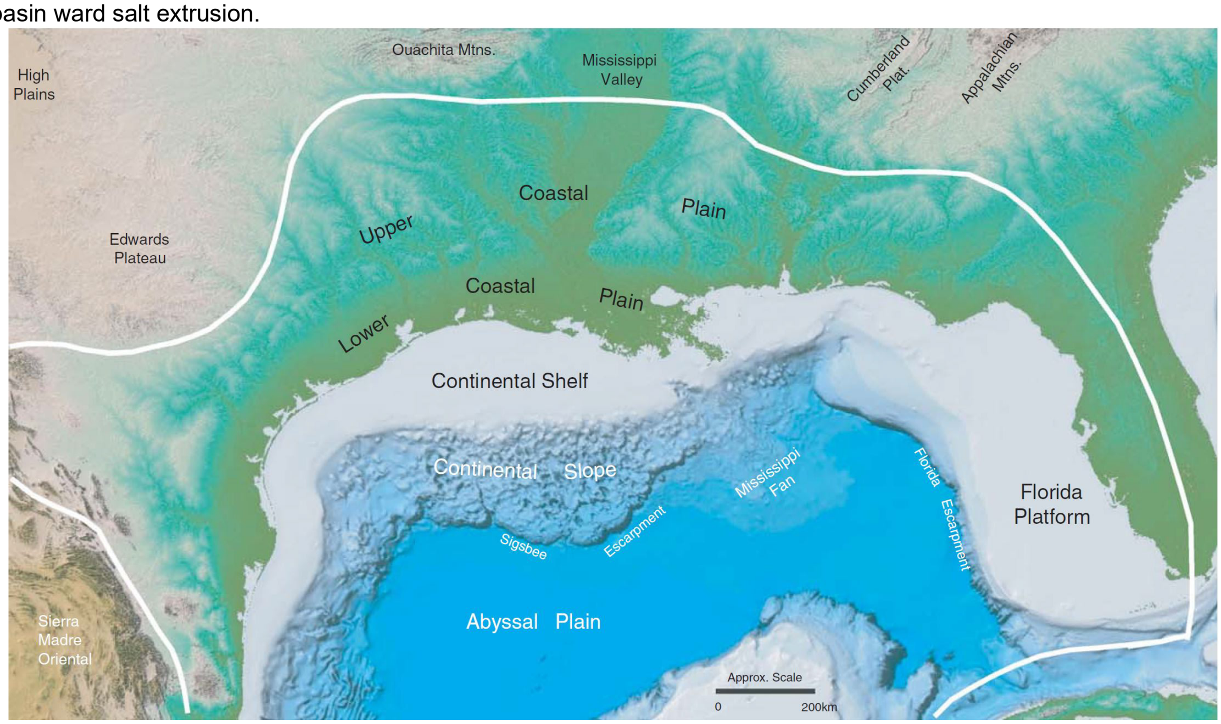
2.2 Sediment Resource Relevant Geologic History of the Gulf of America

The following sections provide a description of the formation of the Gulf of America Basin, the coastal plain of Central and Southern Texas, and the development of the Rio Grande River. This geologic context is required for understanding the origin, evolution, and specific properties of observed deposits that make up the current continental shelf in order to identify promising sediment resources in the Lower OCS.

2.2.1 Gulf Basin Evolution and Early Gulf of America Formation

The Gulf of America Basin is the product of crustal extension, rifting, and seafloor spreading during the breakup of the supercontinent Pangea as the North American Plate separated from the South American and African Plates (Salvador 1991; Buffler et al. 1994; Galloway 2008). The basin is filled with up to 9.5-mi thick (15.3-km thick) sedimentary deposits that range from Jurassic to recent ages with some older Triassic sedimentary rocks preserved locally in graben structures associated with Triassic rifting (Salvador 1991). Extension continued through early Jurassic when flooding of the basin from the Pacific Ocean and subsequent evaporation of sea water resulted in deposition of thick evaporite deposits, primarily the Jurassic Louann Salt (Burke 1975; Galloway 2008). Widespread salt deposition in this period has greatly influenced subsequent surface morphology, brittle deformation, development of shelf stratigraphic sequences, and hydrocarbon production (Galloway 2008). Subsequent to salt deposition, a later phase of seafloor spreading continued opening the basin to develop basaltic oceanic crust that underlies much of the deepwater Gulf of America (Nguyen and Mann 2016). Early Cretaceous carbonate reefs and platforms rimmed the basin and defined its modern extent; however, by the late Cretaceous the area of the North American continent draining into the Gulf increased as did associated terrigenous deposition, inhibiting further carbonate development. This continental scale drainage reorganization led to burial of carbonates by thick clastic (sandstones and mudstones) deposits that persisted from late Cretaceous through Quaternary time producing the broad continental shelf and slope of the northern Gulf (Figure 4).

Figure 4: Gulf basin physiology from Galloway (2008).
Note the broad continental shelf and Sigsbee Escarpment along the base of the continental slope that is the result of basin ward salt extrusion.



Loading of the Louann Salt resulted in extrusion of salt vertically upward through overlying Jurassic through Cenozoic sections in the form of salt diapirs and tongues, as well as laterally basin ward to form sheets that extrude to the surface as observed along the Sigsbee Escarpment (Figure 4 and Figure 5) (Weimer and Buffler 1992; Diegel et al. 1995). This deforming basal deposit greatly influenced Cenozoic structural evolution of the Gulf as younger, protruding deposits forced salt motion and attendant brittle deformation of the overlying strata (halo tectonics) that is characterized by development of uplift in areas where salts are migrating vertically or laterally and subsidence over areas of salt withdrawal (Diegel et al. 1995). This process of creating accommodation space for sediment deposition over evacuating salts facilitates a feedback loop where sediment loading forces extrusion and continued subsidence facilitates further loading and extrusion. Surficial expression of salt domes and associated deformation along the coast and on the inner continental shelf of the Western Gulf are not commonly observed or documented, with the majority of the modern shelf dominated by the Oligo-Miocene detachment province (Diegel et al. 1995). The morphology of the continental shelf and upper slope offshore of South Texas reflects deposition by the Rio Grande system that has buried underlying salt and shale diapir structures with minimal surface deformation compared to the broader western Gulf slope (Figure 6) (Swartz 2019). The location of the Rio Grande river and delta complex is also located roughly with the transition from the Corsair Fault Zone and northern Miocene minibasin province to the Burgos Basin south of the US-Mexico border (Vasquez-Garcia 2018).

Figure 5: Generalized dip-oriented stratigraphic cross-section for the Northern Gulf Basin.
Note the basin ward dipping Jurassic to Pleistocene deposits and influence of salt diapirs. From Galloway (2008).

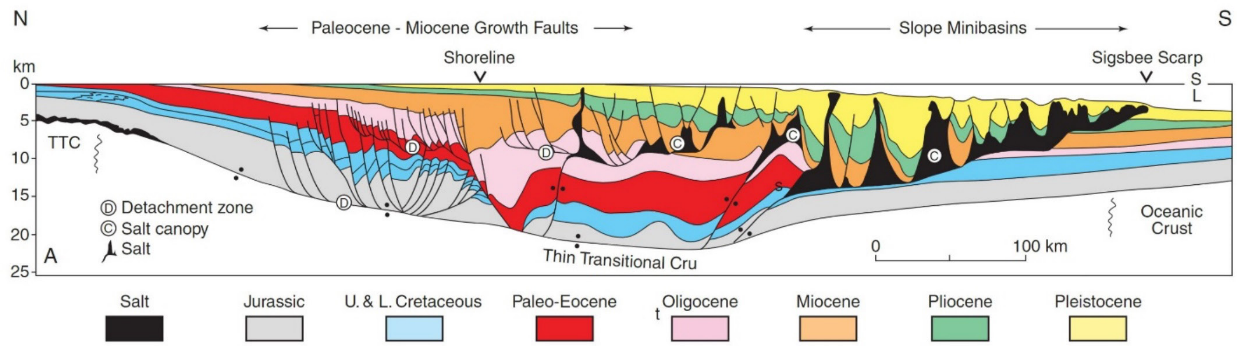
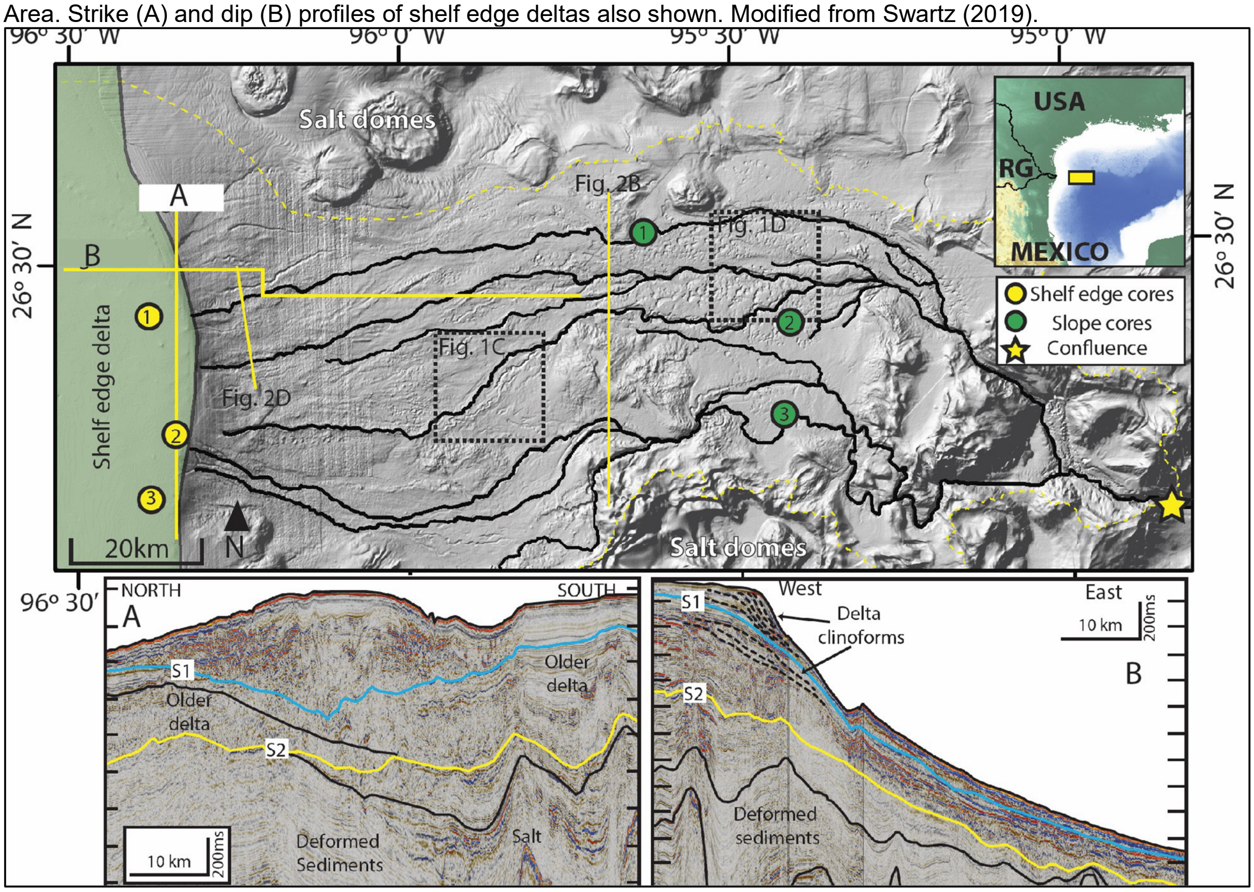


Figure 6: Bathymetric map and multi-channel seismic cross sections from the continental slope offshore the Lower OCS

Note: The continental slope is dominated and built by a submarine fan sourced from the ancient Rio Grande River feeding shelf edge delta systems, with high sedimentation rates that buried and suppressed diapirs and associated surface deformation. Construction of such fans requires sustained transport of coarse-grained material across the continental shelf and predicts the occurrence of significant fluvial and deltaic deposits in the Lower OCS Investigation Area. Strike (A) and dip (B) profiles of shelf edge deltas also shown. Modified from Swartz (2019).



2.2.2 Quaternary Geology

The Quaternary coastal plain of Texas and the offshore inner continental shelf consists of fluvial deposits and coastal deposits associated with sea-level fluctuations and basin subsidence. Stratigraphically, this has resulted in a series of unconformity-bounded, seaward dipping clastic wedges that are Pliocene to Late Pleistocene in age and produce coast-parallel terraces due to variations in erosional resistance (Fisher et al. 1972; Fisher et al. 1973; Brown et al. 1976; Young et al. 2012; Heinrich et al. 2020). Each of these wedge units is characterized by terrestrial deposits that grade basinward into coastal and shallow marine deposits (Figure 7). Of interest to this discussion is the most recent Pleistocene unit, the Beaumont Formation that comprises a complex of Pleistocene depositional units. While initially built for East Texas, the generalized structure is broadly similar to the Central and Lower Texas coastal plain geology as well (Young et al. 2012). Primary differences for the Lower Texas coastal plain are the dominance of the Rio Grande Delta system, colloquially referred to as the Rio Grande Valley (Swartz et al. 2022). The surface of the Beaumont Formation is often characterized by oxidized sands and stiff clays (paleo-soil horizons) due to subaerial exposure during the most recent sea-level lowstand. In most areas of the lower coastal plain, the Beaumont Formation forms the land surface where Holocene coastal and alluvial deposits are absent. Detailed discussion of the Quaternary geology of the Texas coastal plain can be found in Young et al. (2012) and the *Environmental Geologic Atlas of the Texas Coastal Zone* map series produced by the

Texas Bureau of Economic Geology (Fisher et al. 1972; Fisher et al. 1973; McGowen et al. 1976). Figure 8 illustrates the investigation area location and Quaternary geologic features of interest.

Figure 7: Idealized dip cross section for the Upper Texas Coastal Plain from Young et al. (2012).

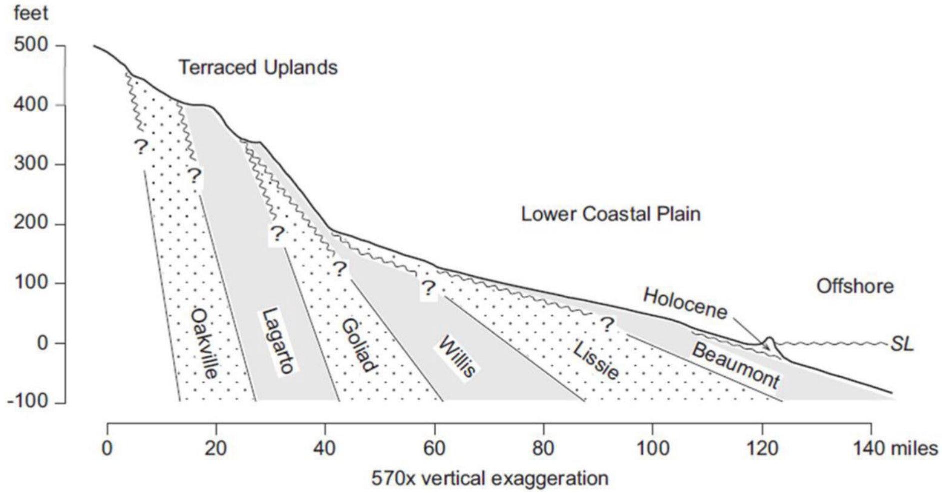
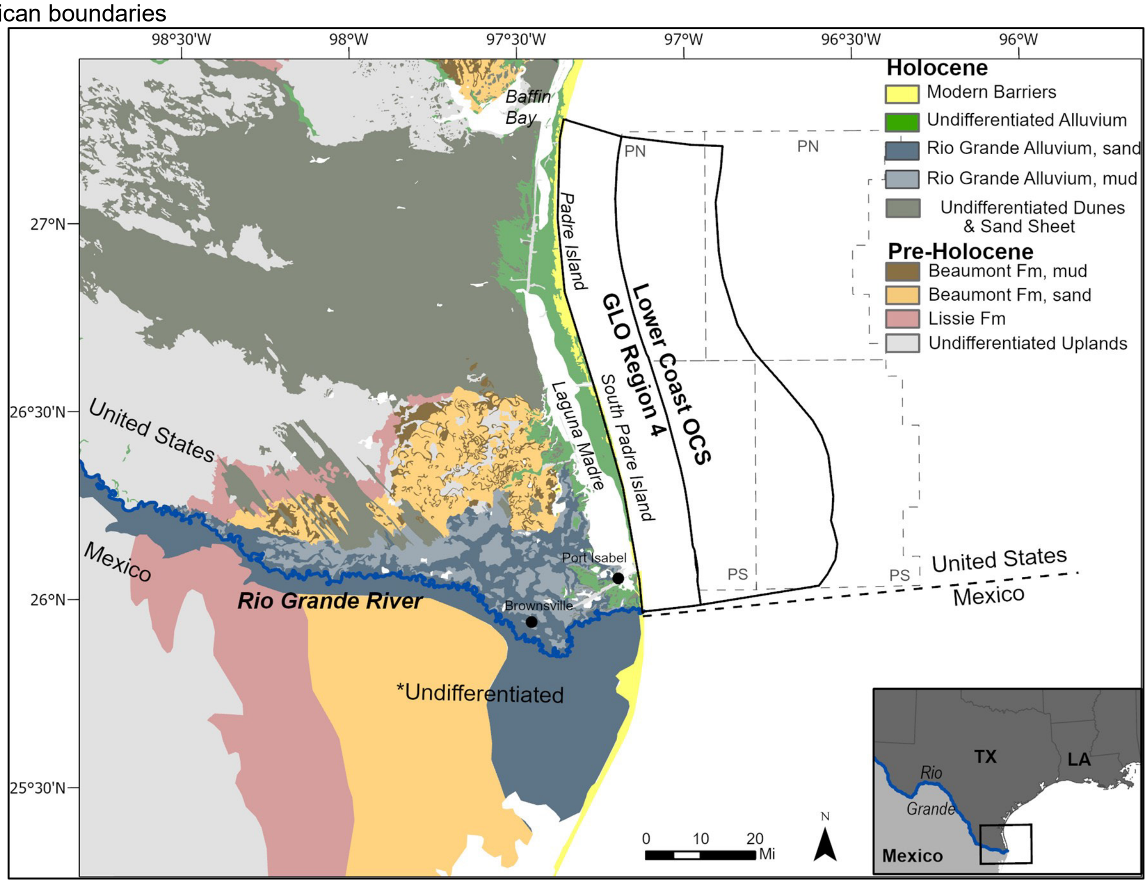


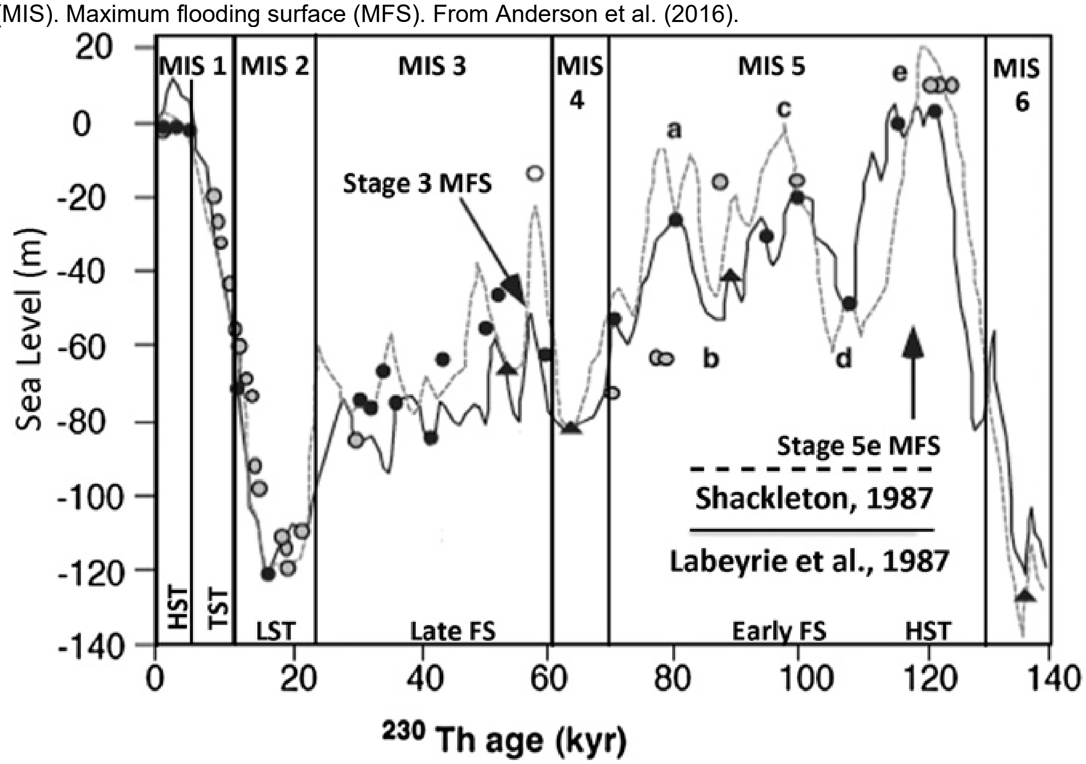
Figure 8: Region 4 and Lower OCS coastal zone and surrounding Quaternary geology.
Note the Beaumont Formation and Rio Grande Alluvium have been subdivided into its mud- and sand-dominated members within United States boundaries. Modified from Brown et al. (1976), McGowen et al. (1976), Moore et al. (2021), and Page et al. (2005). Only general Beaumont Formation and Rio Grande Alluvium are presented within Mexican boundaries



2.2.2.1 Late Quaternary Sea-Level Changes (120,000 Years Ago to Present)

Coastal and fluvial response to sea-level changes in the investigation area has dominated the geomorphic evolution (deposition and erosion of sediments) of the investigation area since the mid-Pleistocene (~900,000 years ago). These changes in sea level are the result of periodic growth of continental ice sheets that reduce the volume of seawater and lower sea levels on the order of hundreds of feet, causing the Gulf shorelines to migrate basinward, referred to as regression, and coincide with the shelf edge during maximum low stands of sea levels. Conversely, melting glacial ice results in sea-level rise, a term referred to as transgression. Changes related to climatic driven shifts in water discharge and sediment flux also affect shoreline regressive and transgressive feedbacks. For the purpose of this discussion, relative to sediment resources within the investigation area, an understanding of the most recent glacio-eustatic cycle (beginning ~120,000 years ago) is crucial to interpreting the resulting stratigraphic record as observed in the continental shelf (Figure 9). During this time, sea level was approximately 30 feet (9.1 meters) above present levels (Simms et al. 2013) and the shoreline correlated with the preserved Ingleside Shoreline that extends from eastern Louisiana to Corpus Christi, Texas. The Ingleside Shoreline represents the high stand barrier island shoreline dating to approximately 120,000 years ago (Price 1933; Otvos and Howat 1996; Simms et al. 2013). After this high stand, sea level began to fall until about 70,000 years ago when it was approximately 250 feet (76.2 meters) below present levels. This was followed by a warming period where sea-level rose to approximately 50 feet (15.2 meters) below present and then fell to about 400 feet (121.9 meters) below present by 22,000 years ago with the shoreline located at the shelf edge (Anderson et al. 2004; Anderson et al. 2016). This most recent lowstand of sea level persisted from approximately 22,000 to 17,000 years ago (Anderson et al. 2004). Between 17,000 and 4,000 years ago sea level rose ~400 feet (121.9 meters) reaching a position similar to the modern coastline (Anderson et al. 2016).

Figure 9: Sea-Level variability over the last 140,000 years.
Note the present and 120,000 year high stands (HS), falling stage (FS) between 120,000 and 22,000 years ago, the lowstand (LST) from 22,000 to 17,000, and transgression (TST) from 17,000 to 4,000 years ago. Marine Isotope Stage (MIS). Maximum flooding surface (MFS). From Anderson et al. (2016).



The following sections discuss depositional and erosional response within the investigation area to changes in sea-level and the development of shelf sand deposits. The discussion is divided into high stand/falling stage and lowstand, transgression (sea-level rise), and high stand deposits.

2.2.2.2 High Stand, Falling Stage, and Lowstand (~120,000–17,000 Years Ago)

During the falling stage of sea-level ~120,000–22,000 years ago, river channels began vertically incising down into pre-existing shelf deposits (e.g., Beaumont Formation and older); however, development of deep incised valleys did not dominate until late falling stage and into the lowstand (Anderson et al. 2016; Anderson et al. 2022). The south Texas shelf was a steep, ramp-like setting during the high stand (120,000 years ago) and provided large accommodation space for the early falling stage (120,000–80,000 years ago) elongate wave-dominated deltas of the Rio Grande (Banfield and Anderson 2004) (Figure 10A). Wave-dominated deltas display concentrated sand deposits from the modern Brazos River delta (Rodriguez et al. 2000). Sediment supply was thought to increase during the falling stage (80,000–22,000 years ago), which allowed for the construction of expansive deltas, building the modern shelf (Banfield and Anderson 2004) (Figure 10B). The fluctuations in sea level during the falling stage impacted the progradation of large fluvially dominated deltas that shifted periodically to wave-dominated deltas or backstepping deltas during sea level rise (Anderson et al. 2016). The shifting between elongate and lobate external form, clinoform packages and five sediment borings are the basis for interpretation of wave-dominated versus fluvial-dominated delta switching throughout the Pleistocene. Erosion and reworking of previous deltaic deposits partially supplied sediment for new delta growth during incisional stage falling sea levels. Archival sediment borings sampling the relict 120,000 year old Rio Grande sandy wave-dominated delta show a coarsening upward sequence of medium sand about 50 feet (15.2 meters) thick (Banfield and Anderson 2004). Sandy deposits potentially associated with younger early falling stage to lowstand deposits (80,000–22,000 years ago) are exposed at the seafloor (Banfield and Anderson 2004). These grey-brown fine sands and silty sands packages are roughly 75 feet (22.9 meters) thick (Figure 11; SP-3, SP-4), likely have cross-shore continuity, and warrant further investigation in the current sand resource mapping effort within the Lower OCS.

Two major delta systems of the Rio Grande system prograded across the shelf during Marine Isotope Stage 3 (MIS3) fed by large fluvial systems (Banfield and Anderson 2004). As sea levels rapidly fell, the fluvial systems incised the shelf and relict deltas. Of the two lowstand incised valleys, the larger southern incised valley system begins as a wide shallow system on the inner shelf, deepening towards the shelf margin with an incisional depth of up to 300 feet (91.44 meters) near the shelf margin (Banfield and Anderson 2004). The Rio Grande has an extensive shelf edge delta (Figure 12) and fan system (Figure 13) associated with this lowstand valley (Suter and Berryhill 1985; Banfield and Anderson 2004; Swartz 2019). Sand-rich deltaic mouth bar deposits over 100 feet (30.38 meters) thick of fine sand with shells outcropping at the seafloor were sampled near the shelf edge (Banfield and Anderson 2004) (SP-1) seaward the current investigation area. Archival seismic shows the sand-rich package extends landward within Lower OCS investigation are at the 164 feet (50 meters) isobath. The falling stage to lowstand delta-fan complex is made up of stacked submarine channel-levee deposits and sand-rich reworked mass-transport complexes (Swartz 2019). The modern submarine channel systems initiate below the shelf-slope break at roughly the ~328 feet (~100 meters) isobath and coalesce downslope into the Perdido Canyon (Rothwell et al. 1991; Damuth and Olson 2015; Swartz 2019). Piston cores of these channels indicate transport of sand from the shelf edge delta systems to the slope during the last glacial maximum (~22,000 years) based on foraminiferal analysis (Damuth and Olson 2015; Olson et al. 2016). Supporting these geologic observations of sustained sediment transport and building of large depositional complexes far above what would be expected for the modern Rio Grande river is paleoclimate evidence and modeling for significantly higher precipitation within the Rio Grande basin during the Last Glacial Maximum, and likely associated higher sediment flux (Oster et al. 2015) (Figure 14).

Figure 10: High stand (top) wave-dominated deltaic deposits and falling stage (bottom) regressive fluvial-deltaic deposits on the Lower Texas shelf.
Note that these deposits are not fully preserved due to subsequent erosion during transgression. Modified from Banfield (1998).

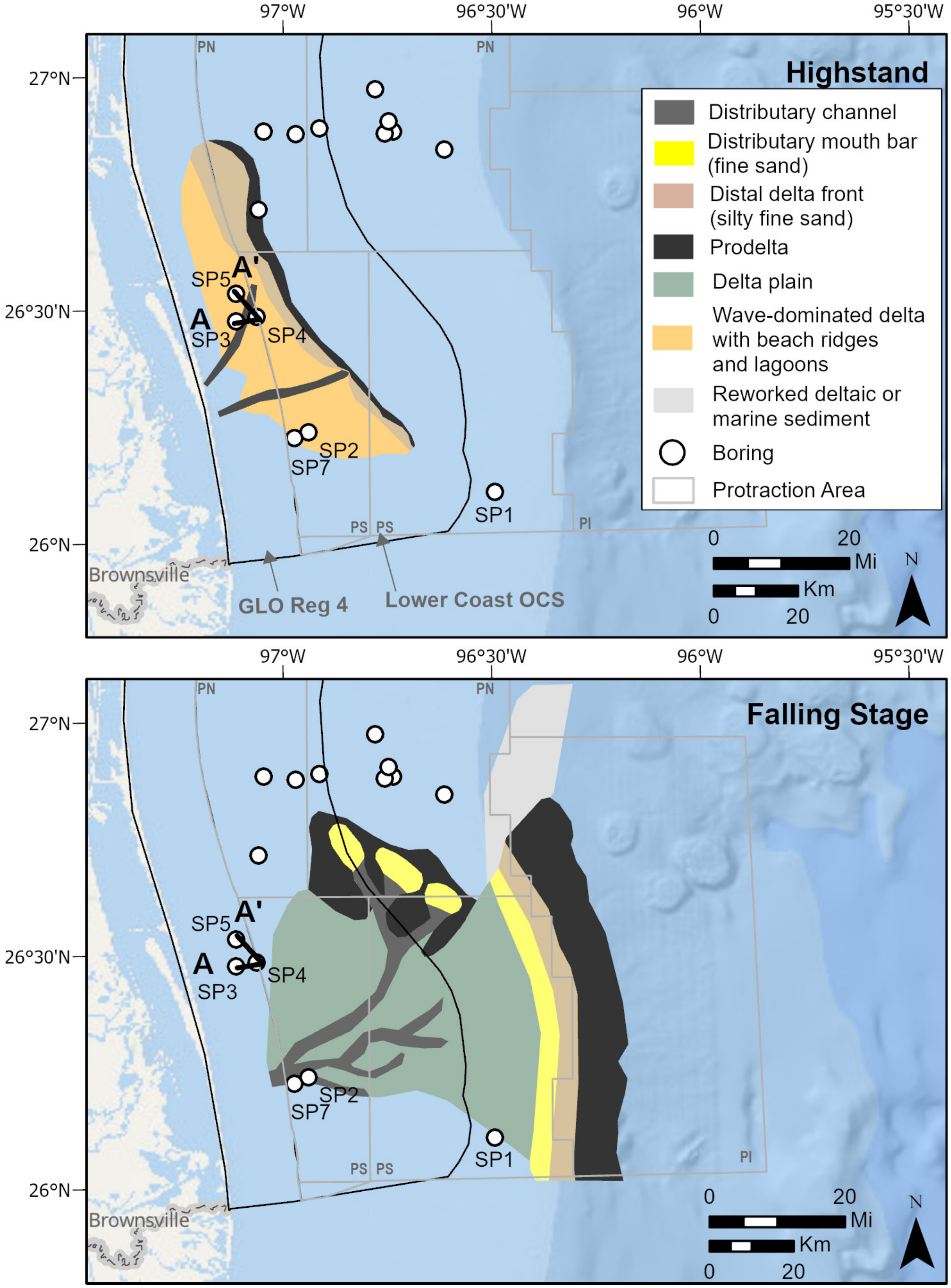


Figure 11: Cross section A-A' showing vertical relationships of stacked fluvial-deltaic deposits. From Banfield and Anderson (2004).

Note these borings are within Region 4 state waters and boring description sheets are found in Banfield (1998).

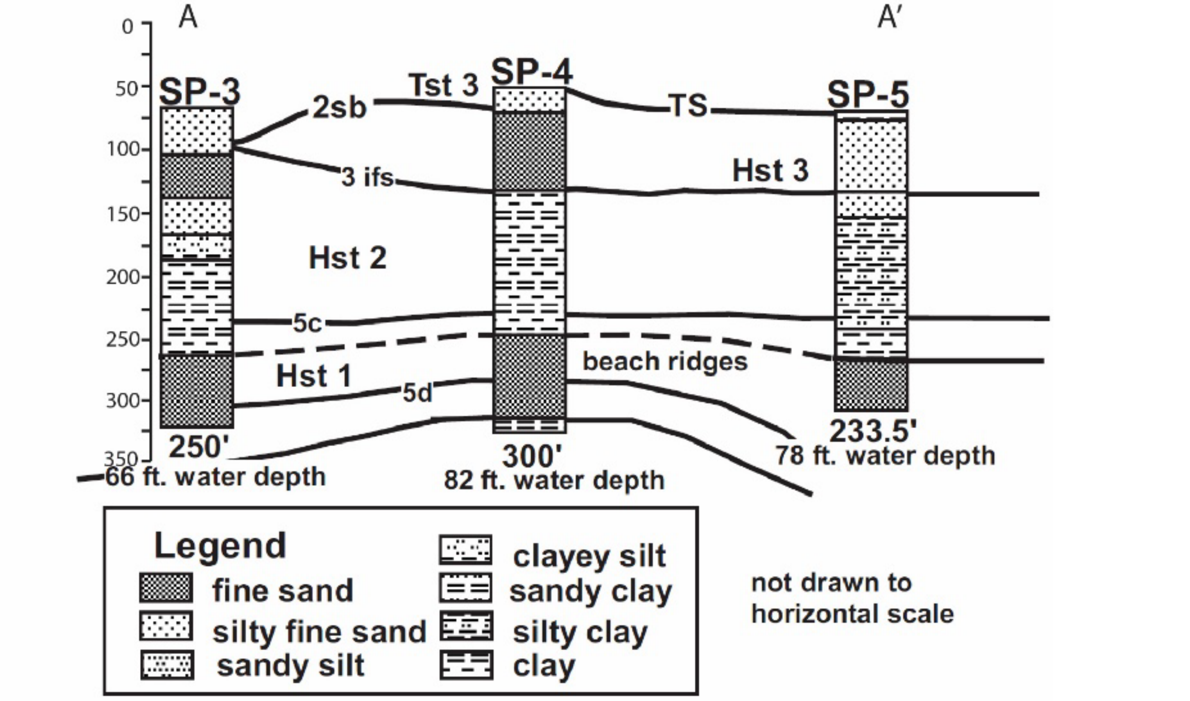


Figure 12: Late falling stage and lowstand valleys and shelf fan deposits and lowstand shelf margin deltas of the Rio Grande system. Modified from Banfield and Anderson (2004).

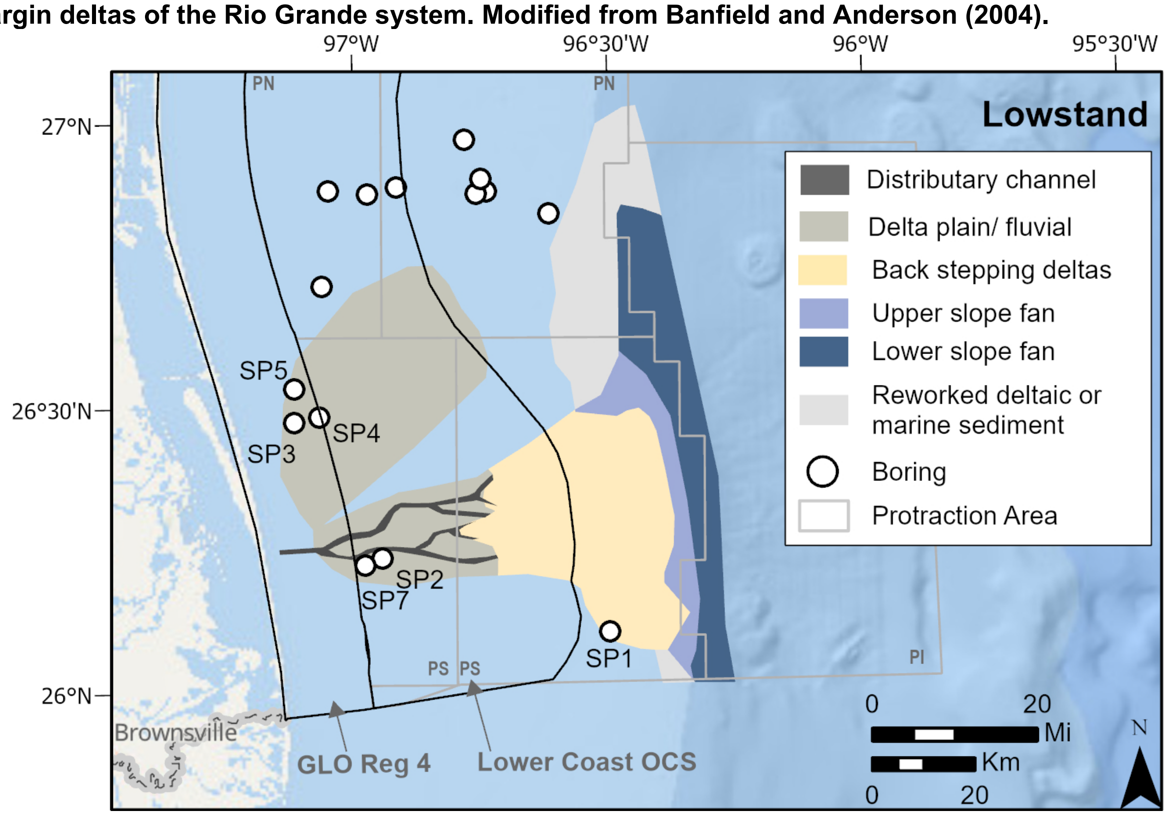


Figure 13: Lowstand valleys and fans of the Southern Texas systems. From Anderson et al. (2016).

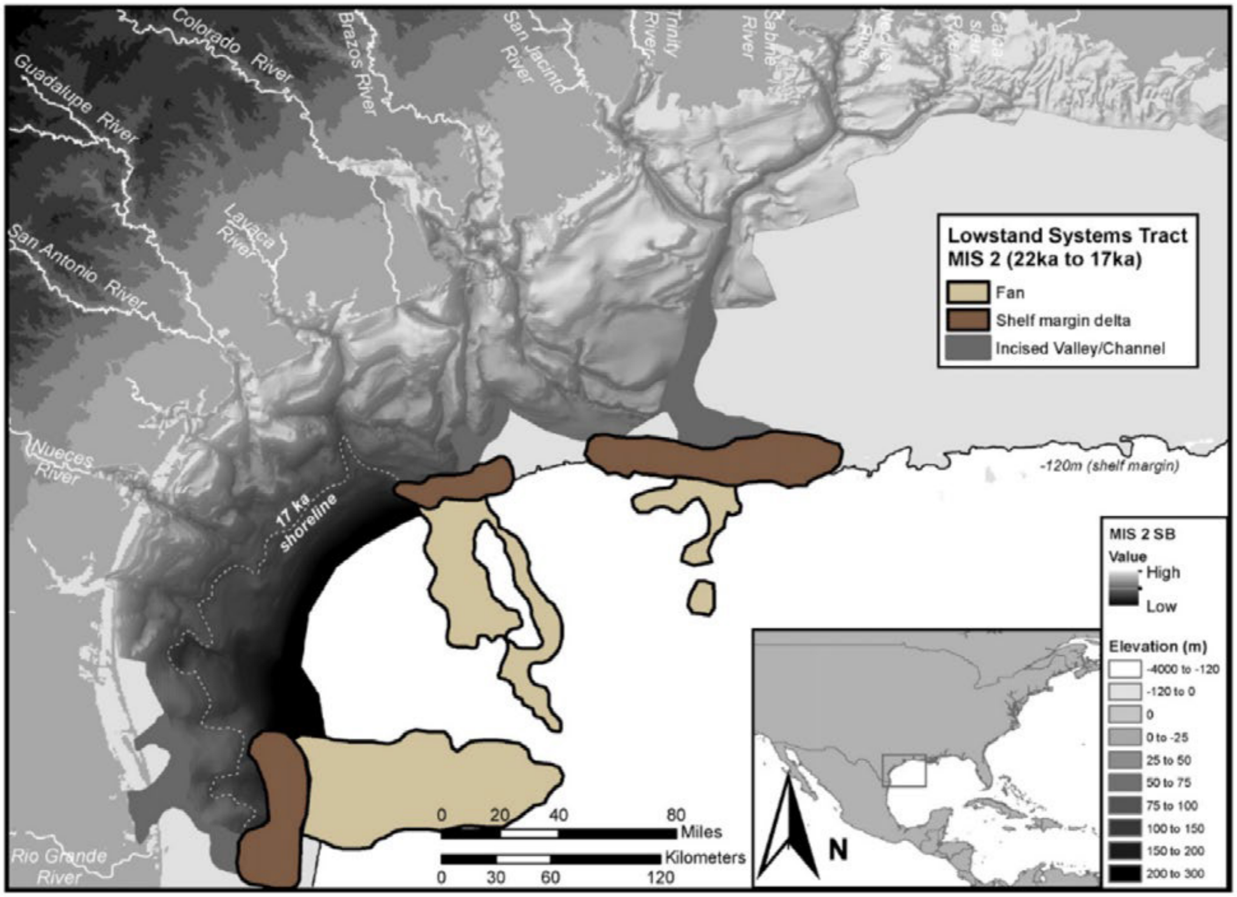
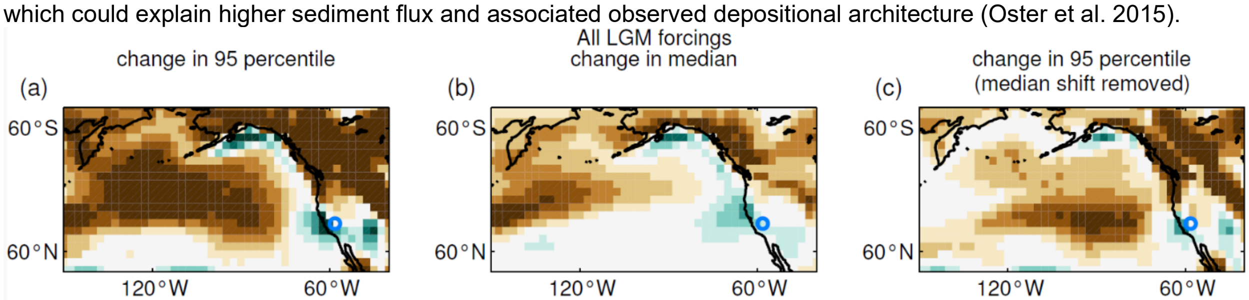


Figure 14: Community Earth System Model (CESM-1) paleoclimate reconstruction of precipitation during the last glacial maximum in the Western United States.

Note: Significant increases in extreme precipitation events are observed within the Rio Grande basin in these models which could explain higher sediment flux and associated observed depositional architecture (Oster et al. 2015).



2.2.2.3 Transgression (~17,000–4,000 Years Ago)

During transgression, lowstand deposits filled the inner shelf incised valley and began building a series of transgressive deltas (Banfield and Anderson 2004). High sediment supply built a fluvial-dominated delta (TST 2) and shifted to more of a wave-dominated delta (TST3; Figure 15) as sediment supply diminished slightly in times of sea level rise rates of nearly a centimeter a year during the transgression (Figure 9). The uppermost deltaic shelf-edge sands were dated between 11,000 and 9,000 years old (Swartz 2019) indicating persistent sediment delivery across the modern shelf to the shelf edge delta and slope systems through the early Holocene (Olson et al. 2016; Swartz 2019). These transgressive deltas are seaward of the 164 feet (50 meters) isobath, or Lower OCS planned data coverage in this investigation. The inner shelf chronology and stratigraphy are poorly constrained. As sea levels rose, transgressive reworking of prior Rio Grande shelf deltas supplied fine-grained sediment through shelf currents to the Central Texas Mud Blanket (Weight et al. 2011; Anderson et al. 2016) (Figure 16). This marine mud deposit has been previously mapped as over 150 feet (45.7 meters) thick within the Lower OCS region and pinches out in Region 4 state waters to less than 5 feet (1.5 meters) thick (Banfield and Anderson 2004; Weight et al. 2011). While not of importance for utilization as sediment resources, it is critical to understand overburden distribution to underlying sandy deltaic and fluvial deposits.

Figure 15: Transgressive stage deltas. Modified from Banfield and Anderson (2004).

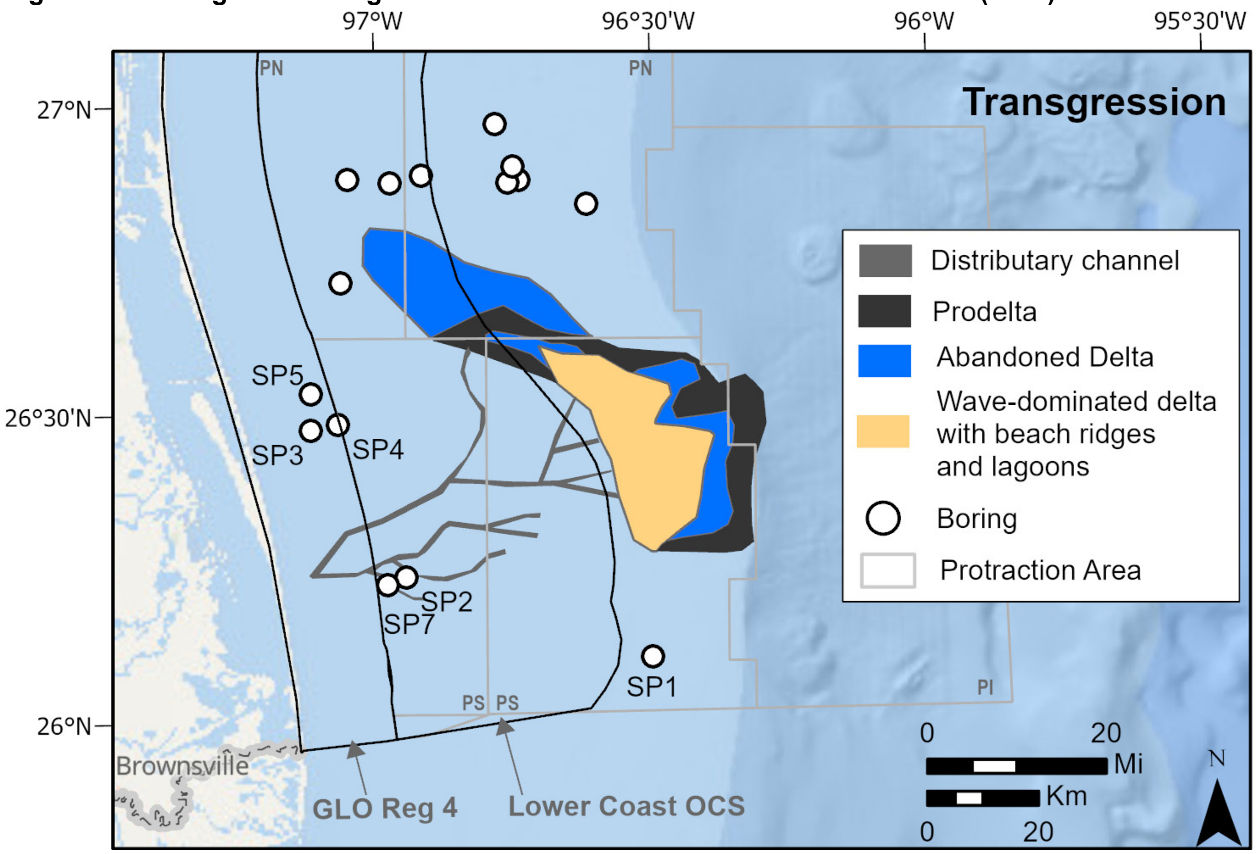
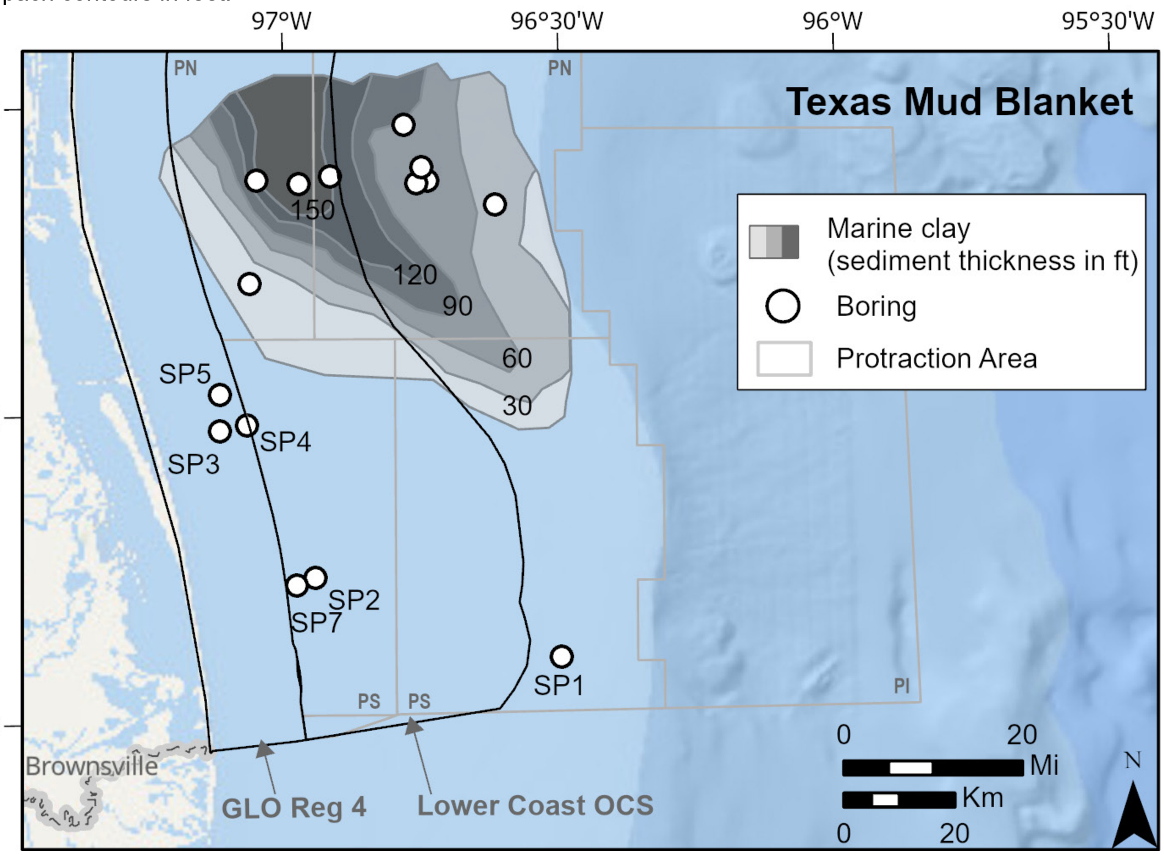
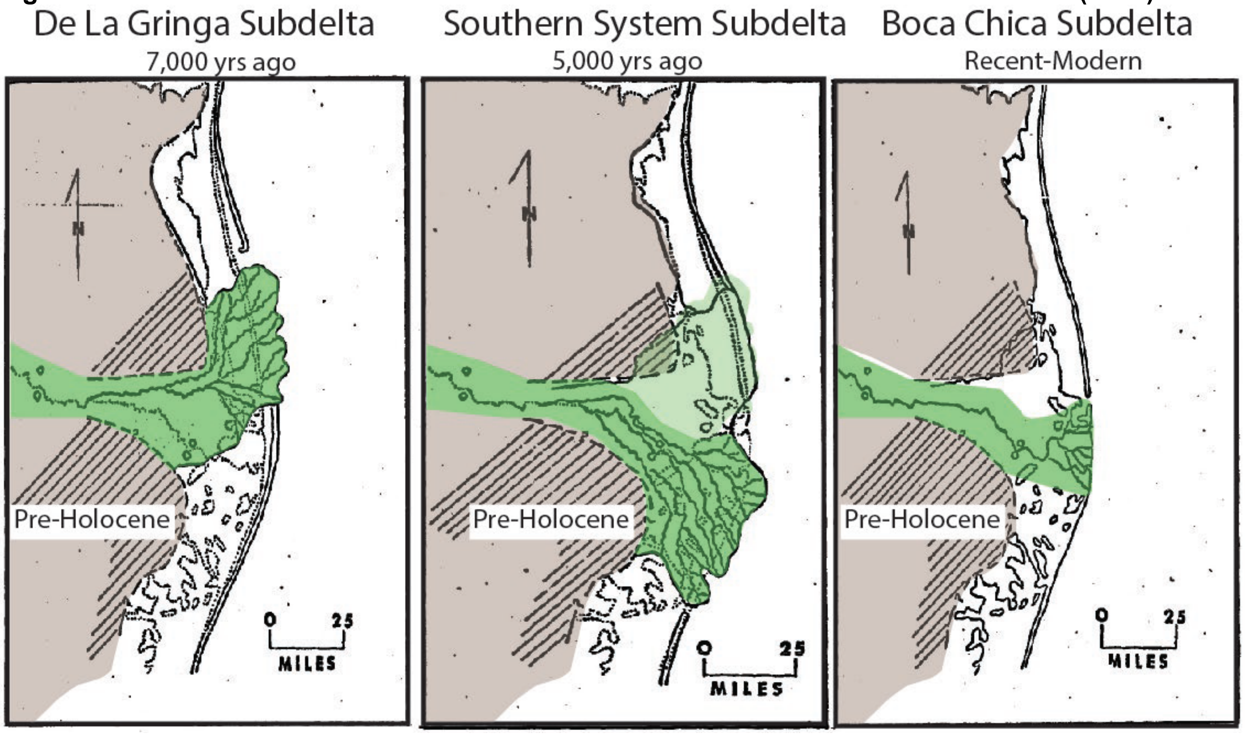


Figure 16: The Southern portion of the Texas Mid Blanket extent and thickness. Modified from Banfield and Anderson (2004).
Note isopach contours in feet.



Onshore, delta building remained throughout the mid-Holocene from 7,000 to 5,000 years ago (Fulton 1976) (Figure 17) before sediment supply was diminished by to climatic shifts from a wet and humid environment to an arid one. This alteration in sediment supply led to transgressive reworking on the delta. (Anderson et al. 2004; Banfield and Anderson 2004; Anderson et al. 2016) Onshore, Fulton (1976) and Lohse (1952) delineate the Resaca De la Gringa sub delta being active about 7,000 years ago (Lohse 1952; Fulton 1976). Avulsions led to lobe switching and progradation of the onlapping southern System sub delta, dated to 5,000 years ago. Fluviatile point bar sands associated with meandering channel belts can be up to 30 feet (9.1 meters) thick and up to 80 percent sand (Fulton 1976). The best developed, most continuous channel belts maintain widths of 1.3 nautical mi (2.4 km) (across and up to 15 feet [4.6 meters] of positive relief) (Fulton 1976).

Figure 17: Mid-Holocene to modern Rio Grande subdelta lobes. Modified from Fulton (1976).



2.2.2.4 Incised Valley Fills

Within the investigation area, the Rio Grande Valley is an overfilled valley (Simms et al. 2006) displaying avulsive, constructional channel belts as evident in modern lidar (Figure 18). The large meander point bars and abandoned meander loops are evident upland to the modern coast (Figure 18B-D) concentrating large sand deposits. The southern valley-fill from onshore to the inner shelf is comprised of variable Late-Pleistocene basal transgressive sand deposits, relatively thin deltaic sequences, but almost entirely with fluvial fill consisting of muddy flood plain with isolated channel sands (Fulton 1976; Banfield and Anderson 2004; Anderson et al. 2014) (Figure 19). The inner shelf portion of the investigation area is poorly constrained, yet it is reasonable to assume these fluvial feeder channel systems continue onto the shelf where a series of extensive deltas and lowstand fans are mapped by Anderson et al. (2016), Banfield and Anderson (2004), and Swartz (2019). Fluvial deposits mapped onshore show good continuity. The fine sand fluvial deposits are up to 30 feet (9.1 meters) thick on land (Fulton 1976) and thicken offshore to more than 50 feet (15.2 meters) (Banfield 1998).

Figure 18: Lidar showing the overfilled valley mapped from borings, note the aggradational alluvial ridges. Modified from Swartz (2019).

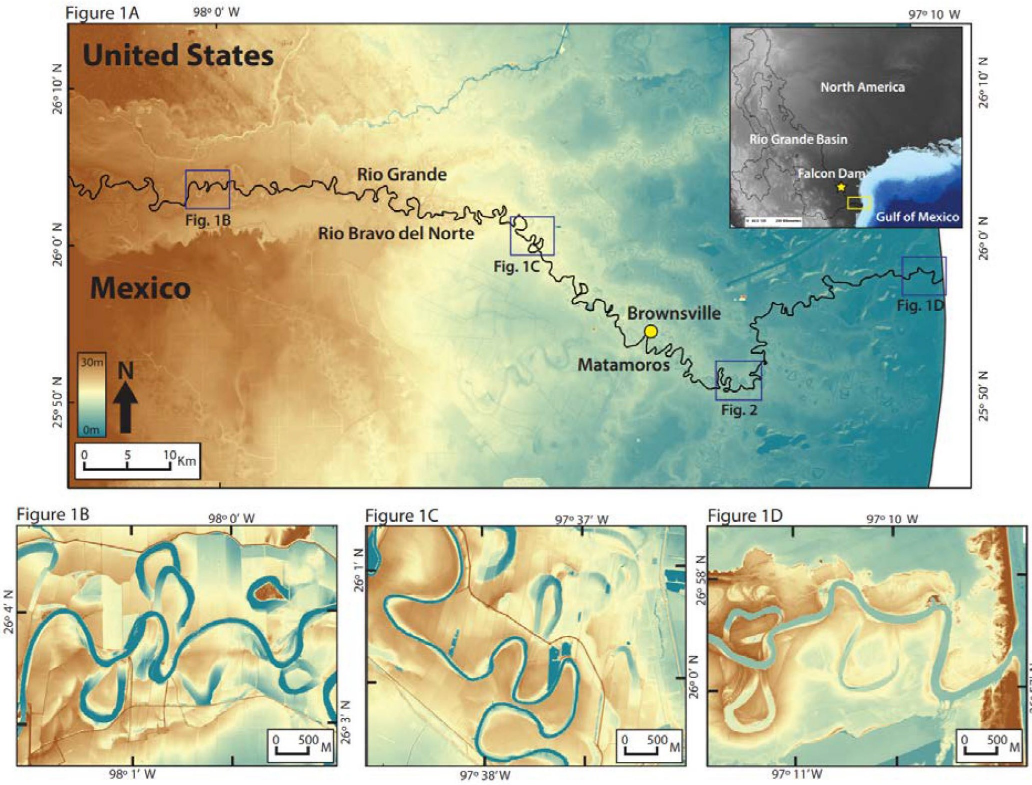
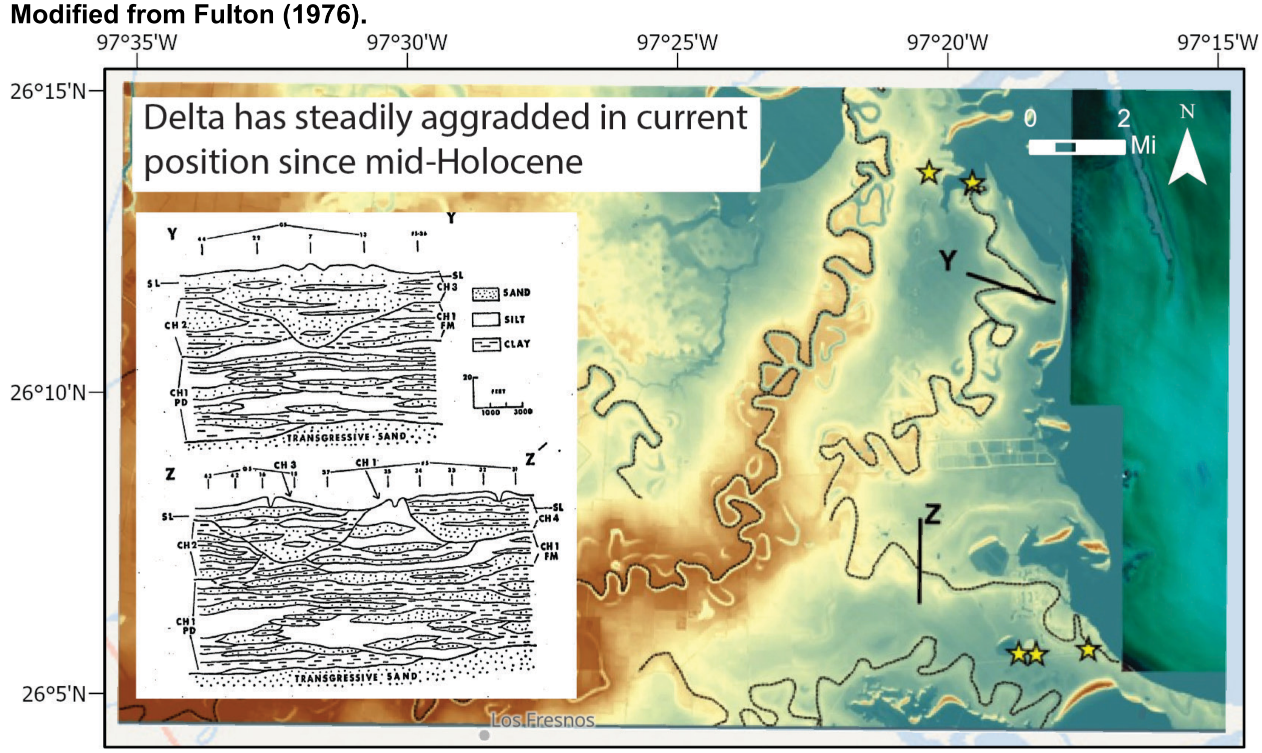


Figure 19: Modern lidar of Rio Grande Delta and channel belts and boring cross sections showing stacked Holocene fluvial-deltaic deposits. Yellow stars show locations of radiocarbon samples. Modified from Fulton (1976).



2.2.2.5 Paleo-Channel Fills

In contrast to incised valley fills that contain multiple channel belts, discrete near-surface channel fills have been observed throughout the investigation area. These channel fills represent stream systems that incised into interfluves during lowstand or were preserved basal channel fills from previous high stand or falling stage streams. In an analysis that mosaiced over 300 shallow hazards surveys conducted for oil and gas development offshore western Louisiana and East Texas, Heinrich et al. (2020) demonstrated the ubiquity of these features in the investigation area (Figure 20). Dellapenna et al. (2009) collected sediment cores in some of these features that had been identified from geophysical data and sand content was minimal or below the depth of core penetration. However, as demonstrated by APTIM-CPE (2001) in support of Holly Beach, Louisiana restoration, high density geophysical and geological data can identify the elusive channel sands that occur within sinuous ribbons of muddy sediment within the fluvial channel belt (Figure 21 and Figure 22) (Heinrich et al. 2020). Adjacent to the investigation area, a previously unidentified laterally migrating channel belt, likely related to a Pleistocene system, was located with a high-density grid of geophysical data and verified to contain beach quality sand offshore of Galveston Island (Figure 23) (APTIM and TWI 2025a). The trend of this system aligns with up dip sandy fluvial deposits of the Pleistocene-aged Beaumont Formation. A similar system was mapped offshore of Matagorda Bay (Figure 24) where the age is unknown but likely resembles offshore components of a Pleistocene Colorado River system identified in Blum and Aslan (2006). These isolated systems provide a reference strategy for other potential sand resources with up dip Pleistocene equivalents within the investigation area. Compared to the Upper Coast of Texas, detailed investigations of potential paleo-channel systems in Lower Texas are minimal. The few detailed investigations do indicate the presence of similar forms as those observed elsewhere in the northern Gulf (Meckel and Mulcahy 2016). A series of highly detailed investigations of channel forms located in the Upper Coast OCS and Central Coast OCS that are likely to be representative of those encountered in the Lower OCS due to similarities in geologic setting and, in some cases, are likely to be formative river systems are described here (Young et al. 2012).

Figure 20: Paleochannel and paleovalley deposits as interpreted on over 300 individual oil and gas hazards survey reports conducted on federal offshore lease blocks (defined by irregular purple grid) offshore Sabine and Calcasieu passes.

Note: The interpretations were mosaiced to develop this map. From Heinrich et al. (2020).

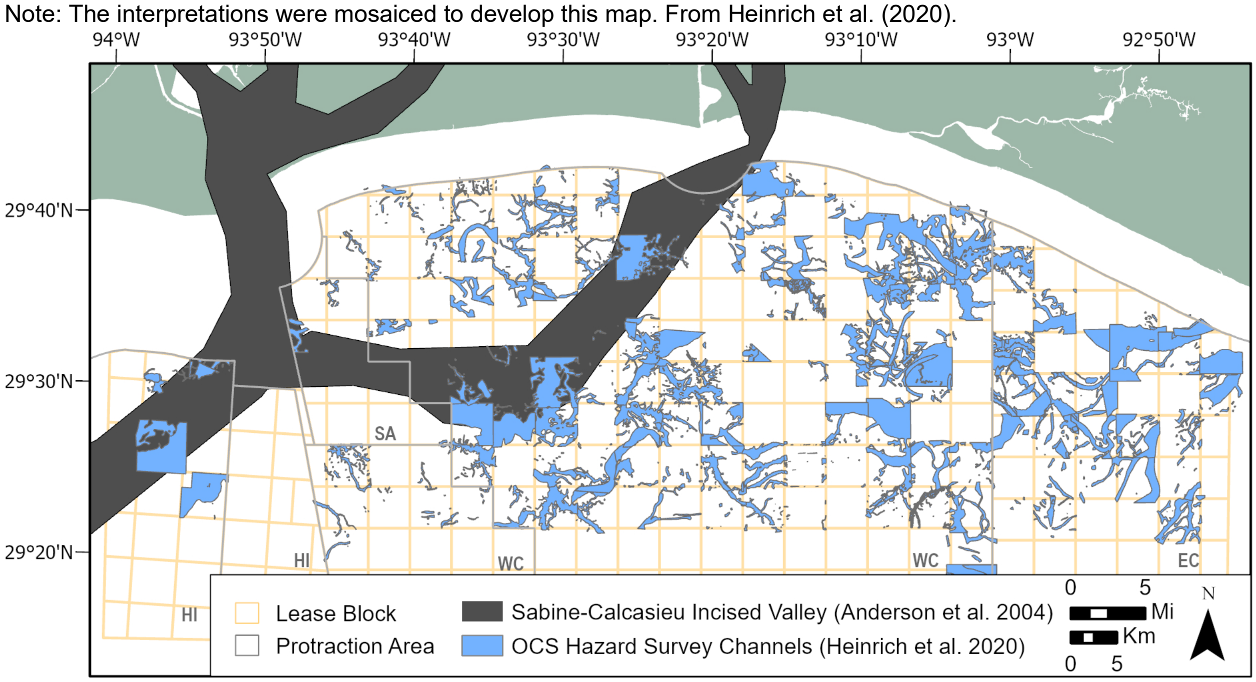


Figure 21: Sand deposit map of the Peveto paleochannel offshore Holly Beach, Louisiana demonstrating the complexity of location channel sands within the channel fill and floodplain muddy deposits.

Note: The southernmost deposits on this map were ultimately extracted to construct the Holly Beach Restoration Project. See Figure 22 for a conceptual model of paleochannel fills. From Heinrich et al. (2020), modified from APTIM-CPE (2001).

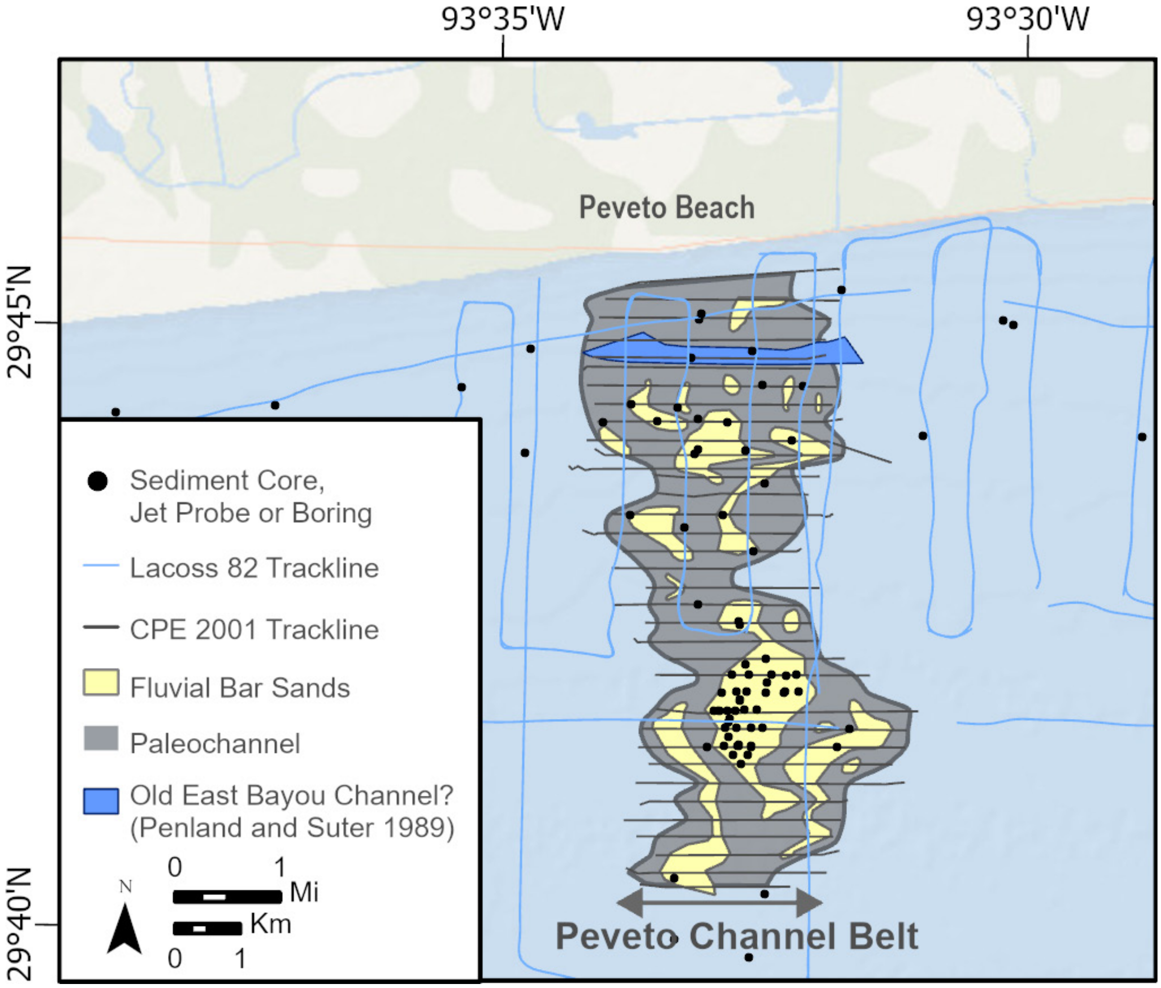


Figure 22: Conceptual hierarchy of fluvial deposits.
From Heinrich et al. (2020).

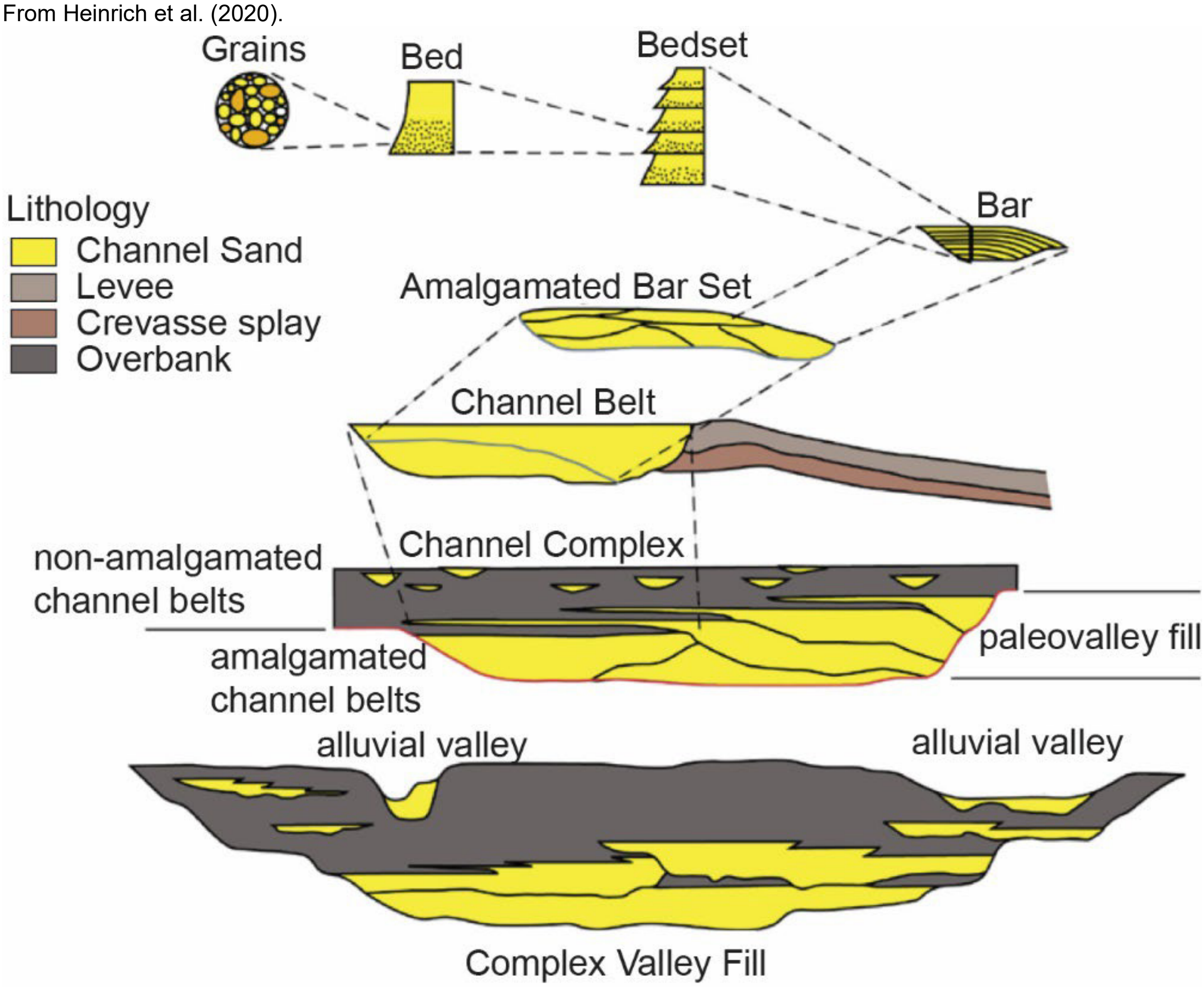


Figure 23: Example of preserved channel belt adjacent to this investigation area, likely related to a Pleistocene Galveston System.

Note: The blue horizon marks the basal unconformity that separates the layered Beaumont stratigraphy from the above dipping clinoforms and variable transparent/chaotic seismic reflectors. The green horizon is the top of the dipping reflector package. Sand ranging from ~10-20% was sampled from within this dipping clinoform package. Note the transition from dipping clinoforms to channel form at the edge of the feature. Modified from APTIM and TWI (2025a).

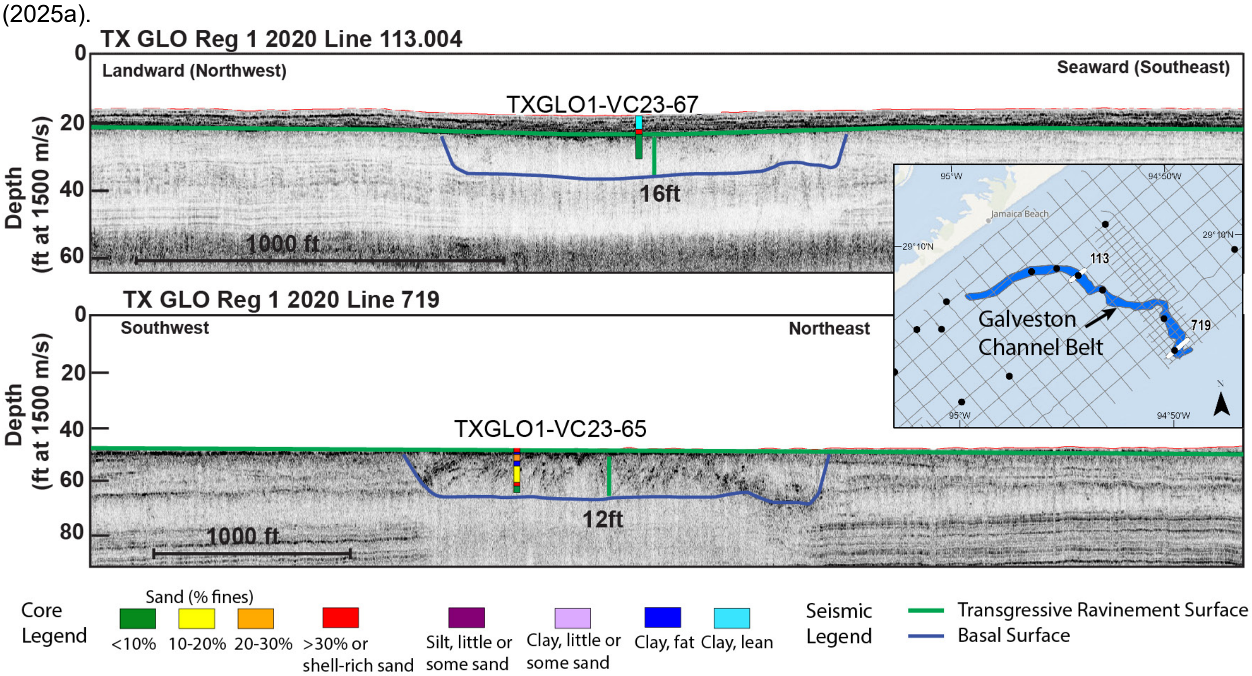
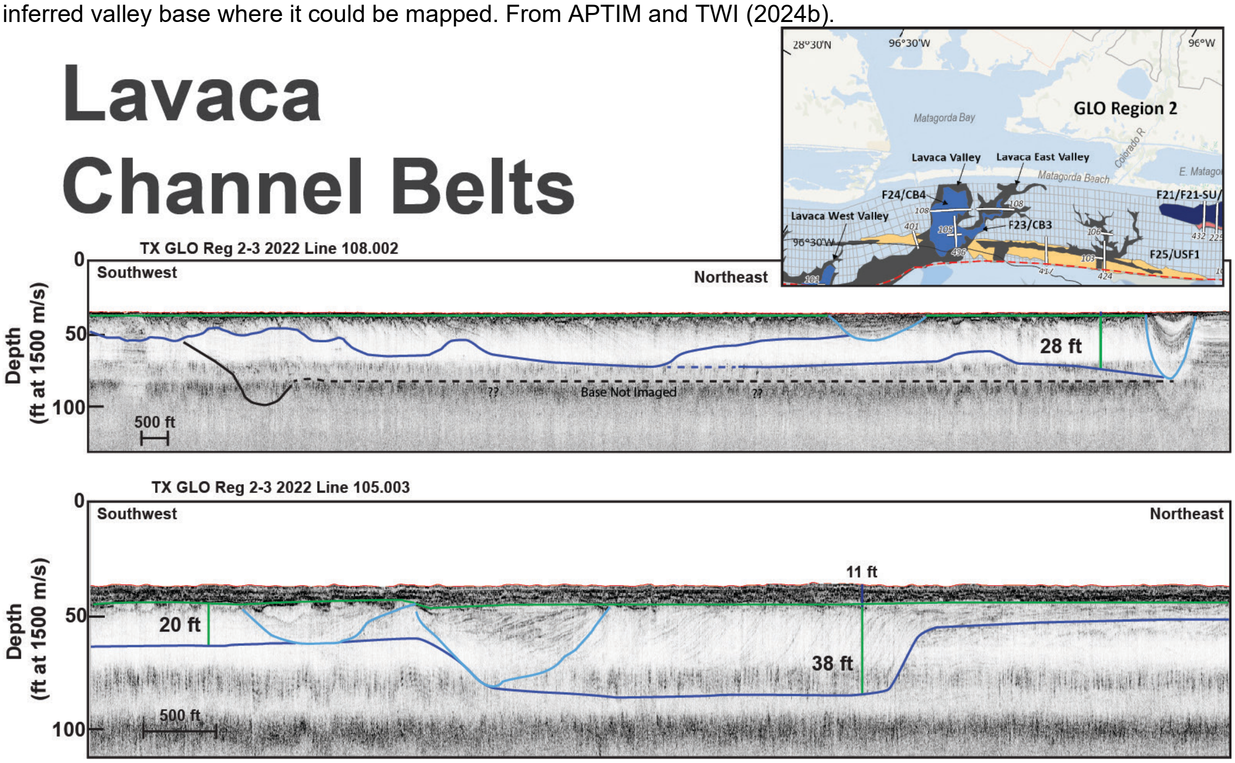


Figure 24: Example of preserved channel belt adjacent to this investigation area, likely related to a Pleistocene Colorado River system.

Note: The dark blue horizon marks the basal unconformity that separates the layered Beaumont stratigraphy from the above dipping clinoforms and variable transparent/chaotic seismic reflectors, light blue reflectors represent the channel form. The green horizon is the transgressive ravinement surface and top of the dipping reflector package. The thickness of potential sand and its overburden are displayed. The black and dotted black line represents the inferred valley base where it could be mapped. From APTIM and TWI (2024b).



2.2.2.6 Transgressive Ravinement

While the depositional response to sea-level rise is manifested as incised valley fills and shelf sand bodies, response to wave and tidal current erosion (ravinement) dominated the investigation area and has resulted in removal of much of the upper sections of fluvial and coastal deposits associated with falling sea level (falling stage deltas and channel systems), lowstand (landforms that developed on interfluves), and early transgression (upper sections of incised valley fills and barrier shoreline deposits). Preservation of coastal deposits is extremely rare with the exception of the sand banks discussed above (Rodriguez et al. 2004; Anderson et al. 2016). Smaller stream channels that did not incise valleys or that were perched on interfluves are also rarely preserved (Anderson et al. 2016). The effective depth of transgressive ravinement in the investigation area was approximately 25–35 feet (7.6–10.7 meters). This depth of ravinement is the same today along the modern shoreface (Wallace et al. 2010); therefore, the upper 25–35 feet (7.6–10.7 meters) of all antecedent deposits were removed as the coastline migrated landward during the transgression (Wilkinson 1975; Siringan and Anderson 1994; Rodriguez et al. 2001).

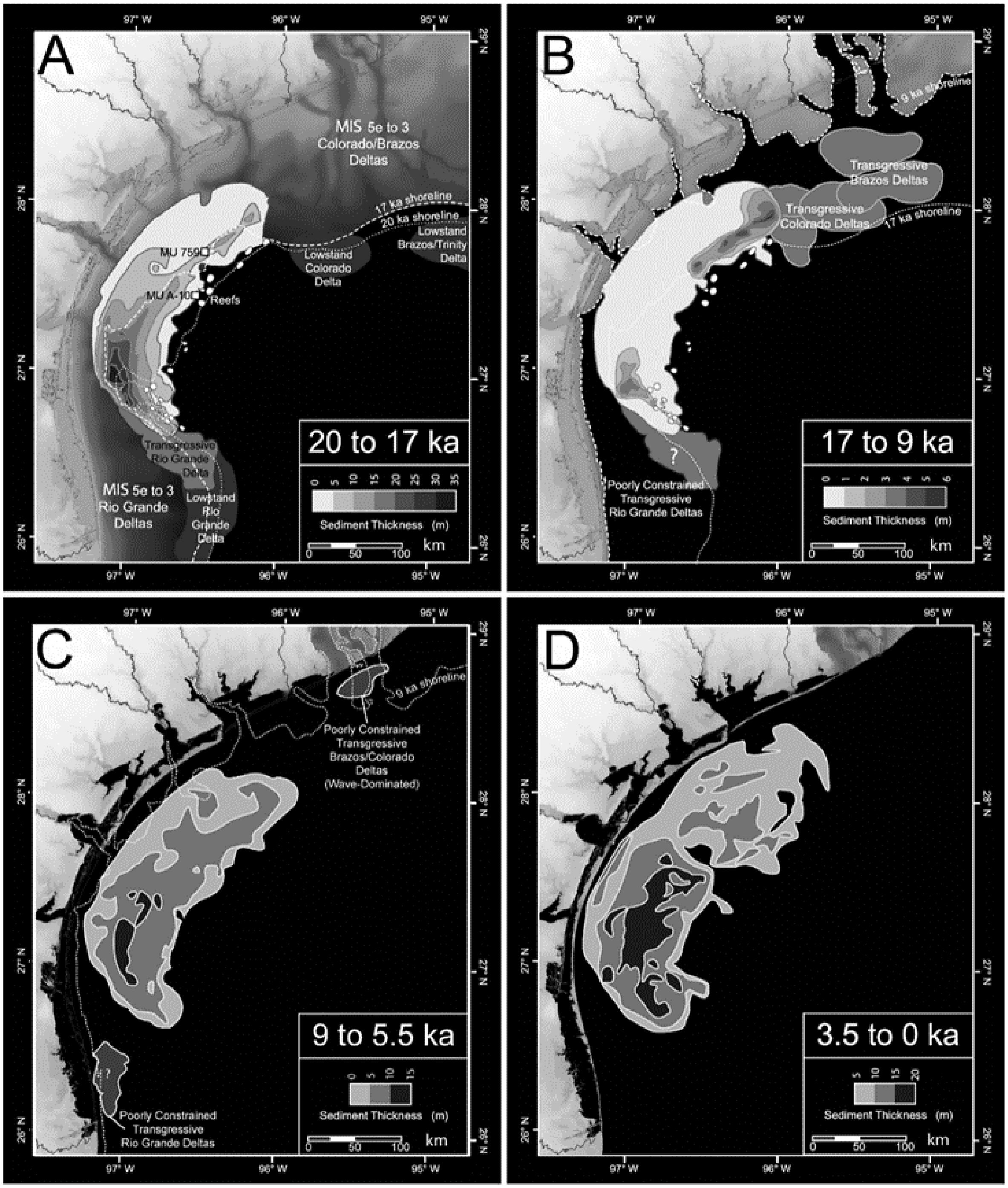
2.2.2.7 High Stand (~4,000 Years Ago to Present)

Approximately 4,000 years ago the rate of sea-level rise drastically slowed to an almost stable ~0.2 inches/year (~0.5 millimeters/year) allowing for the modern coastal system to mature as barrier islands prograde seaward and significant lateral spit accretion from headlands developed peninsulas such as South Padre Island (Anderson et al. 2014). Much of the sand that exists in the modern coastal system was provided during transgressive ravinement of antecedent deposits on the shelf (e.g., falling stage deltas, transgressive barrier islands, shallow stream channels) (Weight et al. 2011; Anderson et al. 2016; Hollis et al. 2019). This concept of the modern coastal system being genetically related to preserved fluvial deposits on the shelf is an important consideration for assessing sand source suitability for beach nourishment. The exact evolution of the Rio Grande Delta is not well constrained, but deltaic deposition is thought to have ceased between 4,000 and 2,600 years ago with lagoonal formation around 2,500 years ago (Fulton 1976; Morton and McGowen 1980). Recent studies suggest that lagoonal bay mud deposition started around 5,500 years ago (Wallace et al. 2010). As the Rio Grande Delta system reached its current position, it began building the modern delta plain and near-surface stratigraphy through numerous cycles of aggradation and avulsion (Fulton 1976; Swartz et al. 2022). The modern Rio Grande maintains a near constant slope and sinuosity across the ~161 nm (~300 km) of the Rio Grande Delta, with historical analysis indicating significant rates of lateral migration along the coastal reach (Swartz et al. 2022). Rates of avulsion are unknown, but at least 17 abandoned Rio Grande channels are observed on the modern delta surface burying at least ~98.4 feet (30 meters) of Holocene fluvial sediment (Fulton 1976; Swartz et al. 2022) indicating an avulsion timescale of hundreds of years. Together, these observations indicate that the late Holocene to historical (last 200 years) Rio Grande system maintained a relatively high sediment flux (albeit lower than that observed of the Pleistocene/Early Holocene system) until anthropogenic modification greatly reduced water and sediment delivery to the coast (Swartz et al. 2022; Goudge et al. 2023).

2.2.2.8 Texas Mud Blanket

The accommodation of the Central Texas shelf embayment, created by subsidence and lack of large falling stage to lowstand shelf deltas, was infilled with transgressive muds of the Texas Mud Blanket during the Holocene (Weight et al. 2011). Deposition occurred at the beginning of this transgression, with the majority of the sedimentation beginning 3,500 years ago (Figure 25). Major sediment inputs were fine-grained plume sediments sourced from the Mississippi, Brazos and Colorado rivers, as well as local ravinement of the Colorado/Brazos and Rio Grande shelf deltas to the north and south (Eckles et al. 2004; Weight et al. 2011). This created a seaward-thickening wedge of overburden overlying the falling stage strand plain deposits and paleo-delta systems associated with the Rio Grande and Colorado Rivers. The Texas Mud Blanket is up to 150 feet (45.7 meters) thick (Banfield and Anderson 2004) within the Region 4/Lower OCS Investigation Areas and severely limits the accessibility of potential subsurface sand resources.

Figure 25: Evolution and thickness of the fine-grained Texas Mud Blanket since the lowstand (Weight et al. 2011).
Note the sediment thickness scale changes between panels.



2.2.3 Upper and Central Texas Shelf Stratigraphy

In addition to the proposed Lower OCS coast acquisition, the proposed geophysical acquisition for this investigation includes an area offshore of GLO Region 1 (Figure 26), where a significant data gap existed between prior collected surveys. This investigation proposes to in-fill this area, named the Upper OCS Data Gap Investigation Area, with an equivalent and comprehensive geophysical survey to bridge the gap between the GLO Region 1 and Federal Upper OCS. The following is a summary of the previous findings of GLO/BOEM investigations of sand resources within Region 1 and the Upper OCS that support the need for additional constraints of this area.

The low gradient, slowly subsiding inner shelf is composed of multiple cycles of fluvial and deltaic sedimentation and progradation, which is then reworked and redistributed during subsequent cycles of sea-level rise and fall by coastal, marine, and alluvial processes (Anderson et al. 2016). The use of a source-to-sink approach to predict sand resource occurrence relies on identifying major sediment pathways and the evolution of major depocenters through time. A summary of depositional systems relevant to sand resource exploration of the Upper and Central Texas shelf are presented here. Generalized cross sections highlighting potential sediment resource distribution for each investigation is presented in Figure 26, Figure 27, Figure 28. For a detailed review of the geologic evolution these areas, please see previous reports by APTIM and TWI (2021; 2022; 2024b; 2024c).

Within the area of Region 1 that lies between the Brazos River to Sabine Point, Texas state waters contain numerous potential sand resources held in regional-scale geologic systems such as the Trinity and Sabine Incised Valleys, the Brazos Alluvial Plain, and the previously unidentified Pleistocene channel belt systems (Figure 27). The Trinity and Sabine Incised Valleys, which are related to the falling and lowstand stages (~120,000 to 20,000 years ago), contain large amounts of concentrated basal fluvial sands. However, these potential sand deposits are overlain with thick sections of muddy deltaic, estuarine, and marine sediment as the incised valleys infilled, making them unviable potential sand resources. However, along sections of the Trinity and Sabine valleys are preserved terrace deposits substantially larger than modern or Holocene Sabine fluvial systems. These thick deposits have less overburden compared to the basal fluvial sands contained with lowstand valleys. Fluvial terrace deposits have a high potential for sediment resources, estimated to contain 265 million cubic yards (MCY; 202.6 million cubic meters; MCM) of sand-rich sediment in Region 1 state waters (Figure 26) and 1.28 billion cubic yards (BCY; 0.98 billion cubic meters; BCM) underlying Sabine Bank in the Upper OCS (Figure 27).

Region 1 state waters contain 11 previously unmapped Pleistocene channel belts that are estimated to contain 2.30 BCY (1.76 BCM) of sand-rich sediment (Figure 26). These discrete channel belts are likely related to fluvial systems of the Beaumont Formation, with very little overburden. Similarly, around Sabine Bank, five previously unidentified Pleistocene channel belts are estimated to contain 694 MCY (530 MCM) of sand (Figure 28). Due to the low subsidence and fluvial reoccupation throughout the Late Quaternary, the upper section Holocene and Pleistocene fluvial systems may occur at equivalent depths below the seafloor rather than being separated by large thicknesses of deltaic or marine deposition. This amalgamation and reworking leads to the “perching” of Pleistocene stratigraphic elements close to the modern seafloor. The Central Texas shelf (GLO Regions 2 and 3, Central OCS) similarly contains numerous Quaternary fluvial channel belts and incised valleys (Figure 28). Characterizing these fluvial channel belts in a source to sink context allows for the prediction of major depocenters, and potentially additional sediment resources outboard, in an efficient exploration strategy.

Figure 26: Cross Section of the Region 1 subsurface stratigraphy and sand-bearing facies. From APTIM and TWI (2021).

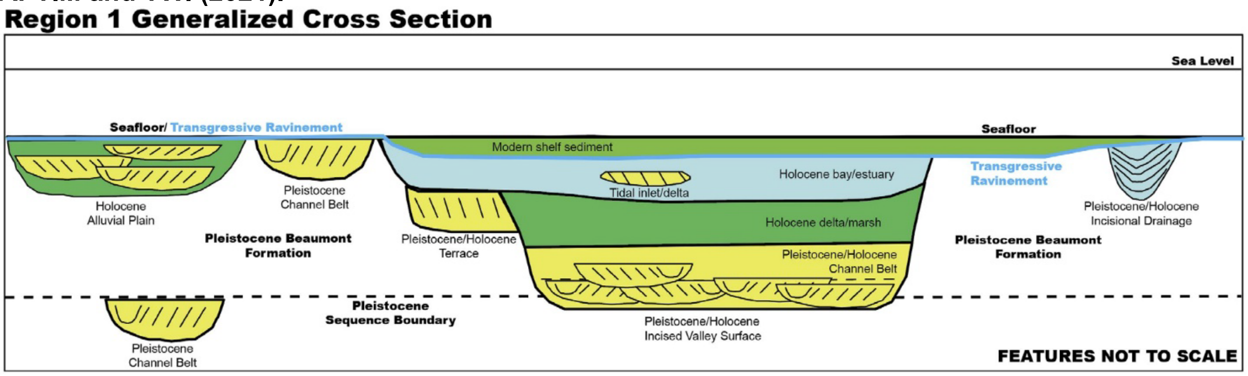


Figure 27: Generalized cross section of major features observed in the Upper OCS. From APTIM and TWI (2022).

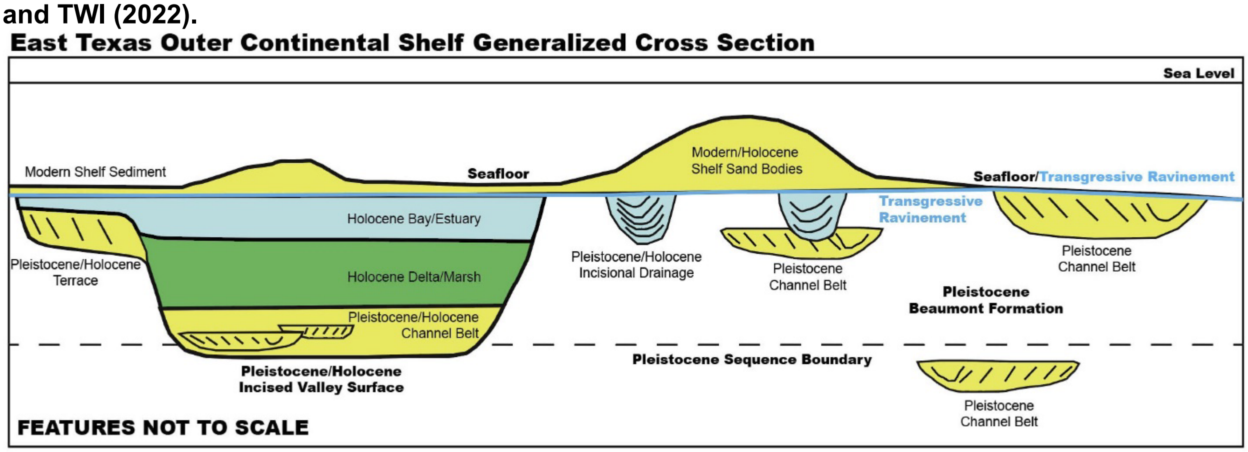
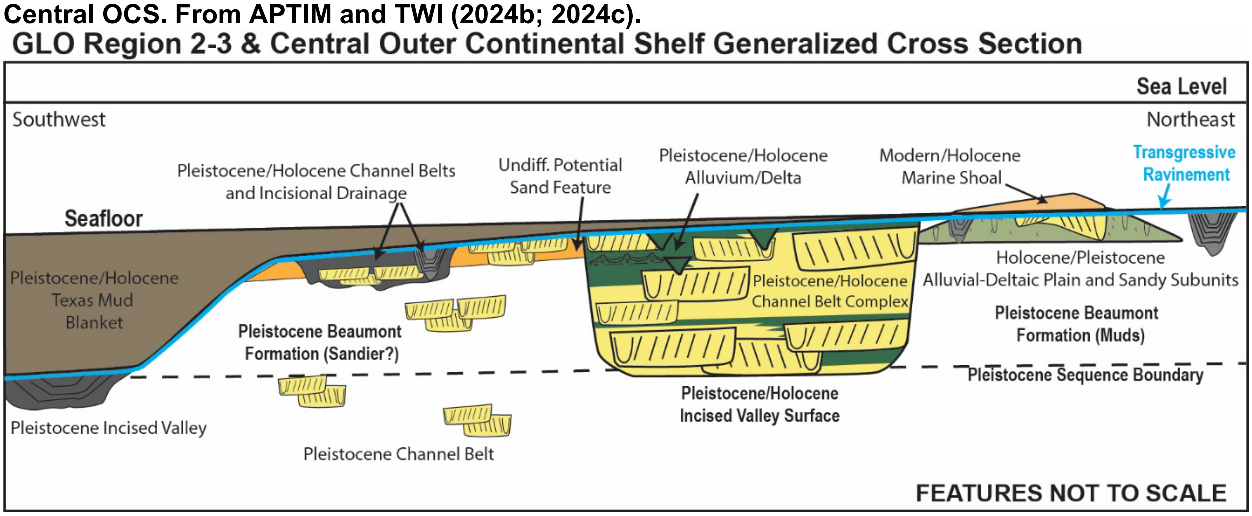


Figure 28: Generalized cross section of major features observed in the GLO Regions 2 and 3 and Central OCS. From APTIM and TWI (2024b; 2024c).

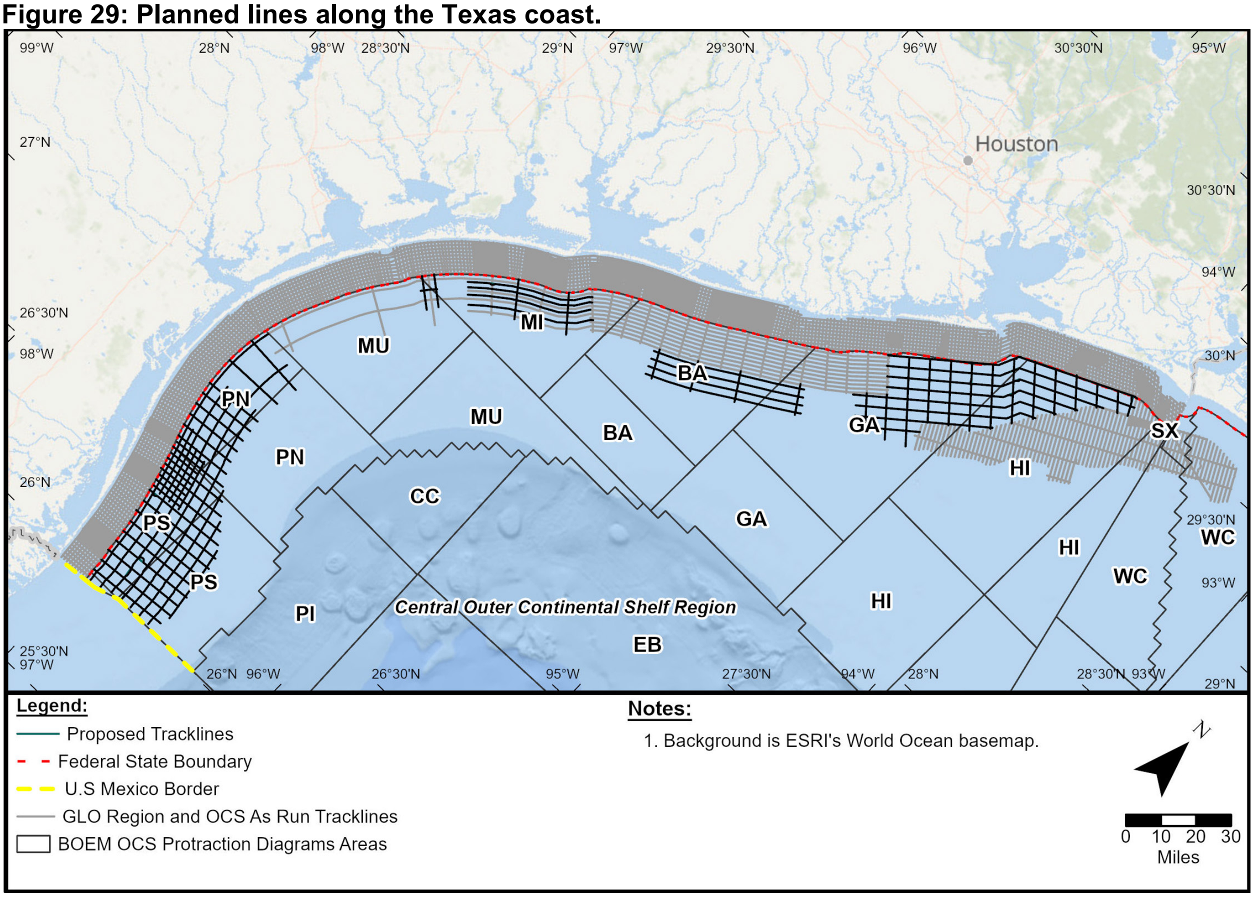


2.3 Survey Plan

APTIM compiled and evaluated available reports, geophysical data, and geotechnical data to develop a geophysical data collection survey plan for the Lower OCS. The final survey plan consisted of a survey grid with various dimensions. The Lower OCS survey conducted from the offshore state-federal boundary to the 164 feet (50-meters) depth contour. Both the Upper and Central OCS Data Gap Investigation Area survey lines were designed to fill data gaps. The sum of which totaled approximately 1,790 nm (3,315.1 km) (Figure 29).

APTIM proposed to collect 1,790 nm (3,315.1 km) of geophysical data, with 800 nm (1,481.6 km) of data to be collected along the Lower OCS Investigation Area. This would be followed by the collection of 353 nm (653.8 km) of geophysical data within the Central Texas OCS Data Gap Investigation Area (Corpus Christi to Freeport, Texas) which builds upon the survey APTIM conducted in 2022 (APTIM and TWI 2024c). Within the Upper OCS Data Gap Investigation Area (defined as Freeport to Sabine). APTIM proposed to collect 549 nm (1,016.7 km) to continue the APTIM 2020 survey in Region 1 and Upper OCS. Finally, the APTIM team allocated 88 nm (163 km) (5% of total base mileage) for investigations into potential sand-bearing resources and/or high priority shallow paleochannels in the Lower OCS Investigation Area in real time in order to properly target features of interest.

Figure 29: Planned lines along the Texas coast.



3 Task 2 Reconnaissance-level Geophysical Survey

On February 8, 2024, the APTIM crew prepared the offshore vessel, R/V *Rachel K.* Goodwin, for geophysical survey operations. From February 9 to March 16, 2024, APTIM conducted a comprehensive geophysical (chirp sub-bottom, sidescan sonar, and magnetometer) and hydrographic (single-beam fathometer) survey offshore lower Texas (Figure 30 and Table 1). Using the R/V *Rachel K. Goodwin*, APTIM conducted 24-hours per day operations during favorable weather conditions. Over the course of

37 operational days, APTIM collected a total of 1,843.9 nm (3,414.9 km) of geophysical data around the clock in 12-hour shifts, averaging a total of 56.6 nm (104.82 km) per day.

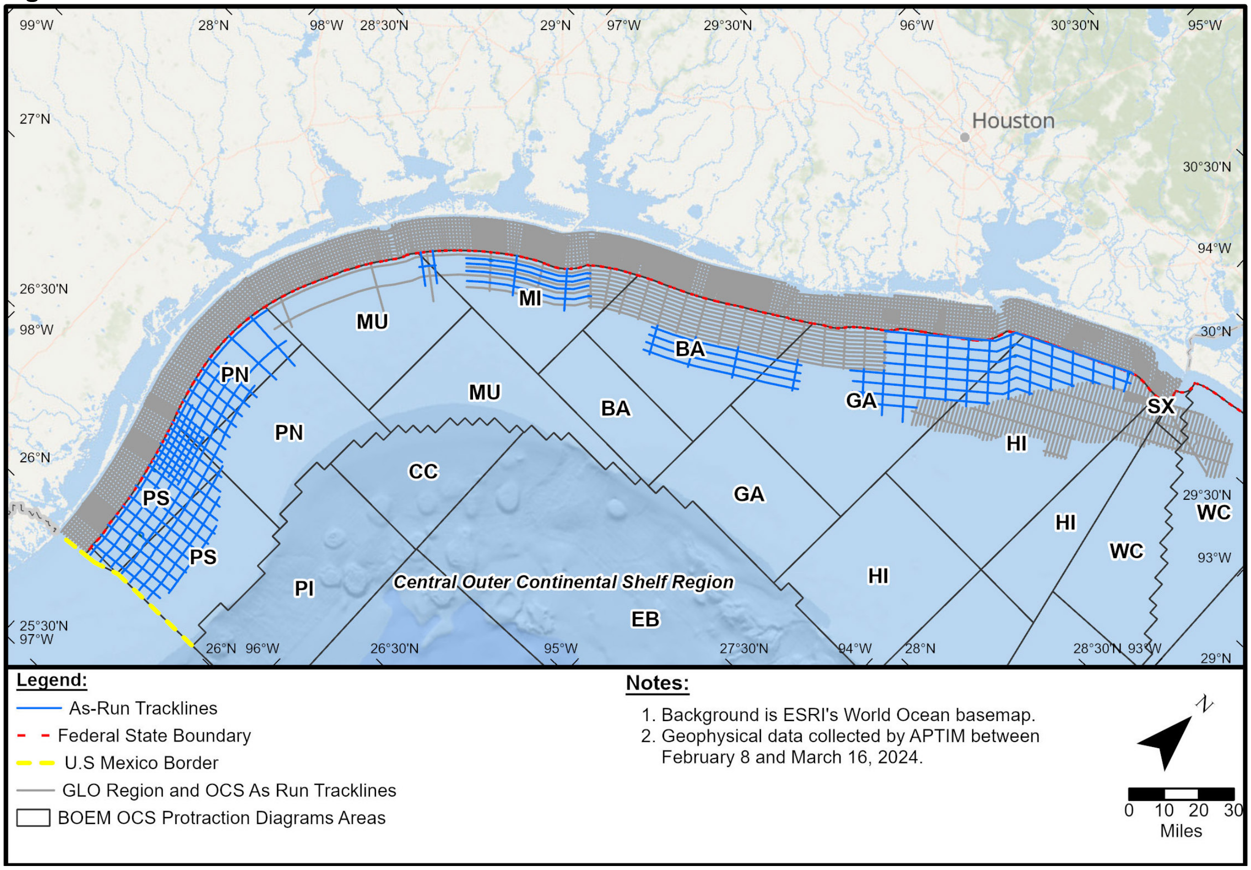
On February 8, 2024, the APTIM crew arrived at Brownsville Shrimp Outlet in Brownsville, Texas and boarded the R/V *Rachel K. Goodwin* and installed the thermal camera system necessary for Protected Species Observer (PSO) operations. Once complete, the crew began transiting to the survey site in the morning of February 9, 2024. The crew arrived on site in the Lower OCS Investigation Area in the early afternoon of February 9, 2024 and began data collection. The survey continued through daylight hours and gear was retrieved that night to address an issue with the thermal camera. The issue was resolved, and surveying resumed at first light on February 10, 2024, and continued through February 23, 2024, when the vessel returned to Brownsville Shrimp Outlet dock for winch maintenance, and this continued through February 26, 2024. On February 27, 2024, a scheduled crew change occurred. The boat continued to stay at the dock through February 29, 2024, due to inclement weather. At midnight on March 1, 2024, the vessel transited back to the survey site and resumed survey operations. The vessel went back to dock for a scheduled crew change on March 2, 2024, and then transited back out to site, beginning survey operations in the late afternoon. Regular survey operations continued until late in the evening of March 16, 2024, when it was completed. On March 17, 2024, the vessel arrived in Patterson, Louisiana for the survey crew to demobilize the R/V *Rachel. K. Goodwin*.

Throughout the duration of the survey, there was one PSO sighting that required a shutdown of the geophysical systems on March 8, 2024, when a Kemp's ridley sea turtle was sighted in the exclusion zone.

Table 1: Proposed and collected line miles of survey data.

Investigation Area	Dates	Proposed (nm/km)	Collected (nm/km)
2024 Lower OCS Investigation Area	February 9, 2024, to March 4, 2024	888/1,644.6	908.3/1,732.9
2024 Central OCS Data Gap Investigation Area	March 4, 2024, to March 9, 2024	353/653.8	362.8/671.9
2024 Upper OCS Data Gap Investigation Area	March 9, 2024, to March 16, 2024	549/1,016.7	572.8/1,060.8
Lower Outer Continental Shelf (Total)	February 9, 2024, to March 16, 2024	1,790/3,315.1	1,843.9/3,414.9

Figure 30: As run track lines.



3.1 Equipment and Survey Methods

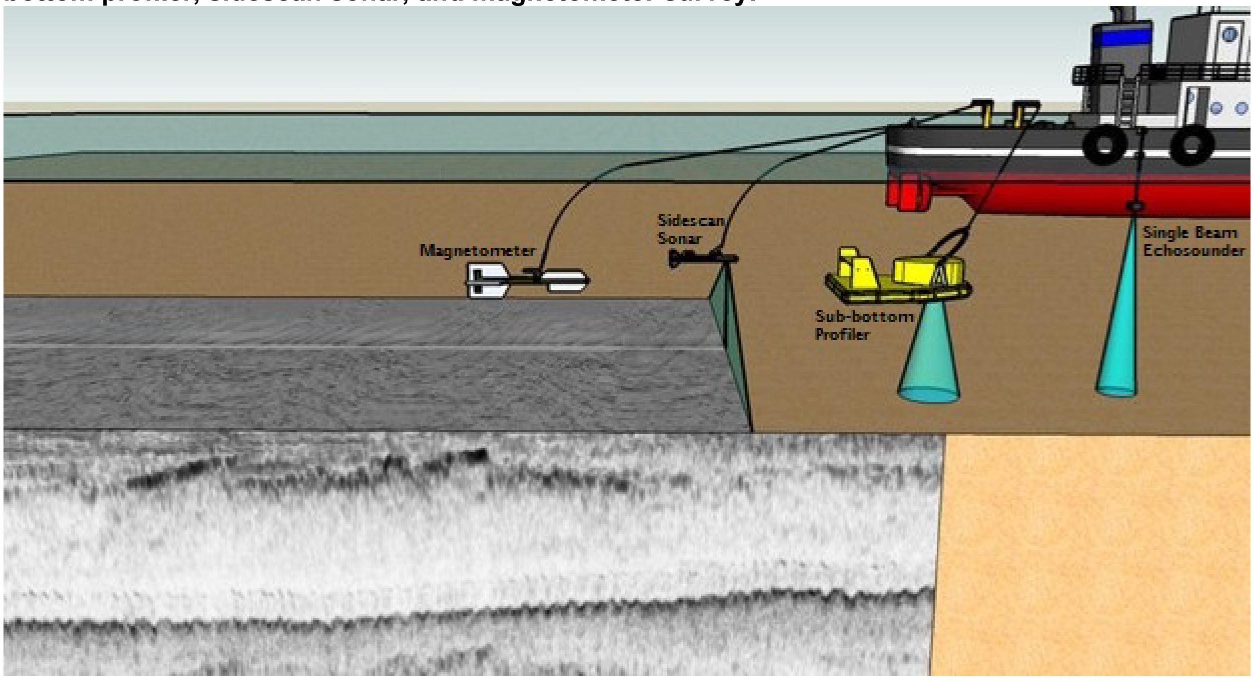
The Task 2 geophysical investigation included single-beam bathymetric, sidescan sonar, seismic reflection profiling, and magnetometer surveys. The survey systems are listed and discussed in detail below and presented in Table 2. The single-beam bathymetric, sidescan sonar, seismic reflection profiling, and magnetometer surveys were conducted concurrently using the setup illustrated in Figure 31. Geophysical data were collected under the responsible charge of Beau Suthard, a licensed Professional Geoscientist (Geology) registered in the State of Texas (License #12902).

Table 2: Equipment used during the geophysical investigation.

Equipment Type	Description	Acquisition Parameters
Navigation	Trimble Post Processing Kinematic, Differential Global Navigation Satellite System (Trimble SPS 461) interfaced with Hypack 2020, TSS DMS-05	N/A
Single beam Hydrographic Echosounder	Teledyne Marine "Echotrac E20"	200 kHz, 4-degree transducer
Sound Velocity Profiler	Valeport SWiFT SVP.	N/A
Sub-Bottom Profiler (Seismic Reflection)	EdgeTech 3200 with SB-512i Sub-bottom Profiler	Pulse: 0.7-12 kHz, Power: 40%; Ping Rate: 7.0 Hz; Acquisition Depth: 40m
Sidescan Sonar	EdgeTech 4205 sidescan sonar system	240 kHz, 350 m Range Scale; 540 kHz, 150m Range Scale
Magnetometer	Geometrics G-882 Digital Cesium Marine Magnetometer	0.02 nT P-P 0.1 second sample rate

Equipment Type	Description	Acquisition Parameters
Processing Software	Hypack 2022, Single Beam Max, ESRI ArcGIS 10.8.1, Chesapeake Technology Inc.'s SonarWiz 7 and Golden Software's Surfer 23	N/A

Figure 31: Schematic diagram showing the typical deployment of sensors: joint bathymetric, sub-bottom profiler, sidescan sonar, and magnetometer survey.



3.1.1 Navigation

The positioning system deployed for the survey was a Trimble SPS-461 Differential Global Navigation Satellite System (DGNSS). The receiver automatically tracked the Global Positioning System, Galileo, and GLONASS satellites, while receiving precisely measured code phase and Doppler phase shifts that enabled the receiver to compute the position and velocity of the vessel. The receiver determined the time, latitude, longitude, height, and velocity once per second. Global Navigation Satellite System (GNSS) accuracy with differential correction provided for a position accuracy of 1 to 4 feet (0.30 to 1.22 meters). A Trimble GNSS receiver was used onboard the survey vessel to provide real time positioning and heading data to Hypack throughout operations at 5 hertz (Hz).

A Trimble R-8 GNSS receiver was also used onboard the survey vessel to log GNSS positions for post processing. Post processed kinematic (PPK) allows for higher quality position and elevation solutions when processed with nearby National Geodetic Survey Continually Operating Reference Stations (CORS). GNSS data were logged at 5 Hz during survey operations.

Coordinates presented in this report for the Lower OCS area are in U.S. Survey Feet, relative to the North American Datum of 1983 (NAD83), Texas State Plane Coordinate System, South. Coordinates for the Central and Upper OCS Data Gap areas are in U.S. Survey Feet, relative to the North American Datum of 1983 (NAD83), Texas State Plane Coordinate System, South Central. Elevations are presented in U.S. Survey Feet, relative to the North American Vertical Datum of 1988 (NAVD88) relative to Geoid 18.

3.1.2 Data Collection and Processing Program

APTIM's navigation, magnetometer, and depth sounder systems were interfaced with an onboard computer and the data were integrated in real time using Hypack 2020 software. Hypack is a state-of-the-art navigation and hydrographic surveying system. The location of the towfish tow points was measured in relation to the center of mass of the vessel. Positioning for each geophysical system was provided by utilizing the towfish layback driver in Hypack. This tool allows the user to set up tow-point offsets for each towfish and, during data acquisition, adjust cable-out lengths which will correct the final system position in real time by taking into account the tow-point offsets as well as the individual catenary factor established for each system. The catenary factor was calculated based on the weight of the system and its towing configuration. The final towfish position is then shared with each of the systems and raw geophysical data is collected with layback corrections. The length of cable deployed between the tow point and each towfish was entered into Hypack to monitor the position of each system in real time. Online screen graphic displays included the pre-plotted survey lines, the updated boat track across the investigation area, adjustable left/right indicator, as well as other positioning information such as boat speed, quality of fix measured by Position Dilution of Precision, and line bearing. The digital data were merged with the positioning DGNSS data, displayed on video, and recorded to the acquisition computer's hard disk for post processing and/or replay. Offsets for the DGNSS antennas, transducer and motion reference unit were calculated by measuring the distance of each system from the center of mass and the waterline then input into the system offset set up within the Hypack Hardware interface.

3.1.3 Bathymetric Survey

The Teledyne Marine ECHOTRAC E20, a single frequency portable hydrographic echo sounder, was used to perform the bathymetric survey. The ECHOTRAC E20 operates at frequencies between 10 and 250 kHz and is a digital, survey-grade sounder. A 200 kHz, 4-degree transducer was pole mounted on the side of the vessel. Soundings were collected at the maximum ping rate to provide the greatest coverage of the seafloor. Teledyne Marine SBES UI software was used to monitor a cross-section echogram of the real time sounding data which was simultaneously fed into Hypack. Sounder calibration was performed periodically throughout the survey (typically whenever the transducer down pole was raised or lowered). The echo sounder was calibrated via bar-checks and a sound velocity probe. A Valeport SWiFT Sound Velocity Profiler (SVP) measured the speed of sound through the water column with the average speed used to calibrate the ECHOTRAC E20. Bar checks were performed from a depth of 15 to 30 feet (4.6 to 9.1 meters) in 5 feet (1.5 meters) increments to verify the transducer draft and speed of sound. Echogram data showing the results of the bar check calibration were displayed on the sounder electronic charts during descent of the bar.

Real-time navigation software (Hypack) was used to provide navigation to the helm to minimize deviation from the line azimuth. This software provided horizontal position to the sounding data, allowing real-time review of the data in plan view or cross section format. A TSS DMS-05 Motion Compensator was used onboard the survey vessel to provide instantaneous heave, pitch, and roll corrections. Tie lines were collected to verify survey accuracies.

3.1.4 Magnetometer Survey

A Geometrics G-882 digital cesium vapor marine magnetometer was used to detect magnetic anomalies within the investigation area (Figure 32). This magnetometer runs on 110 volts alternating current and can detect and aid in the identification of any ferrous, ferric, or other objects that may have a distinct magnetic signature. Factory set scale and sensitivity settings were used for data collection (0.004 nanotesla [nT]/ πHz rms; typically, 0.02 nT peak-to-peak [P-P] at a 0.1 second sample rate or 0.002 nT at 1 second sample rate). The magnetometer was towed at an altitude of no greater than 19.7 feet (6 meters) above the seafloor and far enough away from the vessel to minimize boat interference. It was towed both in an independent configuration and in a piggy-backed configuration attached to the sidescan sonar. Navigation and horizontal positioning for the magnetometer were provided by the Trimble DGNSS system via Hypack 2020 and using a towfish layback correction. Magnetometer data were recorded in the Hypack .raw format using Hypack 2020 survey software. The purpose of the magnetometer survey was to detect the presence of potential underwater wrecks, submerged hazards, or other hazards that would affect borrow area delineation and dredging activities.

Figure 32: Geometrics G-882 digital cesium marine magnetometer.

3.1.5 Sidescan Sonar Survey

APTIM utilized an EdgeTech 4205 sidescan sonar system (Figure 33) for this project. This system uses full-spectrum chirp technology to deliver wide-band, high-energy pulses coupled with high resolution and good signal to noise ratio echo data. The sonar packages included a portable configuration with a laptop computer running EdgeTech's Discover acquisition software and dual frequency towfish running in high-definition mode. This sonar system consists of dual frequency towfish operating at 230/540 kHz, with maximum range scales of 1,148 feet (350 meters) to either side of the towfish at 230 kHz, and 492 feet (150 meters) to either side of the towfish at 540 kHz. These range scales are the largest manufacturer recommended ranges for the frequencies listed above. However, geophysicists in the field based the recorded ranges on the field conditions and may not have used the maximum range scales. For data acquisition during this survey, frequencies and range scales were at 230 kHz/350 meters and 540 kHz/150 meters with the operation range set to high-definition mode. The sidescan sonar data were merged with positioning data from the Trimble DGNSS via Hypack, displayed on video, and recorded to the acquisition computer's hard disk for post processing and/or replay. The location of the fish tow-point (as referenced to the vessel center of mass), together with the length of cable deployed from the tow-point, were entered into Hypack to account for the fish layback and provide accurate positioning of the sidescan towfish during the survey. The sidescan system was run by the Edgetech Discover software program. All sidescan sonar data were collected in the default EdgeTech .jsf file format. The purpose of the sidescan sonar survey was to detect the presence of any surficial geomorphological features, potential underwater wrecks, submerged hazards, or other features that would affect borrow area delineation and dredging activities.

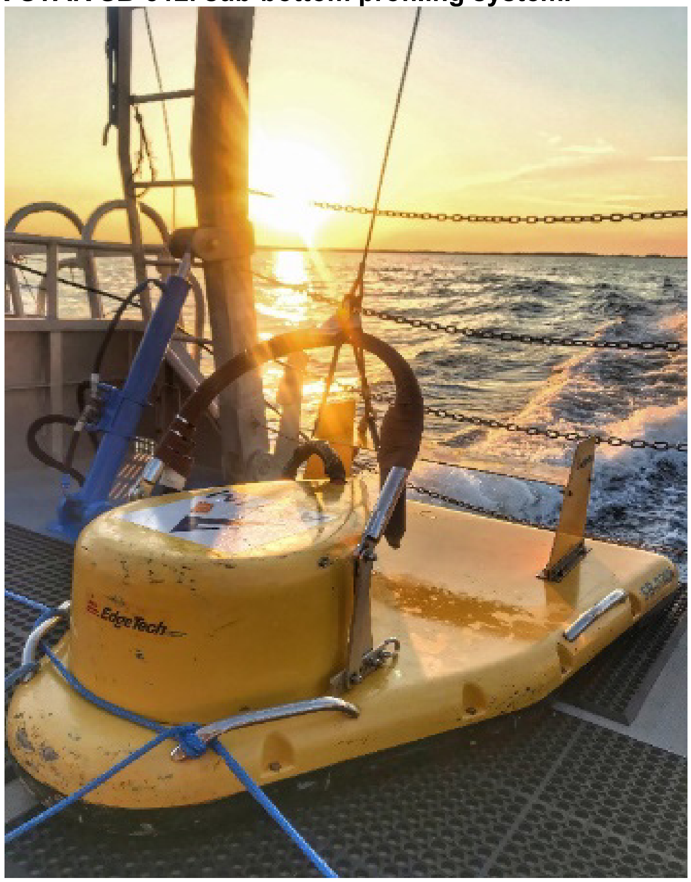
Figure 33: EdgeTech 4205 sidescan sonar towfish

3.1.6 Seismic Reflection Profile Surveys

Chirp sub-bottom/seismic-reflection data were used to show sedimentary stratigraphy and identify potential project-compatible sediment resources. The use of chirp sub-bottom data allowed common stratigraphic layers to be mapped throughout the investigation area while determining the thickness and extent of potential project-compatible sediments.

An EdgeTech 3200 X-STAR sub-bottom profiler with a SB-512i towfish was used to collect the high-resolution seismic reflection profile data (Figure 34). The X-STAR Full Spectrum Sonar is a versatile wideband FM sub-bottom profiler that collects digital normal incidence reflection data over many frequency ranges. Throughout the duration of the survey, operational parameters for the seismic system were a pulse frequency of 0.7–12 kHz, power of 40 percent ping rate of 7.0 Hz and a variable acquisition depth due to drastic changes in water depth. This instrumentation generated cross-sectional images of the seabed (to a depth of up to 50 feet (15.2 meters) in this survey). The X-STAR SB-512i transmits an FM pulse that was linearly swept over a full spectrum frequency range (also called a “chirp pulse”). The tapered waveform spectrum resulted in images that have virtually constant resolution with depth. The Chirp systems have an advantage over 3.5 kHz and “boomer” systems in sediment delineation because the reflectors are more discrete and less susceptible to ringing from both vessel and ambient noise. The full-wave rectified reflection horizons were cleaner and more distinct than the half-wave rectified reflections produced by older analog systems.

Figure 34: EdgeTech X-STAR SB-512i sub-bottom profiling system.



In order to minimize noise related to the survey vessel and sea conditions, the sub-bottom towfish (which operated as both the source and receiver for the sub-bottom system) was deployed and towed behind the research vessel. The sub-bottom system was interfaced with the Trimble DGNSS system via Hypack 2020 navigational software. The location of the fish tow-point (as referenced to the vessel center of mass), together with the length of cable deployed from the tow-point, were entered into Hypack 2020 in order to account for the fish layback and provide accurate positioning of the sub-bottom fish during the survey. The sub-bottom system was operated by the Discover-SB software program. At the start of the sub-bottom profiling survey, the sweep frequencies of the outgoing pulse together with the different gain settings available within Discover-SB were adjusted to obtain the best possible resolution for the survey. The data were continuously bottom-tracked to allow for the application of real-time gain functions in order to have an optimal in-the-field view of the data. Automatic Gain Control (AGC) was used to normalize the data by strengthening quiet regions/soft returns while simultaneously reducing/eliminating overly strong returns by obtaining a local average at a given point. A Time-Varying Gain (TVG) was used to increase the returning signal over time in order to reduce the effects of signal attenuation. During the seismic data collection process, APTIM scientists were constantly monitoring the incoming data for areas where the sub-surface stratigraphy was indicative of sand. When these were observed, targets were made in Hypack and/or notes were taken and reviewed.

3.2 Mitigation Efforts to Minimize Potential High-Resolution Geophysical Impacts to Protected Species

While impacts on marine mammals were not expected, the following mitigation protocols were implemented to reduce the already small chance of High Resolution Geophysical (HRG) survey impacts on marine mammals. These protocols reflected the most recent federal regulatory coordination document to address HRG systems, the *Final Environmental Assessment on Sand Survey Activities for BOEM's Marine Mineral Program* (BOEM MMP 2019) specifically Appendix B: Survey Requirements and Mitigation Measures.

The GLO and APTIM submitted a written Request for Mitigation Exemptions to BOEM on June 25, 2020. The GLO and APTIM requested exemptions from two mitigation measures, (1) Passive Acoustic Monitoring (PAM), and (2) Sea Turtle Frequency Modulation Requirements for Nighttime Operations. The written Request for Mitigation Exemptions provided information on the proposed geophysical survey equipment, the regulations for mitigation measures, proposed mitigation measures, as well as supporting documentation and reasoning for the mitigation exemption request. The Mitigation Exemption Request was granted (via email) by BOEM on July 30, 2020. On October 21, 2020, prior to commencing field operations, BOEM issued project specific "Survey Requirements and Mitigation Measures for all Marine Minerals Program (MMP) G&G" describing the necessary survey requirements. This document confirmed that nighttime PAM operation and the nighttime frequency modulation mitigation requirements were waived.

3.2.1 Seismic Survey Mitigation and Protected Species Observer Protocols

Geophysical surveys may have an impact on marine wildlife, although HRG surveys are the least impactful when compared with surveys utilizing air guns. Non-air gun HRG acoustic sources with frequencies greater than or equal to 180 kHz do not require mitigation because the frequency is outside the general hearing range of marine mammals (National Marine Fisheries Service 2020) The magnetometer produces no acoustic noise whatsoever, while the echosounder and the sidescan sonar use a frequency higher than 180 kHz; therefore, no mitigation plan was necessary for these three systems. Since the EdgeTech 3200 512i chirp sub-bottom profiler operates at a frequency below 180 kHz, the survey implemented mitigation protocols consistent with *Final Environmental Assessment on Sand Survey Activities for BOEM's MMP* produced by BOEM, specifically Appendix B: Survey Requirements and Mitigation Measures (BOEM MMP 2019).

An Acoustic Exclusion Zone (AEZ) of 328 feet (100 meters) was monitored during all sand survey activities. All survey operations were monitored by a NMFS approved, trained PSO. One NMFS approved and trained PSO was always on duty during survey operations. Startup and shutdown requirements were followed every time the survey began. Nighttime operations did not require the use of PAM or any frequency modulation above 2 kHz. This exemption was supplemented with additional measures: the nighttime PSO used night vision goggles to monitor the AEZ, and a thermal imaging camera system also utilized by the PSO. These proposed nighttime mitigations provided the same visual monitoring standards proposed by the EA for daylight hours.

Throughout the duration of the survey, there was one PSO sighting that required a shutdown of the geophysical systems on March 8, 2024, when a Kemp's ridley sea turtle was sighted in the exclusion zone. Throughout the duration of the survey several pods of dolphins were observed in the AEZ, however no shut down was required due to the presence of dolphins.

3.2.2 Vessel Strike Avoidance and Injured/Dead Aquatic Protected Species Reporting Protocols

During survey operations all efforts were made by the vessel operators and crew to avoid striking any aquatic protected species. A visual observer (e.g., captain and PSO) aboard the vessel monitored a vessel strike avoidance zone around the vessel to ensure the potential for strike was minimized. If encountered, vessel speeds were to be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages or any marine mammals were observed near the vessel. The vessel was instructed to maintain a minimum separation distance of 100 meters (328 feet) from sperm whales, and 500 meters (1,640 feet) from any baleen whale to specifically protect the Gulf of America Bryde's whale. The vessel maintained a minimum separation distance of 50 meters (164 feet) from all other aquatic protected species, including sea turtles, with an exception made for those animals that approach the vessel. If the PSO sighted an aquatic protected species while the vessel was underway, the vessel functioned as necessary to avoid violating the relevant separation distance. If the PSO were to sight an aquatic protected species within relevant separation distance, the vessel reduced speed and shift engine to neutral and did not engage the engines until animals were clear of the area. This did not apply to any vessel towing gear (e.g., geophysical towfish). The above stated requirements did not apply in any case where compliance would create imminent and serious threat to a person or vessel or to the extent that compliance restricted the vessel's ability to maneuver.

Any injured or dead aquatic protected species, regardless of whether the survey vessel caused the injury or death, would have been reported to the proper authorities specified in the Marine Mammals Protection Act (MMPA). The PSOs did not observe injured or dead aquatic protected species during this survey.

3.2.3 Gulf of America Marine Trash and Debris Awareness and Elimination Survey Protocols

Marine trash and debris pose a threat to fish, marine mammals, sea turtles, and potentially other marine animals, cause costly delays and repairs for commercial and recreational boating interests, detract from the aesthetic quality of recreational shore fronts, and increase the cost of beach and park maintenance. To mitigate this threat to the environment and marine animals, all personnel involved in conducting the HRG survey had Marine Trash and Debris Awareness Training. This BOEM program is conducted on an annual basis. All offshore employees and contractors actively engaged in offshore operations were required to view the Bureau of Safety and Environmental Enforcement You Tube video entitled "Keep the Sea Free of Debris. A look at preventing marine debris and some best practices" and review NTL 2015-G03. All policies and procedures outlined in this training were observed during vessel operations.

3.2.4 Navigation and Commercial Fisheries Operations Conflict Minimization Requirements

APTIM was required to file a Local Notice to Mariners with the appropriate U S. Coast Guard District. APTIM filed the Local Notice to Mariners on December 6, 2023, prior to beginning the survey. Please see the U.S. Coast Guard Published Local Notice to Mariners below.

TX - GULF COAST - GULF OF MEXICO - Survey Operations

Continuing through March 31, 2024, the R/V RACHEL K. GOODWIN is conducting geophysical surveys in the Gulf of Mexico along the entire Texas Gulf Coast. The survey area is located from the shoreline to 40 nautical miles offshore, and stretches from approximately Sabine, TX to Brownsville, TX. Surveys will be conducted inshore from the offshore boundary line, which is located in the following approximate positions:
29-27-01N 093-58-28W,
28-43-38N 094-38-15W,
28-10-55N 095-46-16W,
28-05-11N 096-10-02W,
27-45-16N 096-42-32W,
27-08-36N 096-53-46W and
26-01-18N 096-36-57W.
Operations will be conducted 24-hours a day, 7-days a week. The R/V RACHEL K. GOODWIN will be restricted in maneuverability and will monitor VHF-FM Channel 16. Approaching vessels are requested to give a wide berth to reduce impacts to survey data quality. Mariners are urged to use caution while transiting the area.

LNM: 06-24

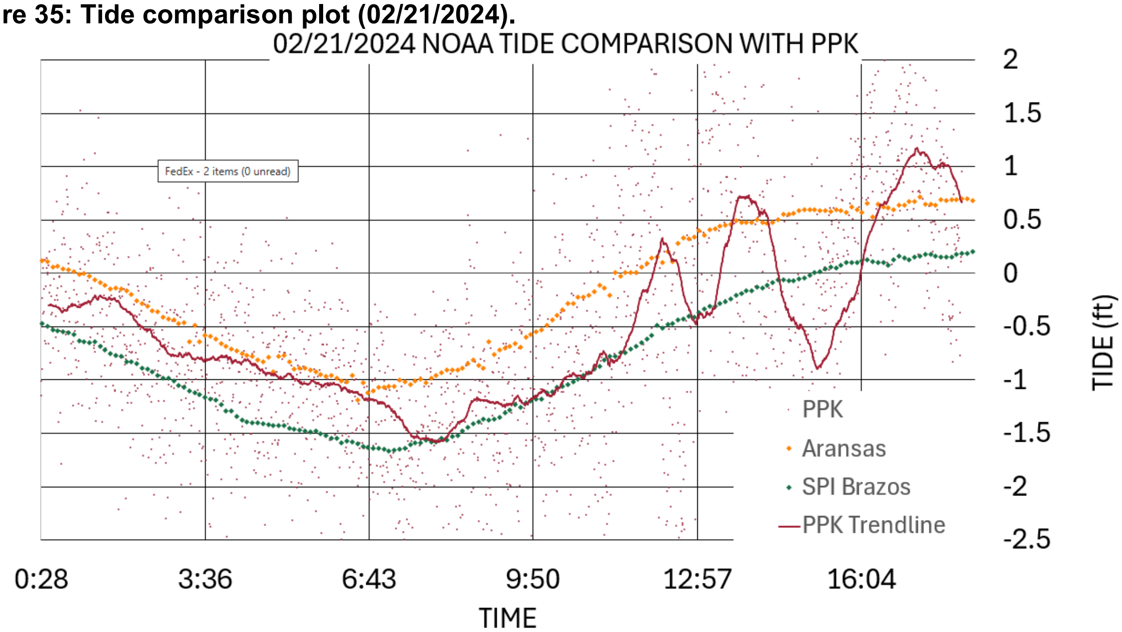
4 Task 3 Data Processing and Data Interpretation

Geophysical data processing, interpretations and results are outlined in the sections below.

4.1 Bathymetric Survey

Upon completion of the field work, data were edited and reduced with APTIM's internal software programs, Trimble Business Center (TBC), and Hypack 2022. The logged GNSS data were processed using TBC to aid with water level corrections. The GNSS derived water level corrections were compared with local National Oceanic and Atmospheric Administration (NOAA) water level gauges for verification purposes. The NOAA recording gauges compared well with the GNSS derived water levels in most areas. It was observed that the NOAA recorded water levels were more stable than the GNSS derived water levels in areas of long GNSS base lines from the CORS station. The final water level solution was derived using the 8775241 Aransas, Aransas Pass, TX NOAA recording water level gauge and the 8779749 SPI Brazos Santiago, TX NOAA water level gauge (Figure 35). All digitized soundings were scanned for noise with errant and false soundings removed. Water depths within the investigation area ranged from -174 to -81 feet (-53.0 to -24.7 meters) (NAVD88). Bathymetric maps are presented in Appendix A.

Figure 35: Tide comparison plot (02/21/2024).

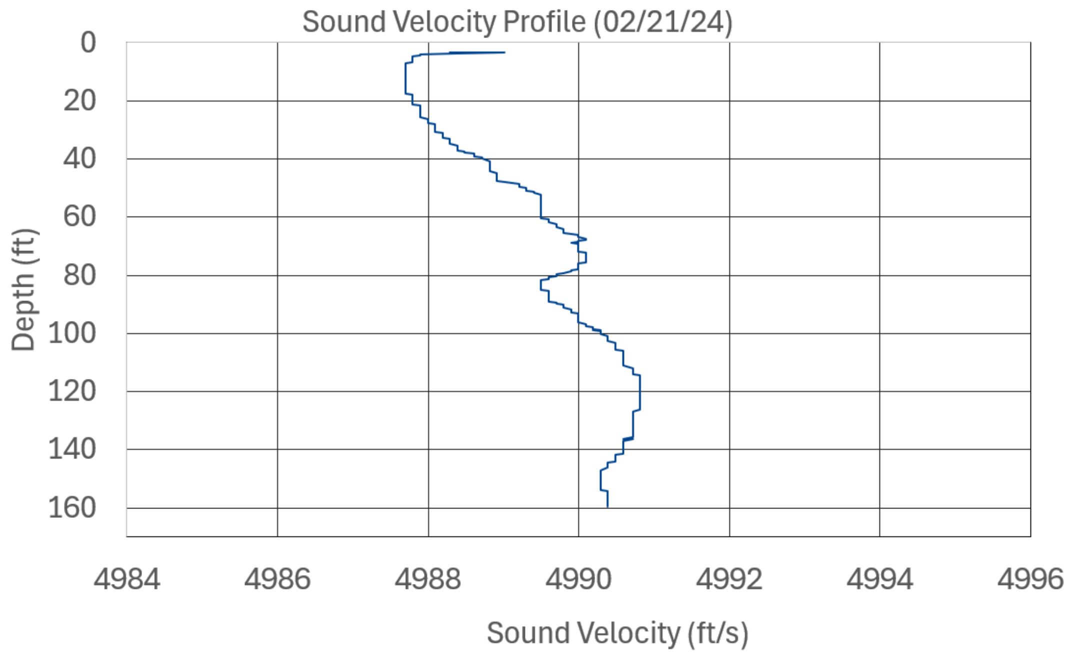


Data uncertainties were mitigated during both collection and processing phases using a range of instruments and procedures. Proper vessel mobilization, attentive and accurate data collection consistencies, as well as a stable processing method were used to ensure data quality and minimize uncertainties.

Prior to data collection, all instruments (including motion reference unit, GNSS antennas, and transducer) were mounted onto the vessel and offsets measured from the vessel center of mass. A vessel diagram depicting these offsets is presented in Appendix B**.** When installing the factory calibrated Teledyne TSS DMS-05 motion reference unit, field calibrations were also performed. During the calibration routine, the instrument measures average roll and pitch angles over an extended period while the vessel is not in motion. These averages are applied to the raw motion reference unit data, which accounts for any mounting angle bias that may be present.

The transducer draft was measured using conventional instruments after mobilization, and periodically throughout operations to ensure accurate depth determination. Bar checks were performed to verify draft/sound velocity corrections and to ensure proper echo sounder operation. Once draft/sound velocity measurements were taken, an acoustically reflective surface (bar) attached to a rope (or cable) is measured at a known distance from the waterline. Measurements are marked in 5 feet (1.5 meters) increments, allowing the bar to be placed at a maximum depth of 30 feet (9.1 meters) from the waterline. Once lowered underneath the transducer at a specific depth, the echosounder reading is compared to that of the true depth of the bar and verified using the digitized depth reading. A factory calibrated Valeport SWiFT SVP was used to measure sound velocity during the survey and can collect sound velocity casts while underway (Figure 36). Sound velocity casts were collected at an interval of approximately 0.5 feet (15.24 centimeters) throughout the entire depth range of the water column approximately every 4 hours or when sound velocity changes are suspected i.e., near inlets. Additional casts would be collected if deemed necessary (change in investigation area, thermoclines observed, etc.). All casts were recorded for post processing of the soundings. The average velocity is applied to the echosounder after each cast. Sound velocity profiles are applied to the processed data within Hypack to account for changes from the average velocity at depth.

Figure 36: Sound velocity cast profile example.



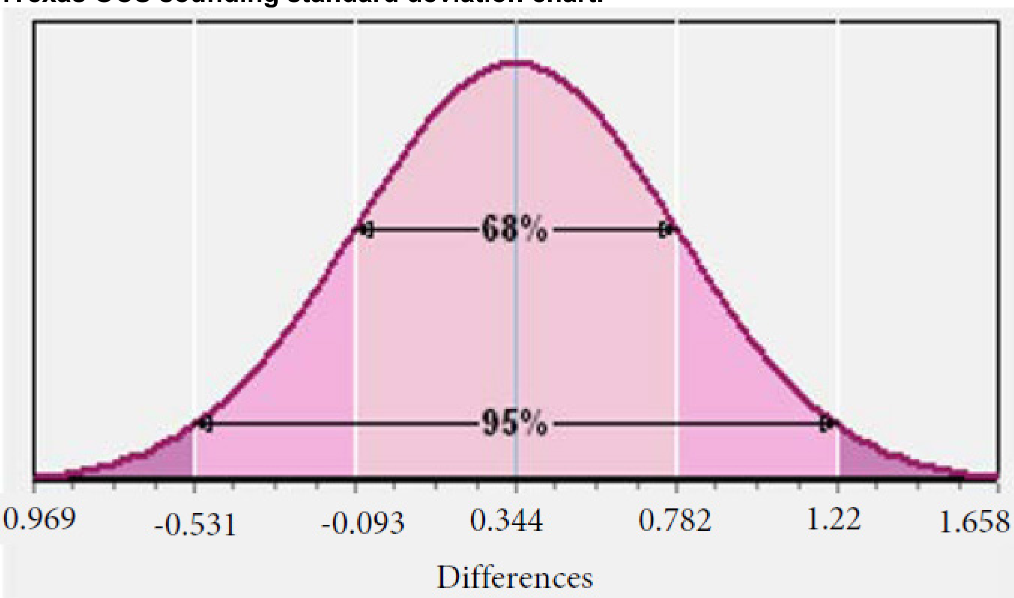
Following data collection, all data files were processed using Hypack's SBMAX64 program. Full sound velocity profiles, tide adjustments, and motion reference unit corrections were applied and analyzed for inconsistencies. Erroneous soundings were identified and removed within SBMAX64. Hypack's SORT Program was then used to reduce sounding data and export to an .xyz file which was used to create bathymetric maps presented in Appendix A. Hypack's Cross Check Statistics program was used to identify potential sounding inaccuracies. Cross Check Statistics provides detailed information regarding differences between data on intersecting lines at a user-defined search radius. The program displays the number of intersections within the given radius, standard deviation, difference mean, arithmetic mean, and minimum/maximum difference between intersections. Table 3 shows the Texas OCS Cross Check Statistical Report, generated using all main survey lines and tie lines. A graphical representation of sounding standard deviation is presented in Figure 37. Channels or large features within the investigation area can have a major effect on minimum and maximum difference depending on the search radius used. These values are not always an accurate representation of uncertainties. Values such as standard deviation, absolute difference mean, and arithmetic mean are of greater importance when performing any quality assurance checks within a given dataset.

Table 3: Texas OCS cross check statistical report.

Cross-Statistics Analysis	Value
Number of Intersections	174
Theoretical Number of Intersections	308334
Search Radius ft (m)	50.0 (15.24)
Standard Deviation ft (m)	0.438 (0.134)
Absolute Difference Mean ft (m)	0.344 (0.105)
Arithmetic Mean ft (m)	0.021 (-0.006)
Minimum Diff ft (m)	-1.453 (-0.443)
Maximum Diff ft (m)	1.175 (0.358)

Note: ft- feet; m- meters

Figure 37:Texas OCS sounding standard deviation chart.



A Trimble SPS 461 DGNSS was used for heading and positioning data during operations. A Trimble R8-4 Receiver was also aboard, allowing for PPK tide corrections. PPK data were processed using Trimble Business Center (TBC) and multiple survey days were compared to three of the nearest NOAA water level gauges (8775241 Aransas Pass and 8779749 SPI Brazos) to ensure accurate water level corrections.

The final tide corrections were derived using the centerline method from NOAA gauges 8775241 Aransas Pass and 8779749 SPI Brazos. A grid file was created with these xyz data using Surfer 23 to interpolate between the data points. A spacing of 250 feet x 250 feet (76.2 meters x 76.2 meters) was used, which was a sufficient resolution for the line spacing that they of the xyz data that were collected. The grid file was opened in ArcCatalog 10.8.2 and was exported as a raster .tif file so it can be viewed in ArcGIS PRO 3.4.0. The xyz data and the .tif file were opened in ArcGIS PRO and a border shapefile was created, allowing interpolated raster data outside of the investigation area to be clipped out. The .tif file was then smoothed using the Focal Statistics tool, and a classified color ramp was applied to the raster file. Contours were created based on the elevation of the raster .tif file using the Contour spatial analyst tool in ArcGIS. The final surface and contours are displayed in Appendix A and submitted digitally in Appendix C.

4.2 Magnetometer Survey

The magnetometer data were processed with Hypack 2024's Magnetometer Editing software to locate magnetic anomalies. The .raw data files were imported into and normalized manually to clean and remove any abnormal spikes or irregularities in the magnetic profile and to account for unwanted interference in the record, such as the survey vessel's effects or environmental and diurnal variations. Objects that possess any ferromagnetic mass (e.g., iron) can be detected with the magnetometer and are indicated by changes in magnetic intensity and visualized as monopoles, dipoles, and multi-component signatures in the profile view of the data. These varying signals distinguish the anomalies from the natural environment.

Each survey line was reviewed and interpreted in detail for the presence of magnetic anomalies. Upon completion of this review, anomalies were plotted and examined together with shapefiles of sidescan sonar contacts, known oil/gas pipelines, wells, and platforms, charted shipwrecks and obstructions, miscellaneous easements, artificial reefs, and buried transmission cables to find associations between the datasets. The Appendix A map series shows the extent of the magnetometer data coverage of the investigation area and the spatial distribution of anomalies.

The magnetometer survey data revealed 397 magnetic anomalies within the Lower OCS Investigation Area, as shown in Appendix A. Anomalies ranged from 4.33 to 14,673.98 nT in amplitude and from 17.39 to 1,142.75 feet (5.3 to 348.31 meters) in duration. Anomaly signatures consisted of 298 monopolar, 62 dipolar, and 37 multicomponent anomalies. Two of the identified anomalies were potentially associated with, or representative of, sidescan sonar contacts and 41 anomalies were potentially associated with, or representative of, features mapped in the shapefiles.

The magnetometer survey data revealed 210 magnetic anomalies within the Central OCS Data Gap Investigation Area, as shown in Appendix A. Anomalies ranged from 5.21 to 3,400.48 nT in amplitude and from 39.64 to 1,023.41 feet (12.08 to 311.93 meters) in duration. Anomaly signatures consisted of 136 monopolar, 52 dipolar, and 22 multicomponent anomalies. One of the identified anomalies was potentially associated with, or representative of, sidescan sonar contacts and 100 anomalies were potentially associated with, or representative of, features mapped in the shapefiles.

The magnetometer survey data revealed 636 magnetic anomalies within the Upper OCS Data Gap Investigation Area, as shown in Appendix A. Anomalies ranged from 4.7 to 16,569.42 nT in amplitude and from 17.05 to 1,519.31 feet (5.19 to 463.08 meters) in duration. Anomaly signatures consisted of 413 monopolar, 158 dipolar, and 65 multicomponent anomalies. One of the identified anomalies was potentially associated with, or representative of, sidescan sonar contacts and 209 anomalies were potentially associated with, or representative of, features mapped in the shapefiles.

A close-order survey with multiple survey lines using a tighter line spacing would be beneficial to refine the magnetic record in the survey area, as it would provide an opportunity to generate a magnetic contour map. Magnetic contour maps can provide valuable insight into the magnetic anomalies present in an area such as their source, size, orientation, distribution, and signature.

4.3 Sidescan Sonar Survey

Sidescan sonar data was processed using Chesapeake Technologies, Inc. SonarWiz 8 software. The raw sidescan sonar data was imported into four SonarWiz 8 projects. Two SonarWiz projects were for low frequency: one was projected in Texas South and the other low frequency project was projected in Texas South Central. The other two SonarWiz projects were for high frequency with one projected in Texas South and the other one projected in Texas South Central. This was due to the large file sizes and data coverage over such a large area. Once the data were imported, they were bottom tracked to remove the water column (nadir) recorded in the data. Bottom tracking was achieved by applying an automated bottom tracking routine that determined the first return signal in the data and provided an accurate baseline representation of the seafloor that eliminated the water column from the data. In some cases, manual bottom tracking was necessary when the automated bottom tracking could not accurately determine the first return in the sidescan sonar record. For these cases, the APTIM geophysicist manually determined the first return in the data.

After bottom tracking, the data was processed to reduce noise effects and enhance seafloor definition. To do this, an Empirical Gain Normalization (EGN) table was built which sums and averages the sonar amplitudes of every ping in the imported files by altitude and range. The EGN is a gain function that can be considered a replacement for Beam Angle Correction. A given sonar amplitude sample is placed in a grid location based on the geometry of the ping, where the x-axis is range, and the y-axis is altitude. The resulting table quantifies the beam pattern of a sonar by empirically analyzing millions of data points. Due to the sea state and shallow water conditions observed in portions of the investigation area, a small percentage of the sidescan sonar lines contain reduced data quality, resulting in noise and stripes. To mitigate this, a Nadir and de-stripe filter were applied. The Nadir Filter is a special version of the AGC filter that runs only along the nadir stripe. It is designed to reduce the difference between the nadir pixel values and the values immediately outside the nadir. The De-Stripe Filter is used to reduce the effects of sonar 'pitching' that is characterized by a stripy pattern perpendicular to the direction of travel. This setting processes each ping by comparing the current ping brightness to a filtered version of the sonar file that has smoothed out the stripes.

Following the processing phase, the data was interpreted to identify areas of potential seafloor hazards such as artificial reefs, submerged platforms, and the surficial geology of the seafloor. Potential areas of interest were digitized and categorized into subsection bottom types. APTIM geologists utilized backscatter intensity, distribution, and texture to make best professional interpretations of the features; however, these interpretations are based solely on the acoustic backscatter data and further ground truthing is recommend for confirmation of the acoustic interpretation.

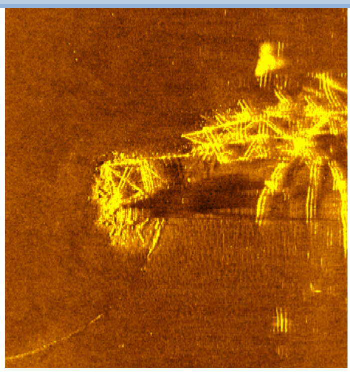
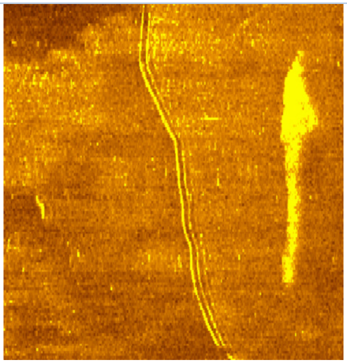
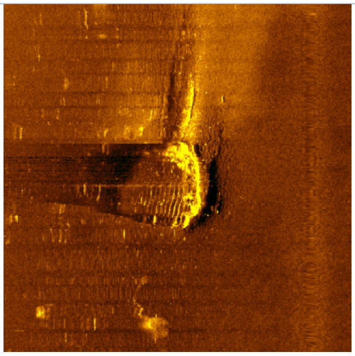
The widely spaced survey lines collected throughout the investigation area covering the Lower OCS Investigation Area were collected with the EdgeTech 4205 towfish which provided a limited image of the seafloor. The maximum range of the system was 1,150 feet (350 meters) at the 230 kHz frequency and 492 feet (150 meters) at the 540 kHz frequency to either side of the towfish, which was insufficient to allow for full seafloor coverage or interpretation between lines given tie line spacing of the survey. Therefore, the digitized features were "isolated" to individual lines but provide a general location and description of areas/features of interest. Identified sidescan sonar targets are submitted digitally in Appendix D and maps with sidescan sonar data can be found in Appendix A. The identified sidescan sonar targets were submitted separately as part of the Marine Minerals Information System (MMIS) deliverable for this project.

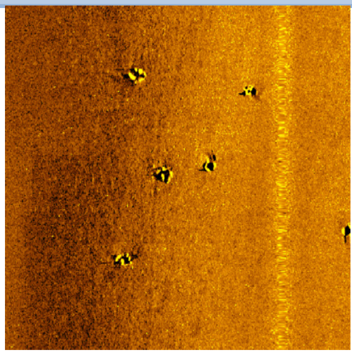
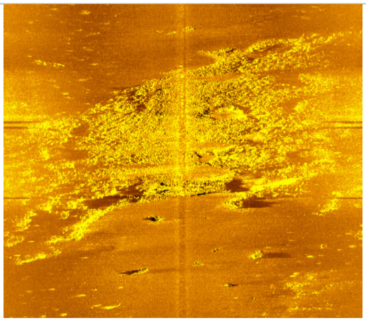
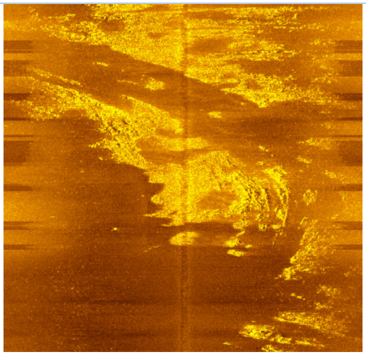
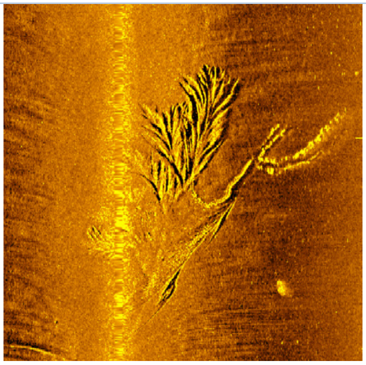
Based on the sidescan sonar interpretations, 86 contacts or targets were identified throughout the investigation area. Contacts and targets include unknown debris and features, schools of fish and dolphins, fishing associated features (Shrimp Trawler Scour Marks), anchor scouring, exposed cables, and oil/gas infrastructure (Platforms, Wellheads, Associated Debris, and Exposed Pipelines). Examples of each identified bottom type are presented in Table 4.

Throughout the Lower OCS Investigation Area, a large pockmark field was identified. Pockmarks are seabed depressions caused by escaping fluids or gases within seabed sediments; in most instances, this is related to hydrocarbon gases. They vary in size according to the nature of the seabed sediments and are generally between a few meters and a few hundred meters across, and from less than 3 feet (1 meter) to about 66 feet (20 meters) deep (Hovland and Judd 1988). Two of the South Texas Banks were observed and identified, one being the East Bank approximately 21 mi (33.8 km) offshore the United States and Mexico border, extending north about 7 mi (11.3 km). The other bank was the Seabree Bank about 14 mi (22.5 km) off South Padre Island, Texas. These banks represent hardbottom (rocky outcrops and ancient coral reefs) off the coast of Texas. Based on the sidescan sonar acoustic backscatter data, no sand ripples or wave bedforms were identified in the Lower OCS Investigation Area. However, higher intensity acoustic backscatter, indicative of sandy material, was identified in areas which correlate with the sub-bottom profiler data. In the Central OCS Data Gap Investigation Area, pockmark fields were identified throughout, and no visible surficial bedforms indicative of sand resources were identified in the sidescan acoustic backscatter. In the Upper OCS Investigation Area, a large strip of sand was identified going through multiple shore parallel lines and runs parallel to the Galveston Ship Channel, on the southwest side. This strip of sand is perpendicular to the shore and is about 0.5 mi (0.8 km) wide, about 13 mi (20.9 km) long and starts 13 mi (20.9 km) offshore Galveston, Texas (

Figure 38). No known Offshore Dredge Material Disposal Sites are in the area. The high intensity backscatter is indicative of coarse sand sediments, sand waves were also observed at the furthest offshore point of this feature.

Table 4: Sidescan sonar bottom feature classification.

Bottom Feature/Description	Example
Oil and Gas Infrastructure High-intensity backscatter feature correlated with an area of known platforms.	 Line 123.008
Exposed Pipeline/Cable medium intensity backscatter linear feature.	 Line 123.008
Potential Debris Obstruction High-intensity backscatter feature with irregular depositional formation correlating with known obstruction	 Line 101.018

Bottom Feature/Description	Example
Pockmark Field Pockets of gas escaping the surficial sediment layer	 Line 110.030
Seabree Bank Part of Seabree Bank hardbottom offshore of South Padre Island in federal waters	 Line 208.006
East Bank Part of East Bank hardbottom offshore the U.S. and Mexico border in federal waters	 Line 203.002
Anchor Scour Scouring formation consistent with anchoring	 Line 109

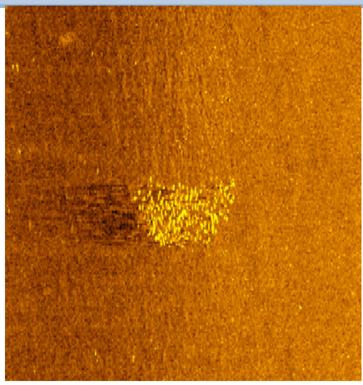
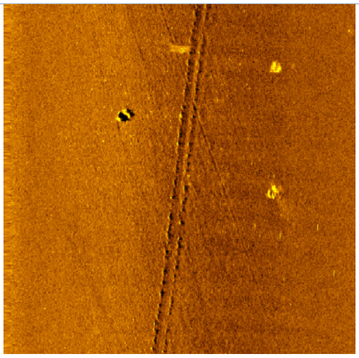
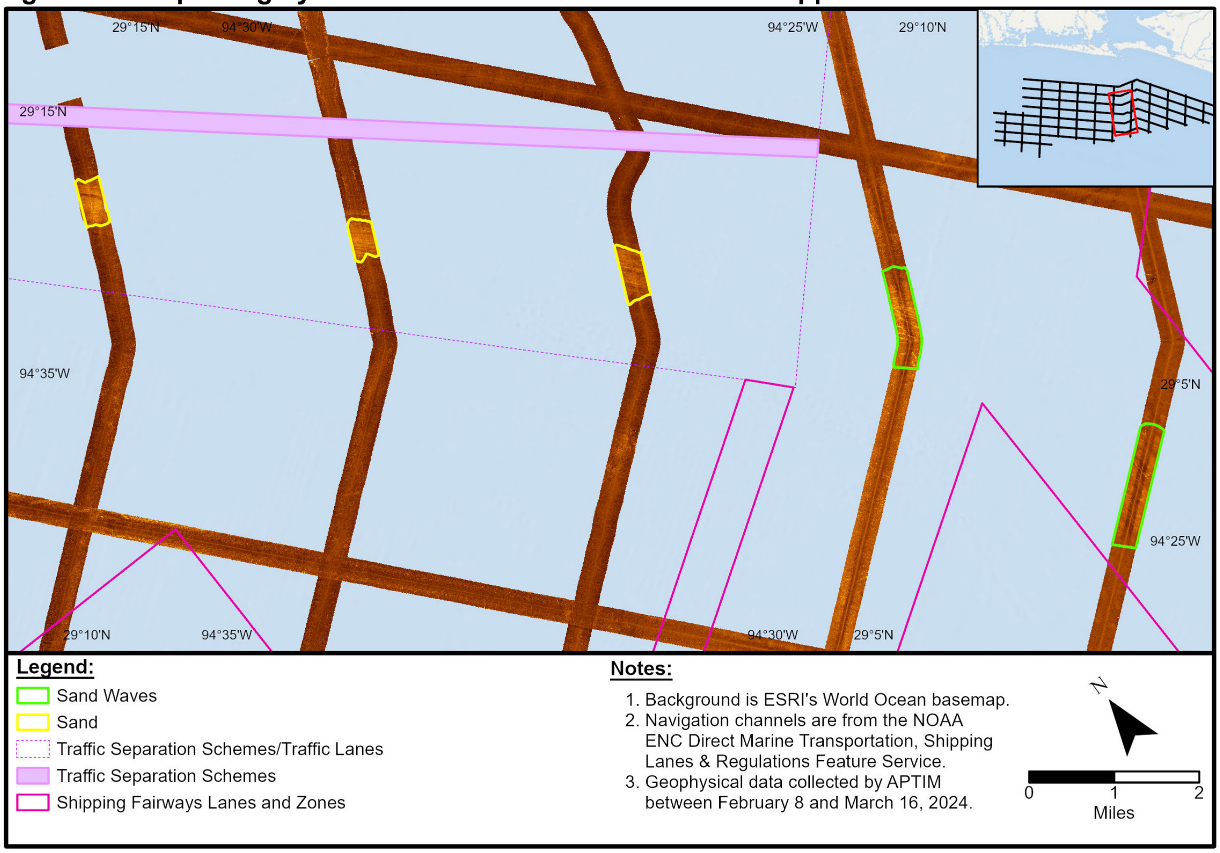
Bottom Feature/Description	Example
Bait Ball Medium-intensity backscatter with small shadow, consistent with schools of fish	 Line 114.004
Shrimp Trawl Marks Scouring consistent with shrimp trawls	 Line 113.001

Figure 38: Strip of highly reflective coarse sand bodies in the Upper OCS sidescan sonar data.



4.4 Sub-bottom Profile Survey

Data processing and interpretation of the chirp sub-bottom data was conducted by APTIM and TWI for the identification and delineation of potential sand resources, the latest transgressive ravinement, localized features and geologic framework. Results from the seismic data are presented below.

4.4.1 Post Processing

Post collection processing of the sub-bottom data was completed using Chesapeake Technology, Inc.'s SonarWiz 7 software. This software allowed the user to apply specific gains and settings to produce enhanced sub-bottom imagery that were interpreted and digitized for specific stratigraphic facies relevant to the project goals.

The first data processing step was to calculate the approximate depth of the reflector below the sound source by converting the two-way travel time (the time in milliseconds that it takes for the "chirp pulse" to leave the source, hit the reflector and return to the source) to feet by utilizing an approximate value for the speed of sound through both the water and underlying geology. For this survey, a detailed hydrographic and geologic sound velocity structure was not available, so APTIM geophysicists used an estimated sound velocity of 5.25 feet per millisecond (ft/ms) (1.6 meters per millisecond [m/ms]) to convert two-way travel time to feet. This estimate of the composite sound velocity is based on several assumptions including the speed of sound through water, which is typically 4.92 ft/ms (1.5 m/ms) as well as on the speed of sound through the sediment that can vary from 5.25 ft/ms (1.6 m/ms) for unconsolidated sediment to greater than 5.58 ft/ms (1.7 m/ms) for limestone.

APTIM geophysicists then processed the imagery to reduce noise effects (commonly due to the vessel, sea state, or other natural and anthropogenic phenomenon) and enhance stratigraphy. This was done using the processing features available in SonarWiz, specifically the AGC and swell filter. The SonarWiz AGC is similar to the Discover-SB AGC feature, where the data are normalized to remove the extreme high and low returns, while enhancing the contrast of the middle returns. To appropriately apply the swell filter, the sub-bottom data was bottom tracked to produce baseline representation of the seafloor. Once this was done, through a process of automatic bottom tracking (based on the high-amplitude signal associated with the seafloor) and manual digitization, the swell filter was applied to the data. The swell filter is based on a ping averaging function that removes vertical changes in the data due to towfish movement caused by the sea state. The swell filter was increased or decreased depending on the period and frequency of the sea surface wave conditions, however, particular care was taken during this phase to not remove, or smooth over geologic features that are masked by the sea state noise. A blank water column function was also applied to cut any features such as schools of fish under the chirp system which produce reflected artifacts within the water column.

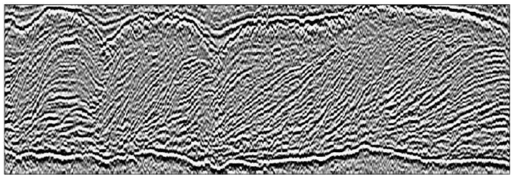
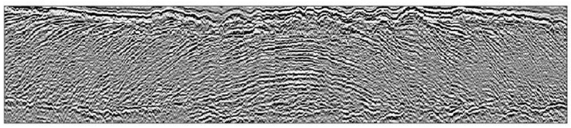
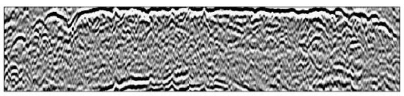
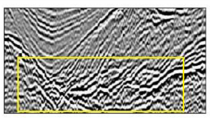
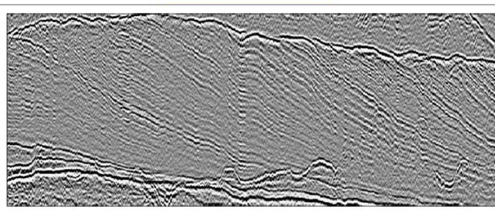
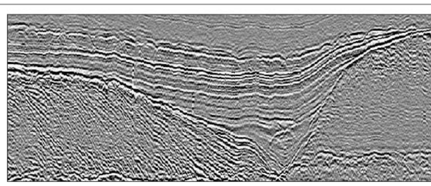
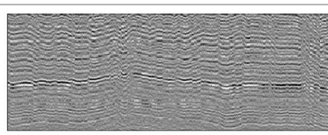
The primary objectives of initial sub-bottom data interpretation were three-fold: 1) identify the latest transgressive ravinement surface and map the thickness of subsequently deposited sediments, 2) identify paleochannels and paleovalleys that could contain accessible sediments and, if necessary, revise the regional geologic model/framework, and 3) identify localized faults and parabolic apexes (indicative of pipelines).

Processed sub-bottom profiler data were interpreted within SonarWiz. Interpretation involved the identification of seismic reflection horizons that serve as boundaries for different seismic facies packages (Figure 39). These horizons can be erosional unconformities such as the basal scour surface of a lateral migrating fluvial channel, or contacts representing a change in environment and associated lithology such as transgressive flooding leading to estuarine fine-grained sediment draping over a previously exposed floodplain (Reijenstein et al. 2011). The character of sub-bottom reflection horizons and geometries in continental shelf seismic stratigraphy can often be related to characteristics of silt, clay, sand, and the environment of deposition (localized features, ravinement, etc.). These principles were used to interpret individual profiles that were combined to develop regional geologic conceptual models, such as defining the paths of paleo-river channels. These conceptual models helped to find zones with potential sand-bearing sediment. It important to note that interpretation of lithology using sub-bottom profiler data must always be "ground-trothed" using geologic cores, and in the absence of core data for validation, these interpretations are regarded as preliminary.

Upon completion of interpretation and digitization, the sub-bottom data were exported as a "Web" based project of HTML/JPEG files viewable in standard web browser software packages and sent separately to BOEM.

Figure 39: Example classifications of sub-bottom profiler data based on seismic horizon reflection character and geometry.

Note: The first four are representative of sandy fluvial channel belt deposits, and the last three represent deltaic, estuarine, and marine deposition. From Reijenstein et al. (2011).

2-D Seismic Facies	Reflection Character / Sedimentologic Interpretation
	**Convex-up lateral accretion surfaces. High-amplitude inclined seismic facies** Point-bar lateral accretion surfaces as seen in a dip-view cross section; Convex-up geometry with downdip increase in slope: 0.49° to 0.62° (point-bar tops) and 0.48° to 3.74° (basal point bar).
	**Convex-up bidirectional downlap; High-amplitude inclined seismic facies** Point-bar lateral accretion surfaces as seen in a strike-view cross section
	**Low-amplitude chaotic seismic facies** Reworked point-bar top deposits
	**High-amplitude channel lag seismic facies** Basal coarse-grained channel lag
	**Concave-up clinoforms; Low-amplitude inclined seismic facies** Clinoform deltaic mouth bar deposits; Concave-up geometry with downdip decrease in slope: 1.76° to 2.04° (clinoform tops) and 0.37° to 0.91° (basal section)
	**High-amplitude, confined, laterally continuous reflections; Seismic terminations onlap against valley walls** Early transgressive estuarine muddy facies
	**Low-amplitude (transparent), laterally continuous seismic facies** Open marine muddy facies

4.4.2 Interpretation of Paleochannels, Potential Sand-Bearing Features, and Development of the Regional Geologic Model

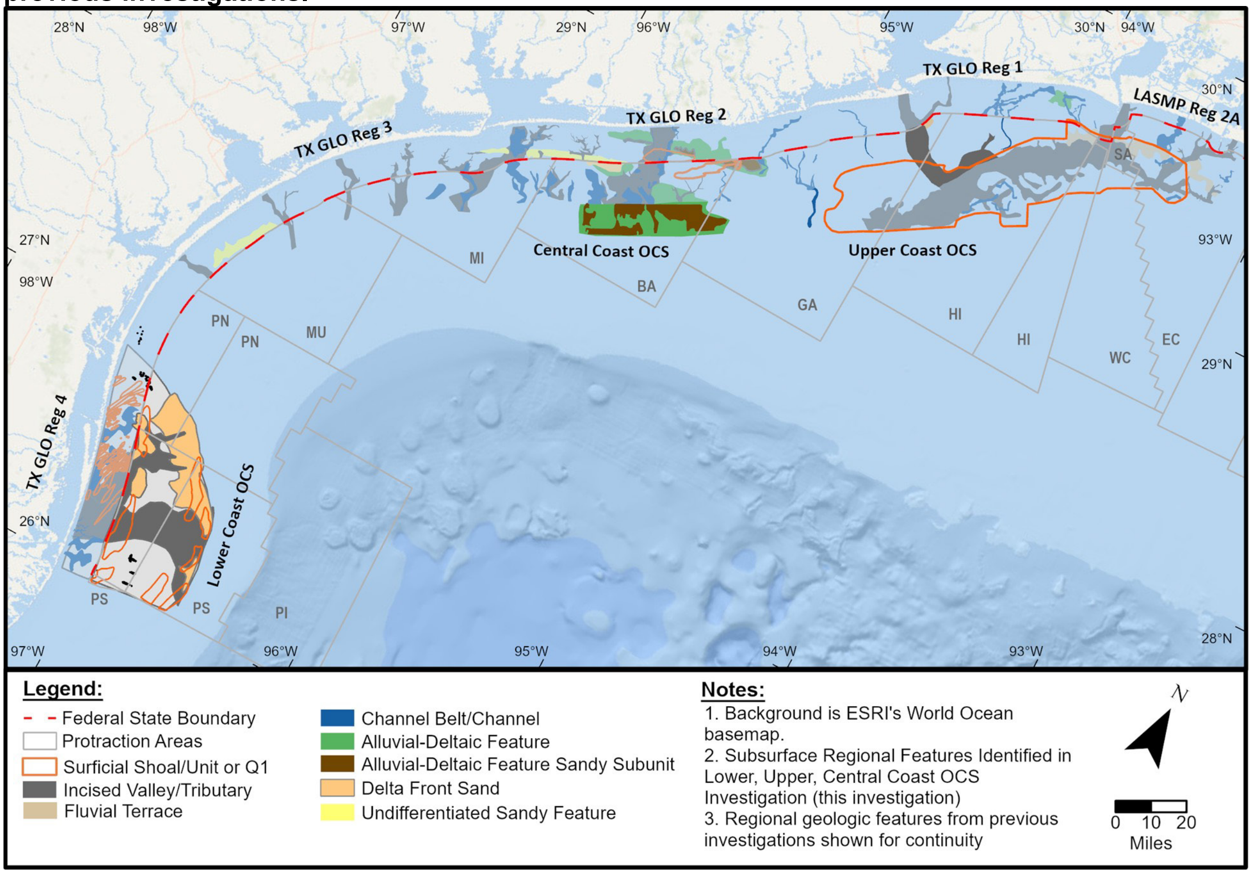
Chirp sub-bottom data were collected in variable grid spacing across Lower, Central, and Upper Texas OCS waters offshore Cameron, Willacy, Kenedy, Kleberg, Nueces, Aransas, Calhoun, Matagorda, Brazoria, Galveston, Chambers, and Jefferson counties in Area Codes PS, PN, MU, MI, BA, GA, and HI. The data were processed in SonarWiz following the procedures outlined in Section 4.4.1 above. The resulting data were systematically interpreted to outline the locations of potential sand-bearing stratigraphy with a maximum of 20 feet (6 meters) of overburden (the overlying non-compatible sediment between the potential sandy deposit and the seafloor). Seismic reflector horizons marking the top and bottom of the potential sand feature were digitized within SonarWiz to generate 2-D surfaces and isopach (unit thickness). Note, several features are presented due to their importance to the regional geologic model but are excluded from potential sand resource quantification due to the presence of excessive overburden. The sections below provide examples of these features within the sub-bottom data and are organized by regions as follows: 1) Lower OCS Investigation Area (PS, PN), 2) Upper OCS Data Gap Investigation Area (GA, HI, MI), and 3) Central OCS Data Gap Investigation Area (MU, MI, BA, GA). Isopach maps for each potential sand-bearing feature where the top and bottom of the feature could be clearly mapped are included in Appendix A.

In tandem with mapping these features, regional surfaces were correlated where possible to inform the preliminary regional geologic model. The only regionally mappable surface identified is the latest transgressive ravinement surface (the erosional surface generated as sea level approached current levels), which is present in nearly all of the OCS investigation area. Most of the features identified incise existing older subsurface stratigraphy and the cross-cutting or overprinting nature of the multiple transgressive and regressive episodes in the slowly subsiding Texas shelf (Anderson et al. 2016) and incomplete preservation of earlier regional surfaces.

This effort focused on identifying the stratigraphic record of major regional fluvial systems such as the Rio Grande, Colorado, Trinity, and Sabine rivers and potential tidal/estuarine/alluvial, deltaic, and surficial shoal systems. The regional geologic model is built by systematically mapping the location, extents, and characteristics of these large-scale features and can be used to identify areas which are likely to contain sand-bearing stratigraphic elements and nomination as potential sediment resource areas. Potentially significant sand-bearing elements identified in the mapping and creation of the model have had surfaces and isopachs generated from the mapped seismic horizons (Appendix A).

Overall, the OCS regions contain a significant number of potential sand-bearing units located within Texas federal waters in the form of surficial shoals, fluvial deposits, alluvial and/or deltaic deposits, as well as other more enigmatic elements (Figure 40**)**. Importantly, potential sand-resource units are interpreted with less than 20 feet (6 meters) of overburden across the entirety of the OCS regions, some of which have never been previously identified. A major limiting factor in the investigation area is the Texas Mud Blanket, a thick mud deposit that fills the central Texas Embayment and overlies several sediment features in the Lower and Central OCS. The following sections summarize the main findings for each sub-region.

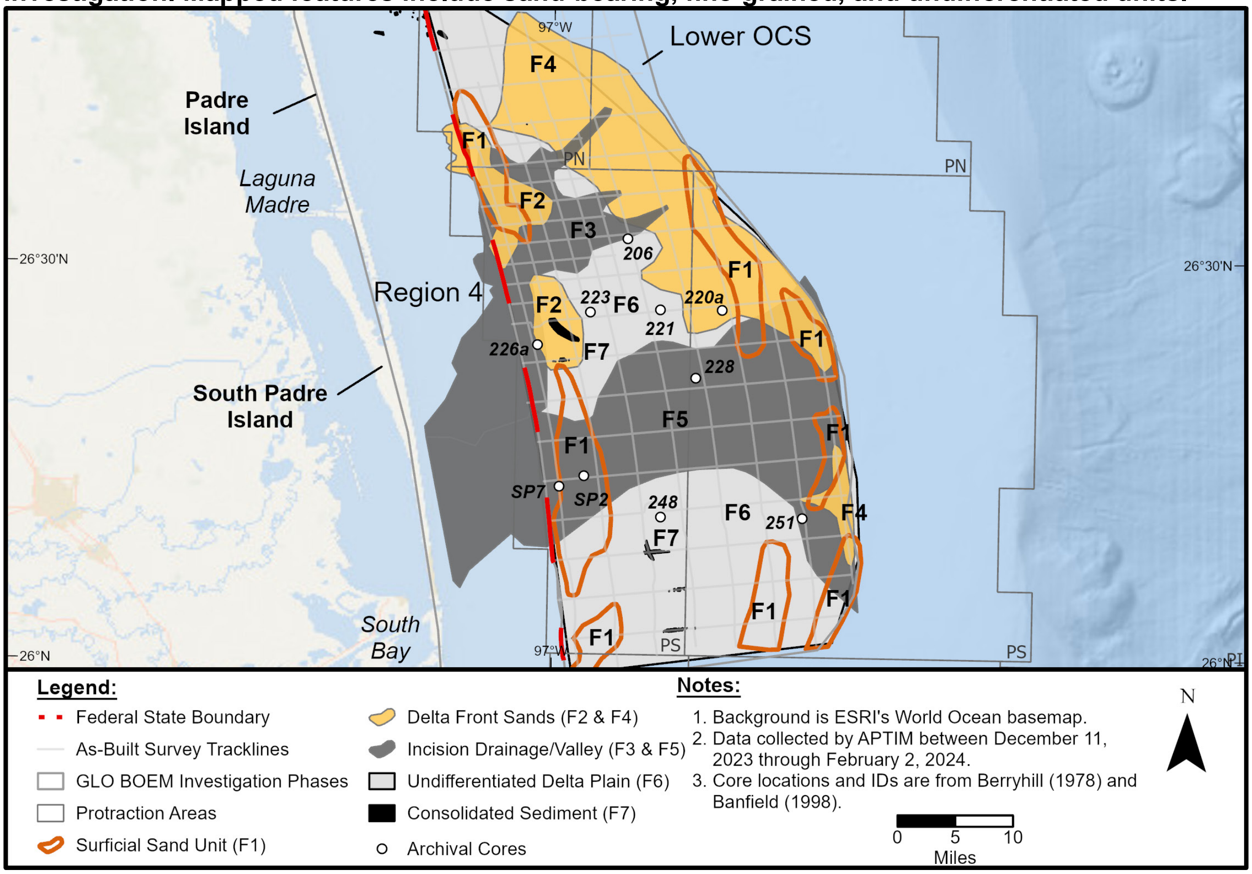
Figure 40: Mapped sub-surface geologic features within the Texas inner shelf from current and previous investigations.



4.4.3 Lower OCS Investigation Area

The Texas Lower OCS extends offshore Padre Island and Baffin Bay. The Lower OCS Investigation Area covers Area Codes PS and PN offshore of Kenedy, Willacy, and Cameron Counties. The investigation area contains numerous potential sand-bearing and non-sand-bearing geologic features that are likely related to growth and deposition of the Rio Grande River during the Late Quaternary (Anderson et al. 2016), preserved river and delta deposits until the recent Holocene, and modern sand shoals (Figure 41). The characteristics, interpretation, and sand-resource potential of each identified of the seven major regional geologic features, as well as the many localized features, are presented below.

Figure 41: Map of all seven described geologic features (Feature 1- Feature 7) from the Lower OCS investigation. Mapped features include sand-bearing, fine-grained, and undifferentiated units.



4.4.3.1 Feature 1 Surficial Sand Units

Feature 1 is composed of eight surficial sand units located in the southern portion of the Lower OCS Investigation Area, south of the Texas Mud Blanket (TMB). The eight identified surficial units have variable bathymetric expressions, some units show prominence while others appear to fill accommodation created by underlying deposits. The surficial sand units have a stronger intensity return in sidescan sonar compared to the central portion of the investigation area and occur at minor changes in bathymetric slope. The shoreline parallel, linear surficial sand units form two trends at the 100 feet (30 meters) and the 165 feet (50 meters) bathymetric contours (Figure 42). These units are characterized by fuzzy to transparent seismic packages bounded by a strong to hazy surficial reflector and the transgressive ravinement surface. The surficial sand units are encountered overlying of a variety of units including Delta Front Sands (Feature 2), Rio Grande valley fill (Feature 3), Shelf Delta Front Sands (Feature 4), and undifferentiated delta plain (Figure 43). The surficial units have an average thickness of 4 feet (1.2 meters) with four units reaching up to 10 feet (3 meters) thick of sand-rich sediment. The surficial units are found either overlying or proximal to subsurface sand-rich deposits. The shore parallel, linear surficial units are interpreted as rough delta lobe boundaries that were partially reworked by oceanographic processes. They not only represent significant sand resources themselves but also likely relate to underlying sand-rich deposits of the older delta system that could provide additional resources. Sediment grain size composition could not be confirmed with available archival core or boring samples. Archival grab samples indicate sand compositions ranging from 5 to over 50 percent sand (Shideler 1976) where the surficial units are delineated (Figure 42) and should be further constrained with geotechnical sampling.

Figure 42: Map displaying the bathymetry and outlines of the surficial sand units (Feature 1) in the Lower OCS Investigation Area (left), map of surficial sand percentages determined from grab samples from Shideler (1976).

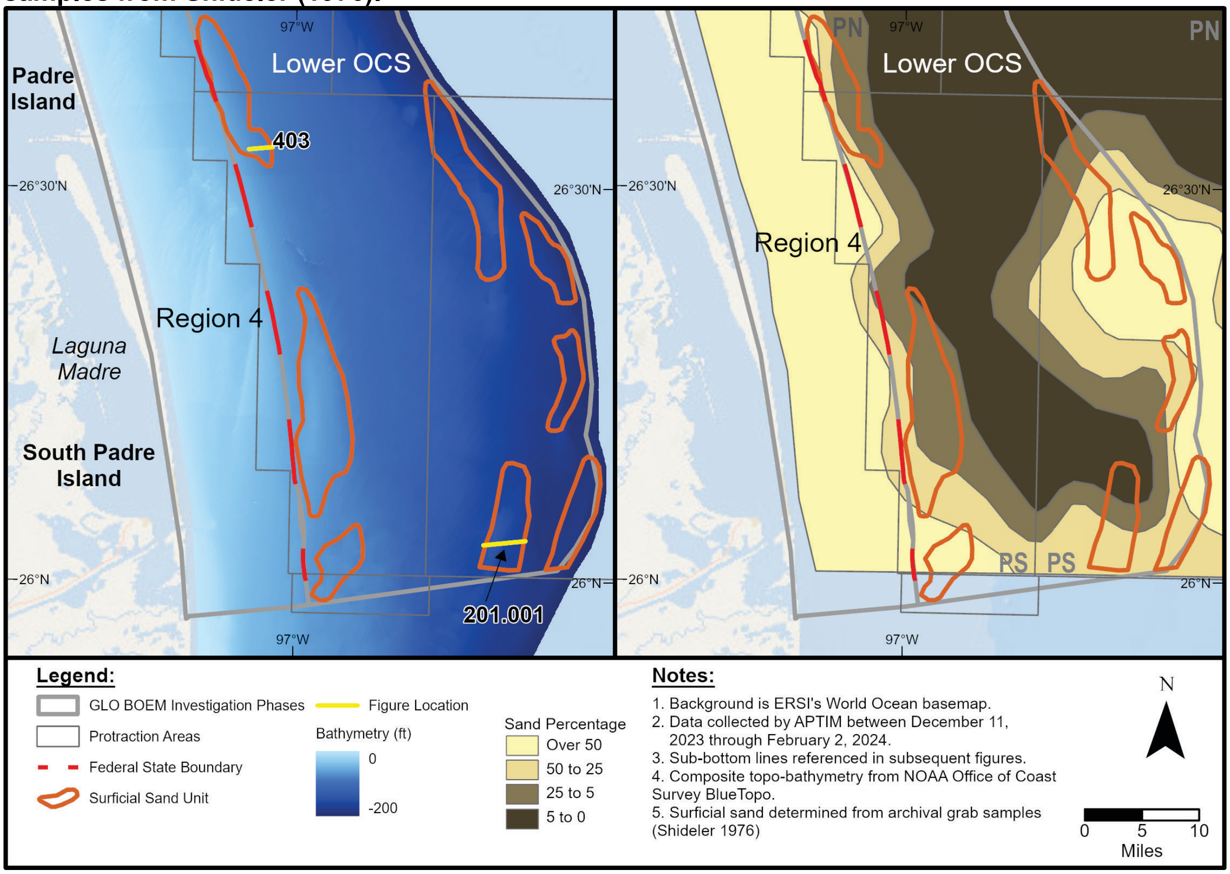
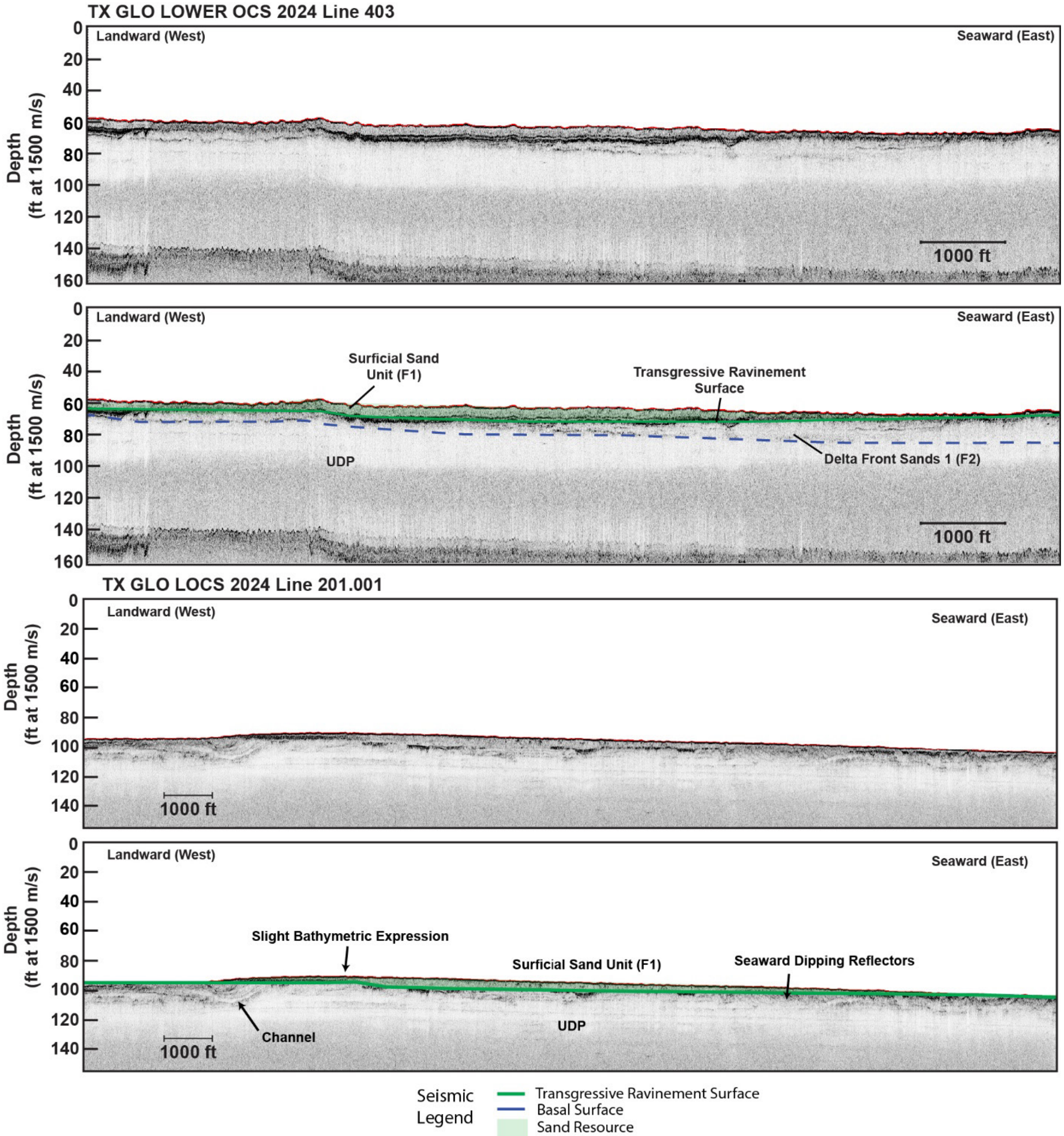


Figure 43: Seismic examples of surficial sand units within the investigation area.
Feature 1 units overly what has been interpreted as Delta Front Sand deposits (Feature 2), Shelf Delta Front Sands (Feature 4), incised valley fill (Feature 5), and undifferentiated delta plain. Some units from Feature 1 display surficial expression on the seafloor, while others do not.



4.4.3.2 Feature 2: Region 4 Feature 5 Delta Front Sands LOCS Extension (DFS1)

Feature 2 are Delta Front Sand deposits that extend from the TX GLO Region 4 investigation area (Region 4- Feature 5) (APTIM and TWI Forthcoming) (Figure 44). This unit is characterized by transparent to seaward dipping internal reflectors in seismic. The overall fill to wedge shaped morphology is capped by the transgressive ravinement surface at its thickest portions. Feature 2's thickness is variable, with an average thickness of 9 feet (2.7 meters) and a maximum thickness of 23 feet (7 meters) from seismic (Figure 45). The total area of this unit, including the Region 4 portion, is 35.4 mi^2 (91.7 km^2) with an average overburden of 8 feet (2.4 meters). This feature is interpreted as Delta Front Sands (Feature 2) extending from similar delta front deposits mapped in the concurrent Region 4 investigation and fed by feeder distributary channel systems mapped in state waters. The Lower OCS Delta Front Sands overlie the Undifferentiated Delta Plain and Rio Grande Incised Valley Fill 2 (Figure 45). In some areas the Delta Front Sand is overlain by the Surficial Sand Unit (Figure 46). Further geologic sampling and age constraint data would help resolve the timing and evolution of this unit.

Figure 44: Map of Feature 2, neighboring features in the Lower OCS, and related units from the concurrent Texas GLO Region 4 investigation (APTIM and TWI Forthcoming)

Note that a large portion of this unit is overlain by a Surficial Sand Unit (Feature 1; outlined in orange), which would further increase sand resource volumes in those areas. This unit extends to the southeast, incising into the underlying Rio Grande Incised Valley unit (Feature 3).

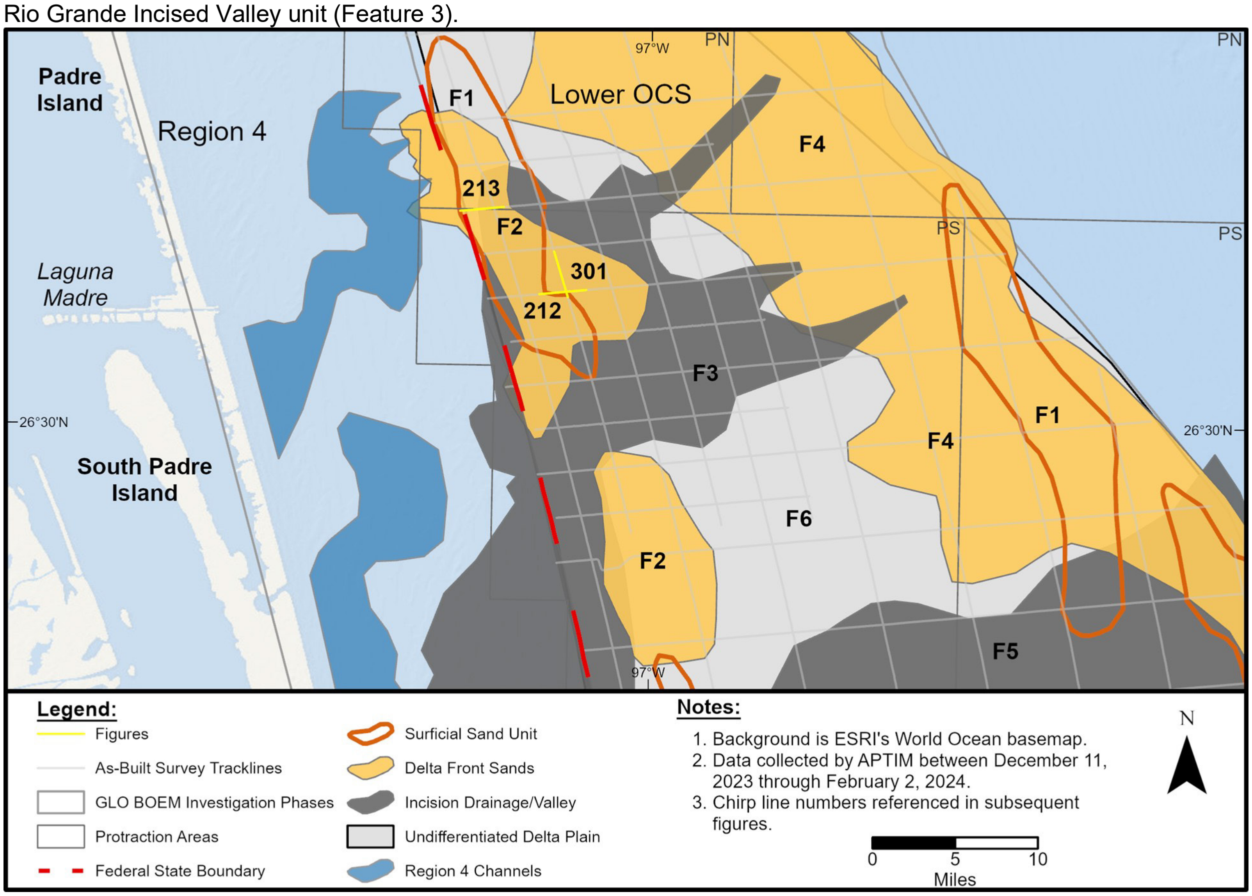


Figure 45: Examples of Feature 2 Delta Front Sands.

Note dipping to transparent reflectors, as well as the blanking beneath the identified sand unit within the laminated Rio Grande Incised Valley fill (Feature 3).

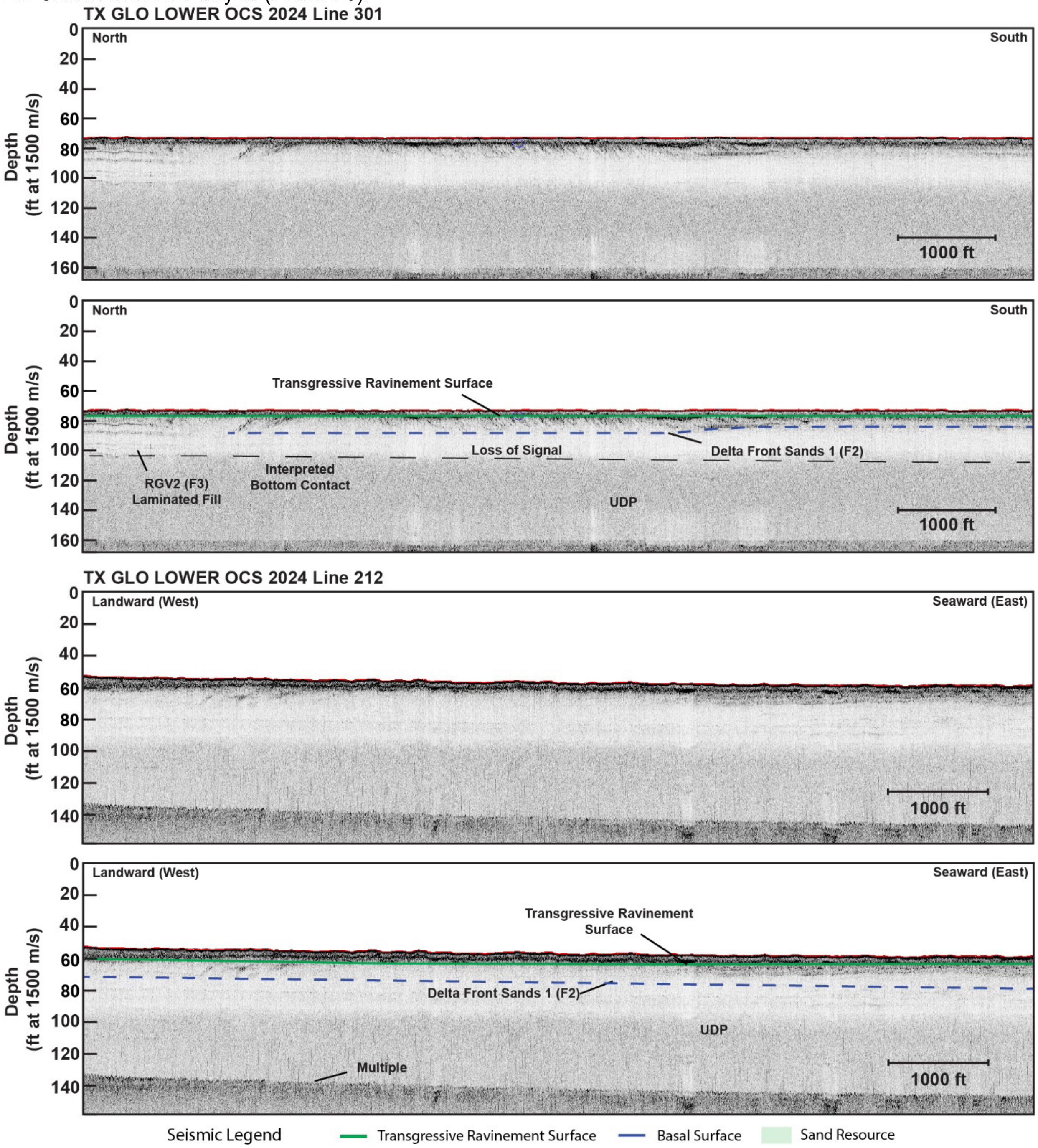
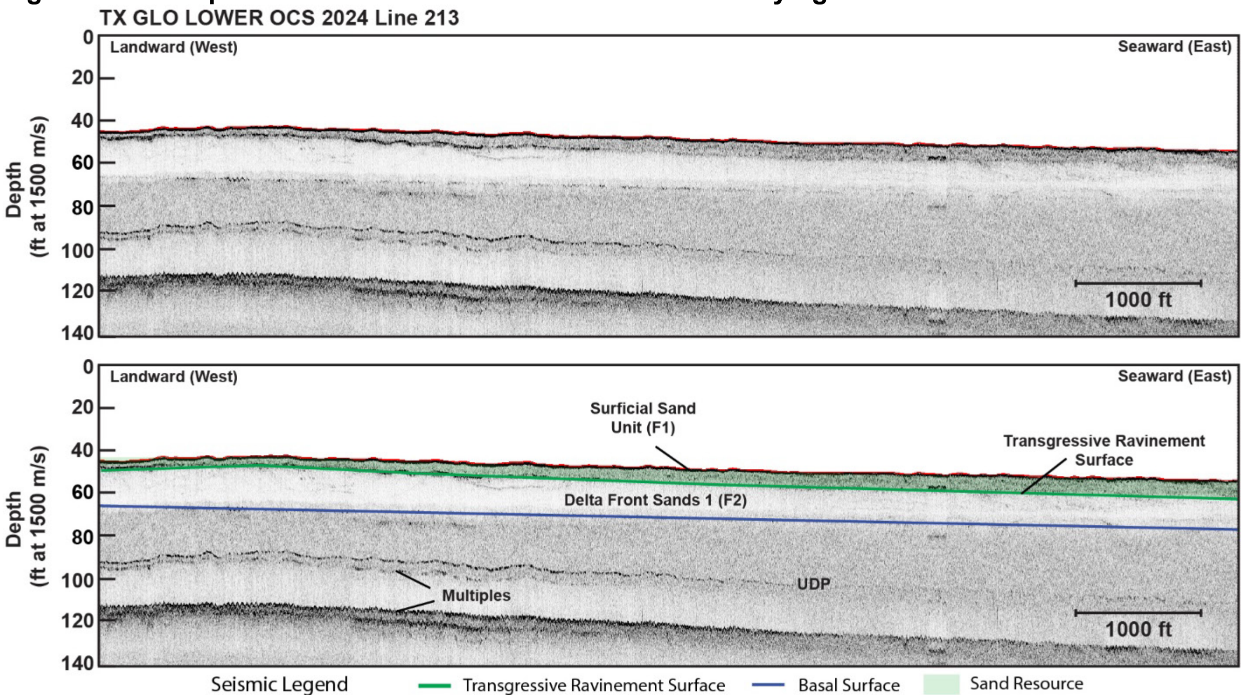


Figure 46: Example of Feature 2 Delta Front Sands with overlying Feature 1 Surficial Sand Unit.



4.4.3.3 Feature 3: Rio Grande Incised Valley 2

The Rio Grande Incised Valley 2 (TX GLO Region 4, Feature 8) extends from the neighboring Region 4 and represents an adjacent of the main Rio Grande Incised Valley to the south (Figure 47). This feature is characterized by a basal erosional unconformity with laminated to transparent fill capped by the transgressive ravinement surface (Figure 48). The generally broad incised valley becomes more channelized and displays multi-generational, nested and cross cutting channels with variable amounts of lateral migrations. Individual channels within the larger valley have incisional depths of roughly 55 feet (16.7 meters). This incised valley has a width of approximately 10 mi (16 km) in the central portion of the feature, and branches into three smaller resolvable valley branches seaward. These channels grade into expansive shelf delta front sands. This feature is also overlain by the TMB in some northern portions. The Rio Grande Incised Valley 2 itself is not a potential sand resource; however, it was the conduit for the Shelf Delta Front Sand deposits (Feature 4) that are interpreted to radiate out from this incised valley and associated valley branches. The potential laterally migrating channel belts are likely sand-rich but have greater than 20 feet (6 meters) of overburden and are discounted as sand resources.

Figure 47: Map displaying Features 3-5; the Rio Grande Incised Valleys and the associated Shelf Delta Front Sands.

The southern, main trunk of the Rio Grande Incised Valley (Feature 5) extends past the data extent of the Lower OCS. The northern trunk of the Rio Grande incised valley (Feature 3) terminates at what has been interpreted as Shelf Delta Front Sands (Feature 4). Figures are shown in yellow and labeled with line numbers.

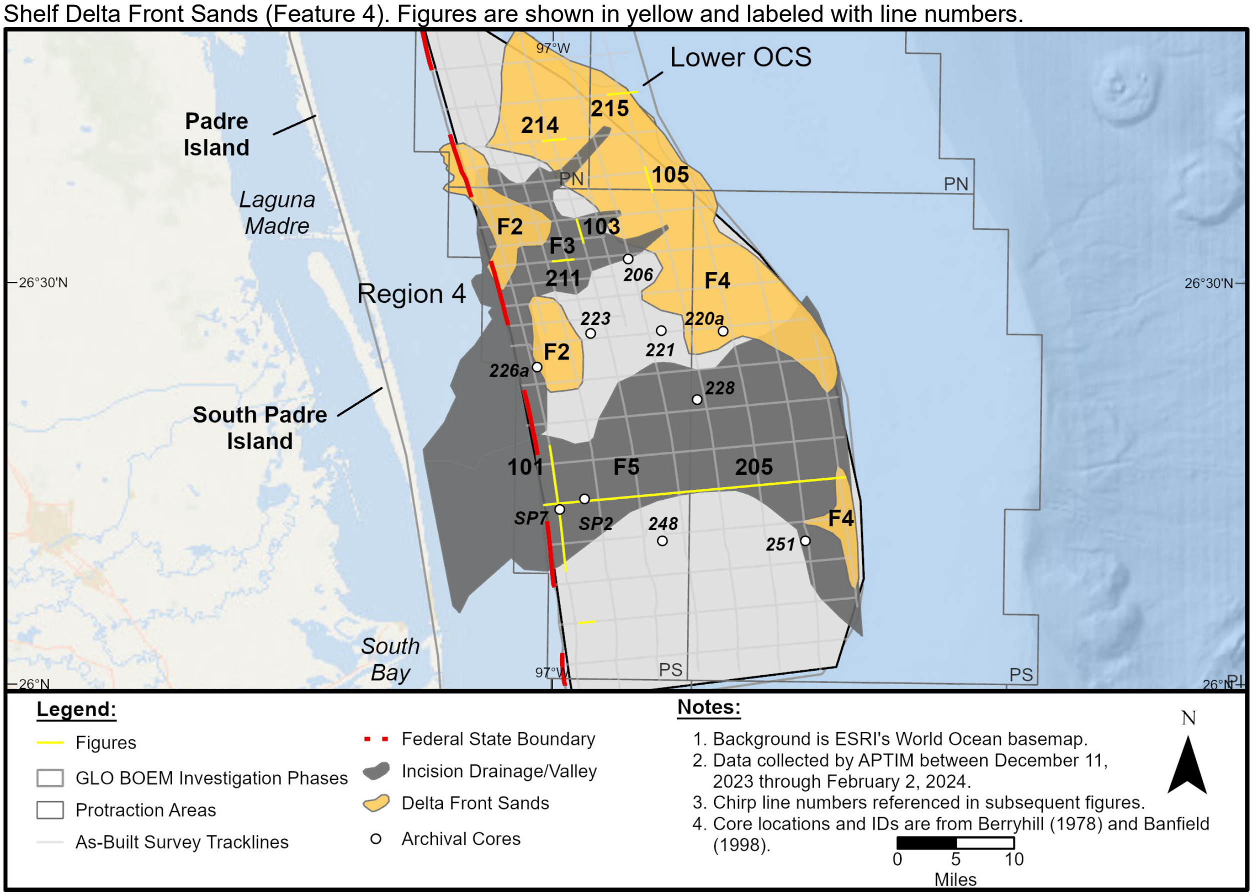
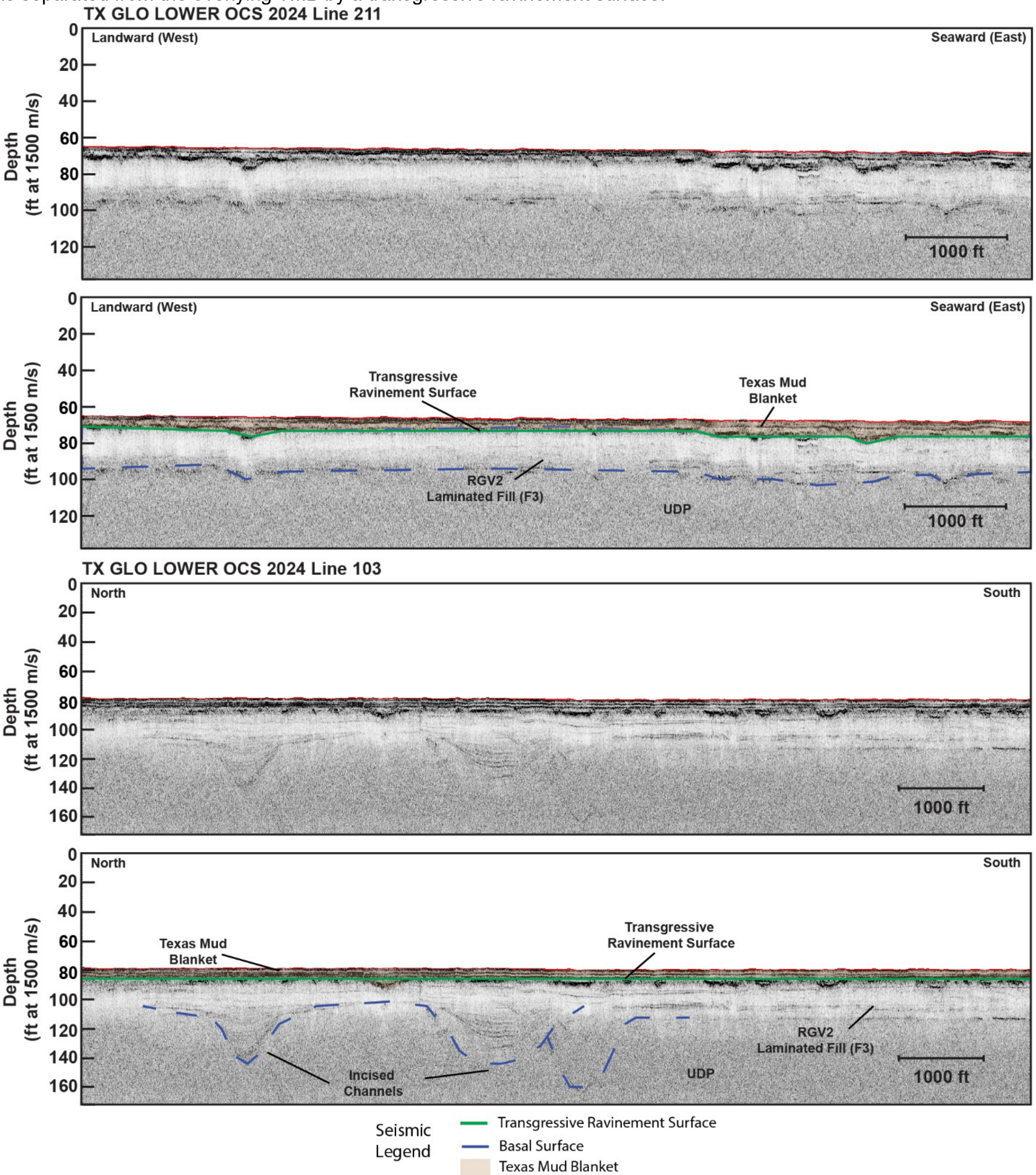


Figure 48: Seismic examples of the Rio Grande Incised Valley fill 2 (Feature 3).
This unit is characterized by mostly laminated packages of reflectors that are sometimes semi-transparent. This unit is separated from the overlying TMB by a transgressive ravinement surface.



4.4.3.4 Feature 4: Shelf Delta Front Sands (DFS2)

A regionally expansive unit is located along the seaward boundary of the investigation area, which coincides with the bathymetric slope break, interpreted as Shelf Delta Front Sands (Feature 4). The resolvable thickness averages 17 feet (5.2 meters) in the investigation area although it is likely much thicker than chirp sub-bottom can image. This unit is characterized by a mostly transparent unit with resolvable dipping reflectors at the top of the unit in some locations (Figure 49). Mounded units of opposite dipping clinoforms are found in some locations. The top of the Shelf Delta Front Sand corresponds to a strong amplitude reflector where there is a thin veneer or overlying fine-grained sediment or outcrops at the seafloor. In some instances, the larger Delta Front Sand unit displays stacking or filling patterns of subunits interpreted as various lobes (Figure 50). Where observable the Delta Front Sand unit grades into more faintly laminated facies below. This feature is found to the north and south of the Rio Grande Incised Valley.

This regional unit is made up of smaller scale, overlapping units but are grouped generally in this investigation. The thicknesses presented here should be treated as a conservative estimate if verified to contain viable sand composition as the unit thickens towards the shelf break beyond the investigation area as shown in Swartz (2019). The laminated reflector package of the TMB onlaps the Shelf Delta Front Sands in the north. The amount of overburden increases beyond the 20 feet (6 meters) threshold used in this investigation, and only viable sand resources were estimated for this unit.

Figure 49: Seismic examples of the Shelf Delta Front Sands (Feature 4) associated with the ancestral Rio Grande and overlying Texas Mud Blanket. The Shelf Delta Front Sand feature is likely thicker than resolvable in chirp sub-bottom.

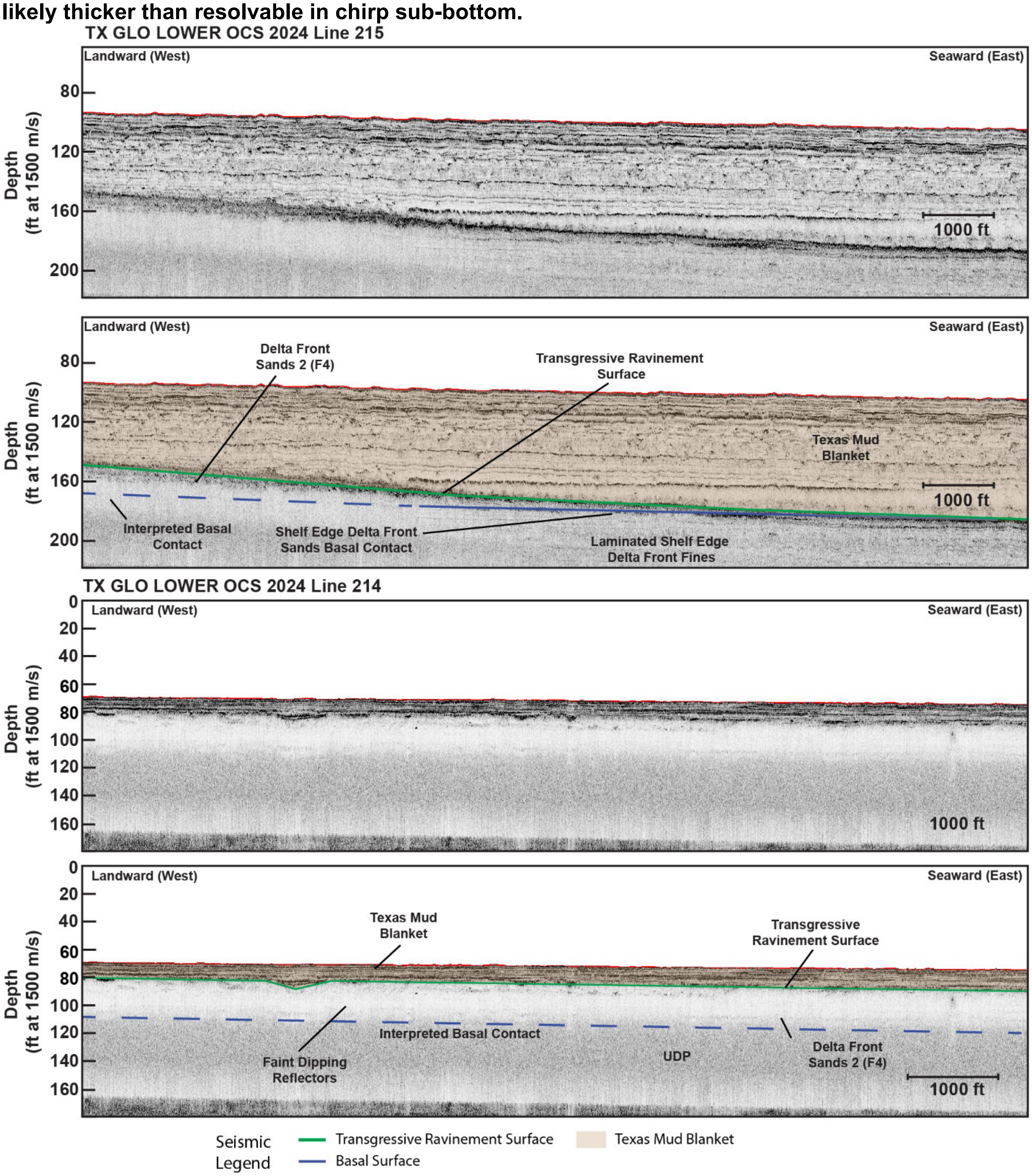
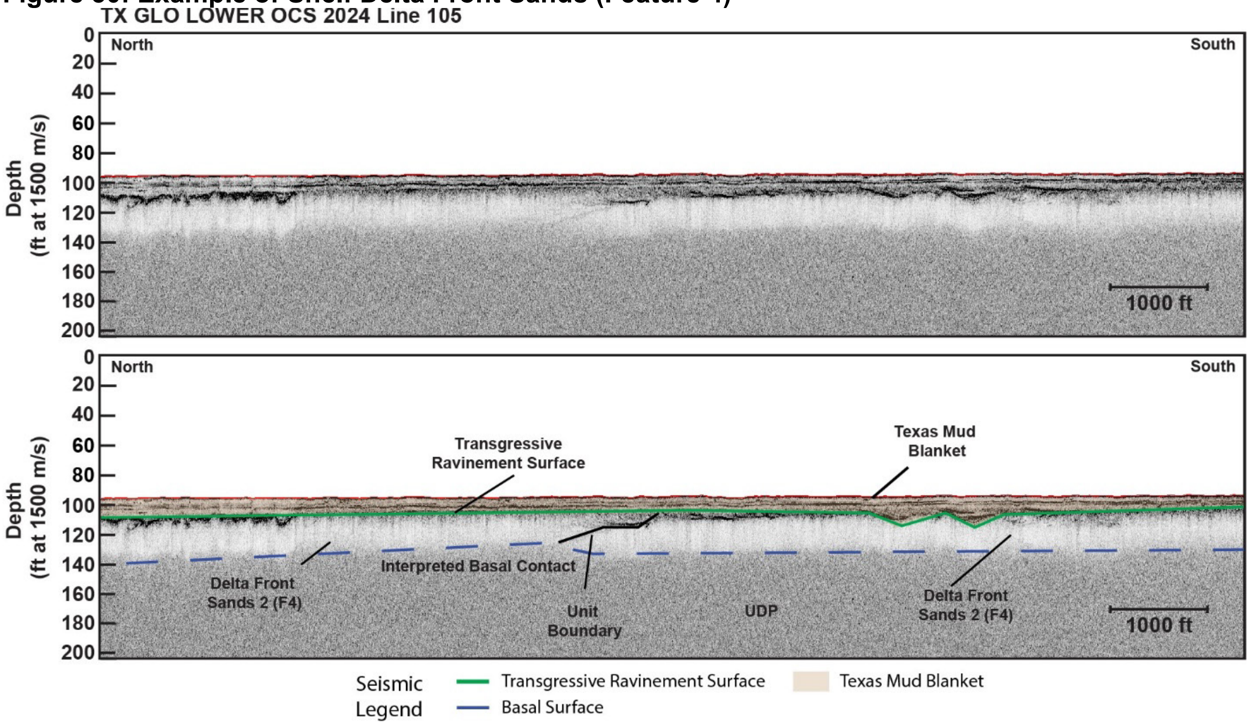


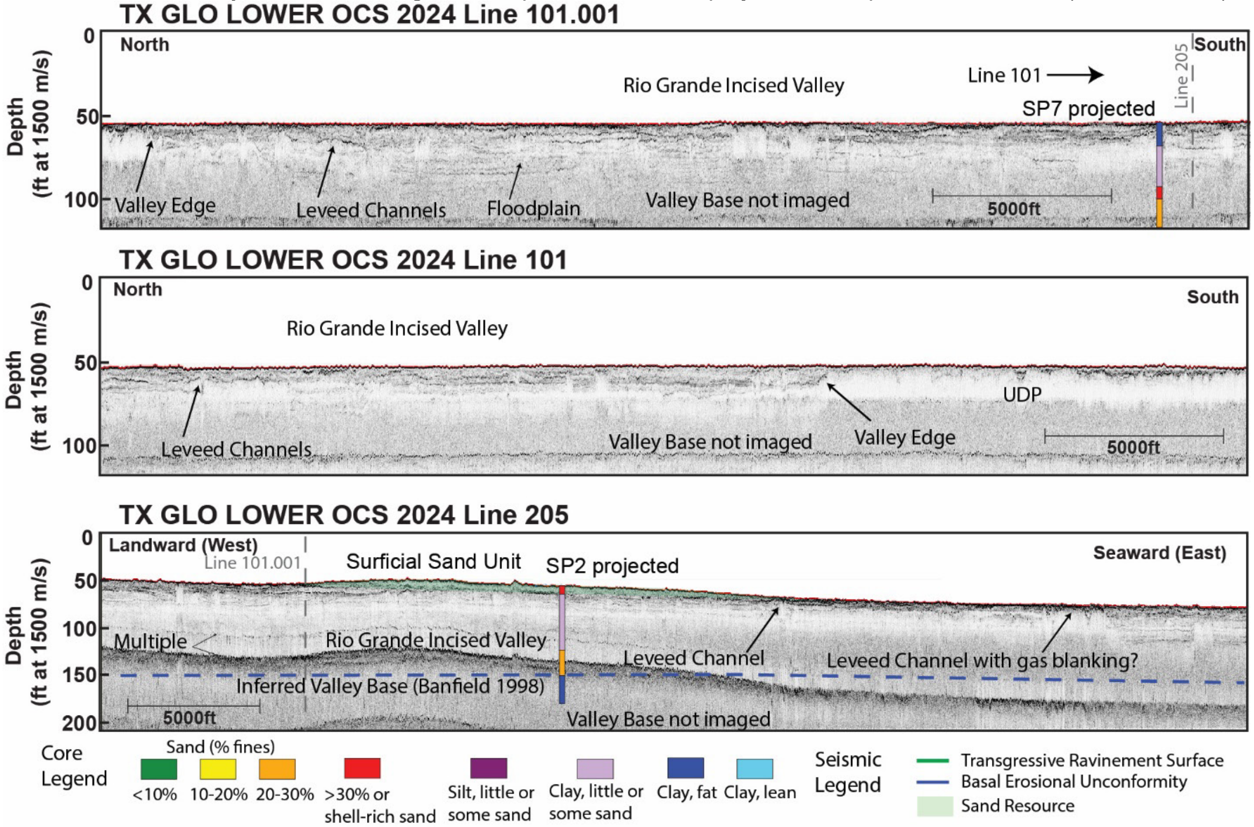
Figure 50: Example of Shelf Delta Front Sands (Feature 4)



4.4.3.5 Feature 5: Rio Grande Incised Valley 1

The Rio Grande Incised Valley (Feature 5) identified in TX GLO Region 4 extends into the Lower OCS Investigation Area. This large regional incisional feature is roughly 10 mi (16 km) across, its valley edges are relatively well constrained but is more difficult to discern further seaward. The incised valley truncates the Undifferentiated Delta Plain (UDP) that extends from TX GLO Region 4. The valley fill consists of laminated to slightly wavy reflector packages. Isolated semi-transparent, lenticular seismic packages interpreted as leveed channel systems are present throughout the vertical valley fill sequence (Figure 51). The leveed channels are stacked but offset, filling accommodation created by the positive topography of leveed systems called compensational stacking. The base of the valley is not imaged in chirp sub-bottom, however, Banfield (1998) interprets the valley as being completely filled with fluvial and deltaic deposits up to 100 feet (30 meters) thick with the base of the valley roughly 150 feet (46 meters) below sea level based on archival borings. Gas blanking is present in areas that make further delineation difficult. The ancestral Rio Grande River was depositing shelf edge deltas up to at least 10,000 years ago (Banfield and Anderson 2004; Swartz 2019). Overall, the Rio Grande Incised Valley and its fill contain isolated sand-rich channels, but the majority of the fill sequence is fine-grained floodplain or delta plain deposits and does not represent a sand resource.

Figure 51: Examples of the Rio Grande Incised Valley, fill, and overlying surficial sand unit.
Note the incised valley base is not imaged in chirp sub-bottom but projected from previous research (Banfield 1998).

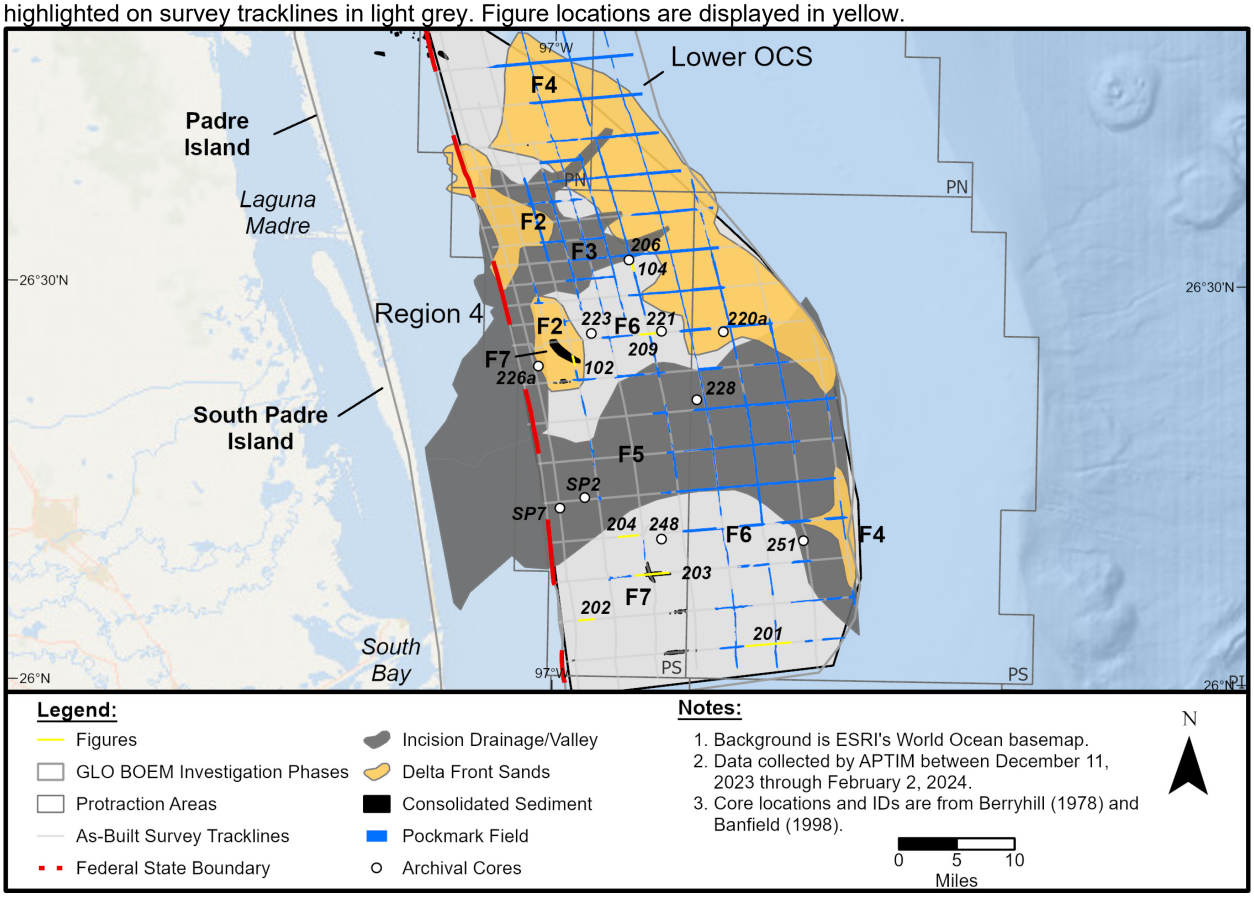


4.4.3.6 Feature 6 Undifferentiated Delta Plain (UDP)

Feature 6 is present across the majority of Region 4 and Lower OCS Investigation Area and has been interpreted as the UDP. The UDP outcrops at the seafloor where no other identified features are present (Figure 52). This unit is capped by the transgressive ravinement surface or the basal erosional unconformity of incisional features such as the Rio Grande Incised Valley and smaller channels. The base of the unit is not imaged in chirp sub-bottom. The internal architecture is variable but overall, generally transparent facies, in some cases gentle, faint seaward dipping reflectors are present (Figure 53). In other areas, where there are overlying laminated facies, it appears there is gas partially trapped at the boundary of the UDP and overlying sediments (Figure 53). In the sidescan sonar imagery, large pockmark fields were identified throughout the central portion of the Lower OCS Investigation Area. The pockmarks are created by gas or liquid escaping through surficial sediments.

Figure 52: Map of the Undifferentiated delta plain (Feature 6), the Rio Grande incised valleys (Feature 3 and Feature 5), Delta Front Sand units (Feature 2 and Feature 4), and consolidated sediments (Feature 7).

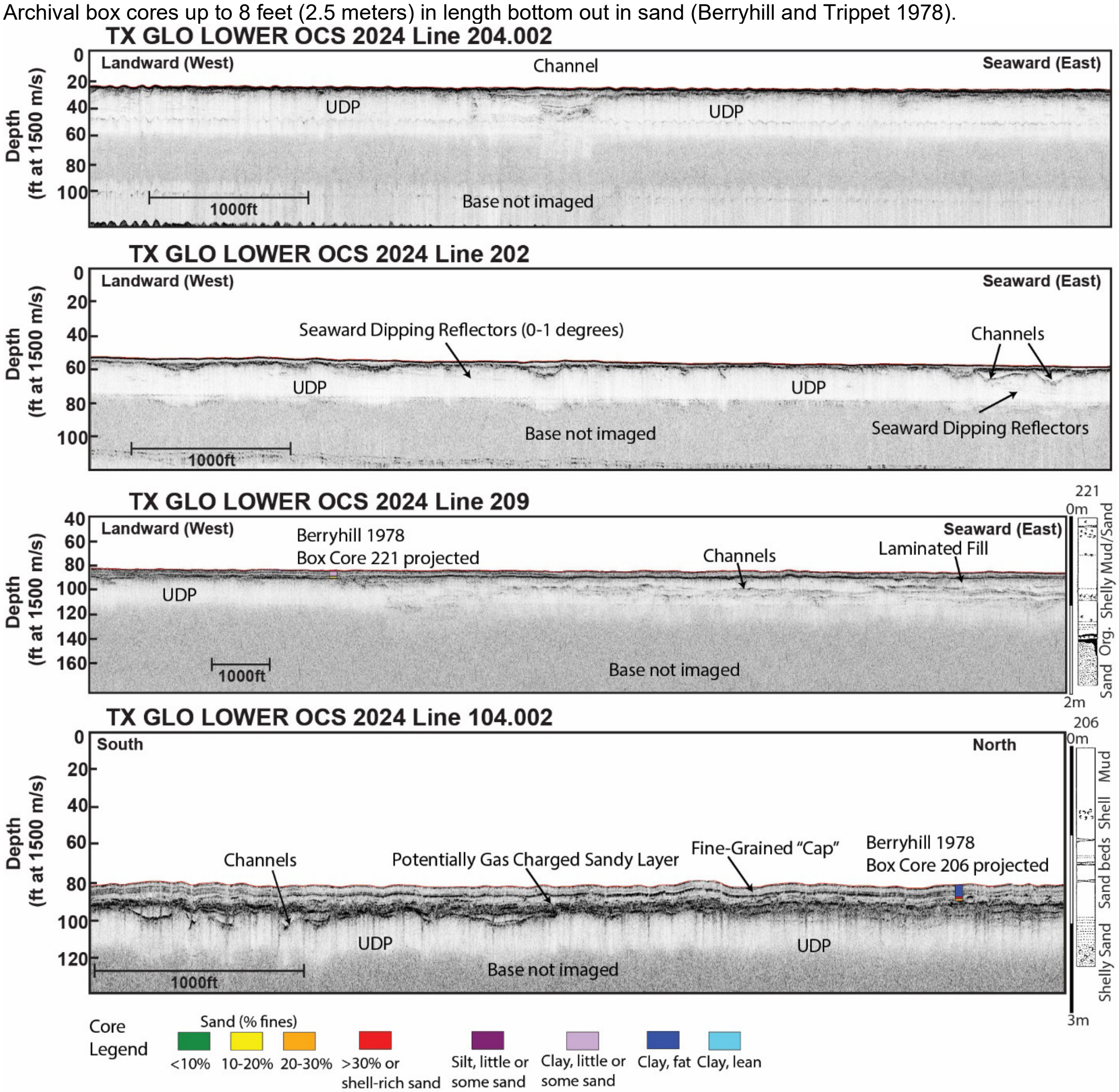
This unit is encountered underneath all other described units. Pockmark fields that appear in sidescan sonar are also highlighted on survey tracklines in light grey. Figure locations are displayed in yellow.



The UDP has a generally homogenous, transparent acoustic signature that extends seaward from TX GLO Region 4 (APTIM and TWI Forthcoming) throughout the Lower OCS Investigation Area. The UDP correlates to stacked fluvial-deltaic systems, up to 300 feet (90 meters) thick, deposited over the last glacial period identified by previous researchers (Fulton 1976; Berryhill and Trippet 1978; White et al. 1984; Banfield 1998; Banfield and Anderson 2004). There is a high potential for other sand resources within viable subsurface intervals in the UDP; however, these cannot be differentiated without additional geologic sampling and are not considered resources at this time. It will likely be greatly refined with future geotechnical sampling to further constrain potential sediment resources.

Figure 53: Example sub-bottom of the Undifferentiated Delta Plain displaying its variable internal architecture and overlying units where present.

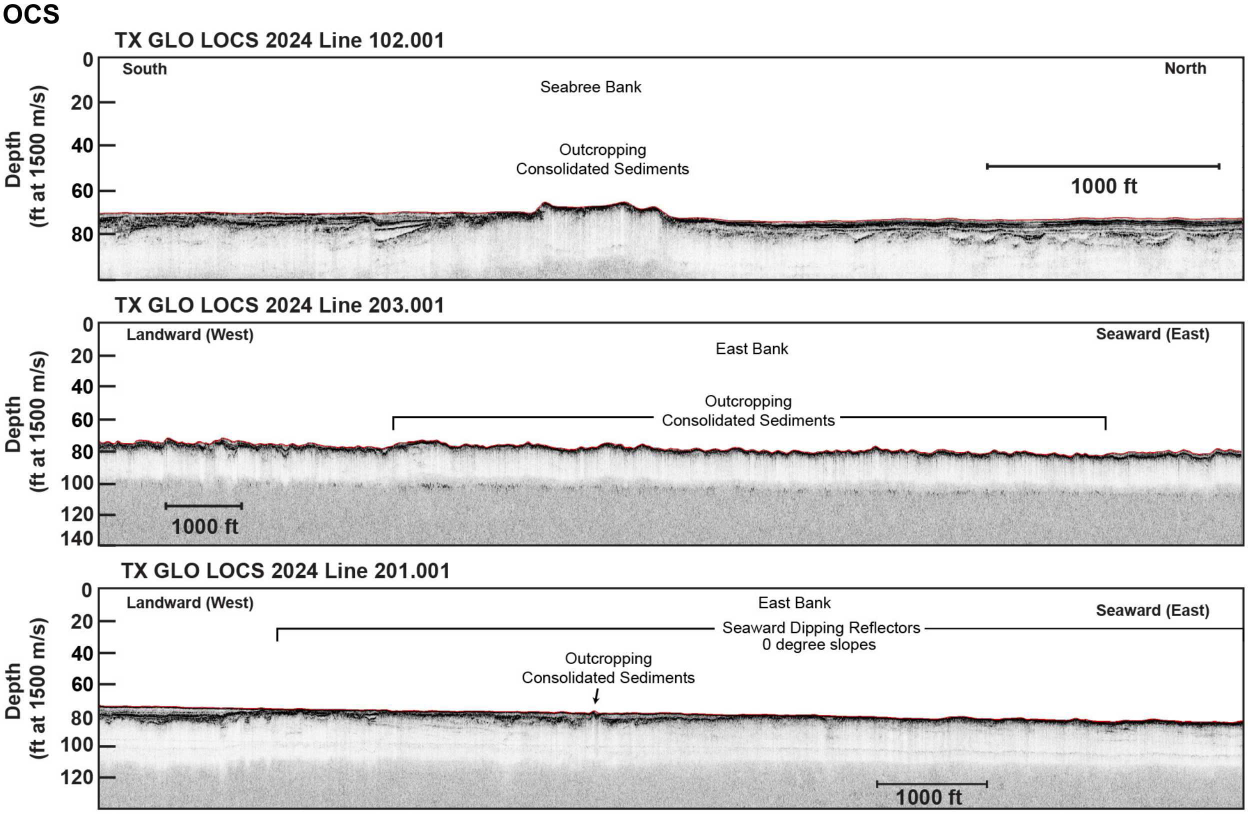
Archival box cores up to 8 feet (2.5 meters) in length bottom out in sand (Berryhill and Trippet 1978).



4.4.3.7 Feature 7 Consolidated Sediment

A regional trend of consolidated sediment (Feature 7) extends from the Lower OCS Investigation Area into TX GLO Region 4 (Forthcoming). In the sidescan sonar data, these outcropping consolidated sediments have a strong contrast to the surrounding onlapping sediment, showing either blocky platform-like structures with several depressions or ridge-like morphologies. In the seismic, the outcropping consolidated sediment is characterized by a very strong top reflector that protrudes from the seafloor, with acoustic blanking below (Figure 54). It is unclear how expansive these consolidated sediment features extend in the shallow subsurface, but there are portions that appear to be buried by younger laminated sediment. Where resolvable, reflector packages below the consolidated sediment appear transparent or contain gentle seaward dipping faint reflectors. This agrees with interpretations and findings from previous research utilizing sparker and boomer seismic data (Berryhill and Trippet 1978). These outcropping consolidated sediment correlate to previously named Steamer, Seabree, and East Bank of the South Texas Banks (Nash et al. 2013). The timing and origins of these consolidated sediments is unclear, but they occur seaward of Delta Front Sand packages identified in this investigation. In the Central Texas OCS portions of outcropping consolidated sediments were composed of calcite cemented reworked material of the underlying Beaumont Formation (Winchester 1971) and interpreted and dated as a 90,000 year old shoreline feature (Simms et al. 2009) and further offshore are a series of terraced coralagael reefs that formed roughly 20,000 years ago and were drowned as soon as 10,000 years ago (Khanna et al. 2017). The interpretations of the consolidated sediments found in this investigation will be refined within the future geotechnical investigation.

Figure 54: Examples of sub-bottom data of outcropping consolidated sediment found in Lower OCS



4.4.3.8 Potential Sediment Resource Quantity Estimates

Sand resource targets delineated in Lower OCS Investigation Area were Surficial Sand Units and Delta Front Sand units containing an estimated 5.12 BCY (3.92 BCM) of sand-rich sediment (Figure 55). Some geologic subsurface features were mapped but excluded from sand resource quantification due to their amount of overburden (the overlying non-compatible sediment) or were important to the regional geologic framework understanding of the area but consisted of dominantly fine-grained sediment. To be considered viable, a sediment resource must be at least 5 feet (1.5 meters) thick in the subsurface with less than 20 feet (6 meters) of overburden. Other sand resources likely exist in the shallow subsurface but could not be regionally correlated in this survey based on reconnaissance-scale geophysical data alone. A large portion of the investigation area displays shallow outcropping delta plain deposits, likely of Pleistocene age, which could not be confidently constrained or quantified based on chirp sub-bottom. The correlative unit mapped within Region 4 state waters (APTIM and TWI Forthcoming) is demonstrated to contain sand up to 75 feet (23 meters) thick (Banfield 1998). Isopachs and volume estimates were created by taking the feature thicknesses generated in SonarWiz and gridding XYZ thickness points using kriging interpolation in Surfer 23. All resource volumes presented are first order estimates and will be greatly refined with geologic sampling and future higher resolution survey spacing.

The eight Surficial Sand Units (Feature 1) are estimated to contain 813 MCY (621 MCM) of sand-rich sediment with no overburden. The two shore parallel trends have little bathymetric expression using available data, differing from the shore oblique shoal complexes identified in the concurrent state TX GLO Region 4 investigation. Both types of surficial shoal units have a clear basal surface correlating to the transgressive ravinement surface.

Two separate depocenters are interpreted as Delta Front Sands related to discrete depositional episodes on the modern shelf. The inboard (Feature 2) and outboard (Feature 4) Delta Front Sand units are estimated to contain 529 MCY (404 MCM) and 3.78 BCY (2.89 BCM) of sand-rich sediment, respectively. In some areas additional sand resources related to the Surficial Sand Units (Feature 1) may overlie Feature 2 and Feature 4. The presented volumes excluded areas of greater than 20 feet (6 meters) or more of overburden due to the TMB to the north.

Several localized features that could not be correlated regionally could also present as sediment resources if further constrained with increased survey density and geological sampling to verify its composition. These features are found throughout the investigation area and are likely related to fluvial or deltaic deposits in the subsurface.

Figure 55: Map of viable potential sand resource targets within the investigation area.

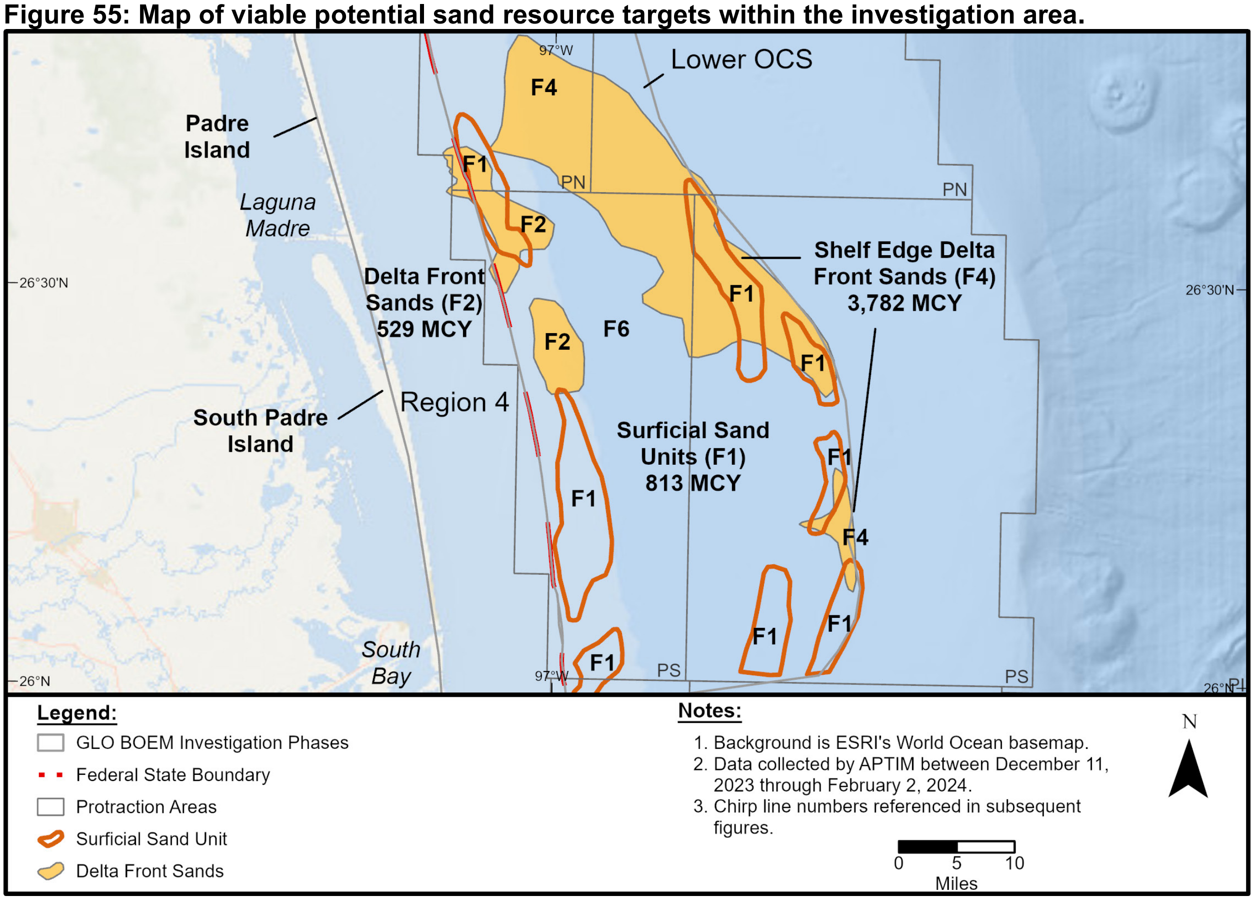


Table 5: Summary of regional geologic features in Lower OCS Investigation Area and quantified viable potential mixed sediment resources with less than 20 feet (6.096 meters) overburden.

Total gross sediment volume totals 5,124 MCY (3,917 MCM)

Feature Number	Protraction Area	Viable Resource (Yes/No/ Potential)	Preliminary Interpretation	Area sq ft x 10^6 (sq m x 10^6)	Average Unit Thickness ft (m)	Average Overburden Thickness ft (m)	Gross Sediment Volume MCY (MCM)	Example Data Figure Number
1	South Padre Island Area, South Padre Island (East Addition), North Padre Island Area	Yes	Surficial Sand Units	6,311 (586)	4 (1.2)	0	813 (621)	Figure 43 Figure 45
2	South Padre Island Area, North Padre Island Area	Yes	Delta Front Sand	1,983 (184)	8 (2.4)	12 (3/6)	529 (404)	Figure 45
3	South Padre Island Area, North Padre Island Area	No	Rio Grande Incised Valley 2	NA	NA	NA	NA	Figure 48
4	South Padre Island Area, South Padre Island (East Addition), North Padre Island Area, North Padre Island Area (East Addition)	Yes	Shelf Delta Front Sand	8,710 (809)	17 (5.2)	18 (5.5)	3,782 (2,891)	Figure 49
5	South Padre Island Area, South Padre Island (East Addition),	No	Rio Grande Incised Valley 1	NA	NA	NA	NA	Figure 51
6	South Padre Island Area, South Padre Island (East Addition), North Padre Island Area, North Padre Island Area (East Addition)	Potential	Undifferentiated Delta Plain	NA	NA	NA	NA	Figure 53
7	South Padre Island Area, North Padre Island	No	Consolidated Sediment	NA	NA	NA	NA	Figure 54

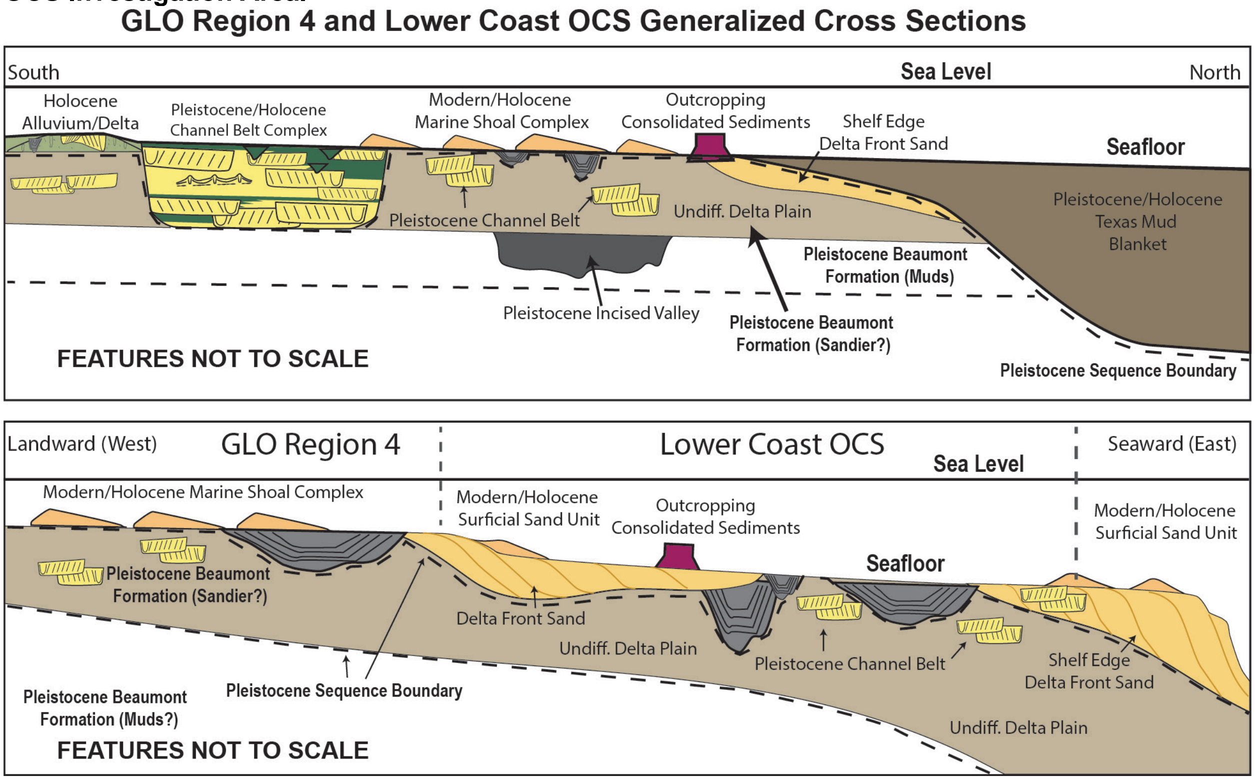
sq f- square feet, sq m- square meters, ft-feet, m-meters, MCY- Million Cubic Yards, MCM- Million Cubic Meters.

4.4.3.9 Regional Geologic Summary

A regional geologic framework was constructed to identify and map all major geologic elements observed within the reconnaissance geophysical survey, evaluate the sand resource potential of each, and understand their origin and evolution. The Lower OCS Investigation Area contains potential sand resources within regional-scale geologic systems such as deltaic Delta Front Sands and Surficial Sand Units in addition to numerous smaller scale deposits. These regional-scale features are confidently interpreted across 3 mi (4.8 km)-spaced reconnaissance geophysical lines. Several other regional-scale geologic features were identified and important to the regional geologic framework understanding but are interpreted as containing dominantly fine-grained sediment. Some of these feeder systems are sediment transport pathways to major depocenters. Additionally, numerous localized features are observed within the geophysical data that could not be correlated with the current survey spacing but still represent potential sand resources pending further investigation. While all geologic interpretations based on sub-bottom geophysical data are preliminary until ground-truthed by geologic sampling, these initial observations indicate the occurrence of multiple potential sand resources related to fluvial-deltaic stratigraphy and oceanographic processes across the southern Texas shelf throughout the Pleistocene and Holocene.

A strike and dip generalized cross-section was developed from the mapping of regional depositional systems and localized features from the concurrent investigations within Region 4 and Lower OCS Investigation Areas, demonstrating stratigraphic relationships of sand resource bearing geologic features both alongshore and extending offshore (Figure 56). There is relatively minimal research of the geologic framework of the South Texas Shelf compared to other portions of the Texas shelf. The onshore portion of the Rio Grande Valley fluvial architecture and composition of individual avulsive channel belts and recent chronology of Holocene delta lobes were presented in Fulton (1976). The onshore Pleistocene Rio Grande fluvial-deltaic deposit's aerial extent was mapped in detail (Brown and Hartmann 1980; Page et al. 2005) providing analogues for offshore equivalent units. During the late 1970s and early 1980s, a series of reports on the South Texas Shelf assessed the geology, geochemistry, surficial sediment distributions, and depositional settings of the inner shelf and shelf edge using a series of sediment grabs, box cores, and shallow geophysics (Berryhill and Trippet 1978; White et al. 1984; Suter and Berryhill 1985). Regional shelf evolution throughout the last glacial cycle of the Rio Grande System was proposed by more recent works, highlighting the rapid sedimentation throughout all sea level trends in the Pleistocene and Holocene (Banfield 1998; Banfield and Anderson 2004; Swartz 2019) compared to smaller fluvial systems along the Texas Coast (Anderson et al. 2014). These studies all help resolve the evolution of the regional geologic framework related to the Rio Grande system throughout the Pleistocene and Holocene. The concurrent Region 4 and Lower OCS Investigation Area geophysical investigations fill a large gap in data coverage and spatial resolution of the area. Without any age constraints, and with the amalgamation of Holocene and Pleistocene units at similar stratigraphic positions, this investigation only presents relative ages rather than an absolute chronology.

Figure 56: Generalized cross-section of major features observed in the GLO Region 4 and Lower OCS Investigation Area.



The modern South Texas continental shelf is composed of a full succession of fluvial-deltaic to marine sediments related to the ancestral Rio Grande River and its long history of building the South Texas continental margin. The lowermost observable stratigraphy within Region 4 begins with hundreds of feet of fluvial-deltaic sediments deposited by the Rio Grande River from the Pleistocene to present (Fulton 1976; Banfield and Anderson 2004; Swartz 2019). This unit is referred to as a UDP due to its regional scale and is observed in both GLO Region 4 and the Lower OCS Investigation Area. It is typically observed as an acoustically transparent unit with a high-amplitude upper bounding surface which likely represents the ancient floodplain surface, the transgressive ravinement, or some combination of the two. This thick succession records multiple generations of sea level change and associated advance and retreat of the Rio Grande Delta, building the south Texas margin seaward to its modern position (Banfield and Anderson 2004; Swartz 2019). The uppermost fluvial-deltaic units have been interpreted as recording the history of Rio Grande growth and retreat from the Pleistocene sea-level lowstand, when the ancestral Rio Grande extended to the current shelf edge (Swartz 2019) to the subsequent retreat of the Rio Grande Delta towards the modern Texas coastline over the last several thousand years (Fulton 1976; Banfield and Anderson 2004). The UDP unit has been interpreted in this investigation as being composed of a mixture of sandy river deposits, muddy floodplain intervals, sandy delta front units. The UDP stratigraphy is likely correlative to portions of the Beaumont Formation on land (Brown et al. 1976; McGowen et al. 1976; Page et al. 2005; Moore et al. 2021) and elsewhere in the Texas shelf from the literature (Anderson et al. 2016). Contrasting to other areas investigated along the Texas coast, Region 4 is dominated by shallow loss of acoustic chirp signal. The inner shelf is composed of deposits that have a drastic impedance change with the water column and veneer of modern shelf sediment displayed as a strong amplitude reflector with very little signal below in the shallow subsurface. This acoustic signature of the Region 4 and Lower OCS Investigation Area made mapping with confidence difficult. From previous literature this unit of stacked Pleistocene-Holocene delta lobes can reach up to 300 feet (91.4 meters) thick and contain up to 75 feet (22.8 meters) of fine-grained sand with minimal overburden (1998) and is likely the offshore extension of the sand-rich Pleistocene Beaumont mapped onshore (Brown and Hartmann 1980). The UDP unit bounding surfaces are not clearly identified in chirp sub-bottom, thus the thickness and overall composition of this unit is not known. The UDP contains both sand and mixed sediment resources but will require further geologic sampling to constrain even at the reconnaissance scale.

The most recent depositional event is related to the onlapping Texas Mud Blanket and surficial shoals. The Texas Mud Blanket is a fine-grained unit sourced from riverine plumes and erosion of ancestral Colorado and Rio Grande Deltas that fills the Central Texas Embayment during the Holocene (Weight et al. 2011). Surficial sand sheets and shoals are found throughout the Region 4 and Lower OCS Investigation Areas. In state waters are a series of shore-oblique shoal complexes found in water depths 26–80 feet (8m–24m). The thickest shoal complexes overlie sand-rich deltaic plain deposits verified by sediment cores and borings (Banfield 1998; Alpine 2008). In the Lower OCS Investigation Area, the Surficial Sand Units and shoals are shore parallel forming linear trends in 100–180 feet (30–55 meters) water depths. These Surficial Sand Units overlie sand-rich delta front deposits and on the shelf edge mark the seaward boundary of various shelf edge delta lobe positions beyond the investigation area. The surficial shoals and sand units appear to be formed by oceanographic processes sourced from local sand-rich deposits. The correlation between the surficial units and underlying sand-rich geology has proved a successful resource prospecting strategy with the available archival geologic sampling data available.

Outcropping consolidated sediment forms a linear trend from the Lower OCS Investigation Area to the nearshore region offshore of Padre Island. The consolidated sediments have platform to ridge-like morphologies in sidescan sonar and it is unclear how far they extend in the subsurface if partially buried, most were originally identified by (Berryhill and Trippet 1978). They are correlated to named units of the South Texas Banks (Nash et al. 2013) although most have unknown origins and ages. In other portions of the Central Texas OCS there are cemented relict shorelines dating back roughly 90,000 years before present (Winchester 1971; Simms et al. 2009) but most of the offshore South Texas Banks were thought to die off during the Late-Pleistocene or Holocene (Khanna et al. 2017). It is unclear their relationship in the larger geologic framework at this stage.

This investigation identifies high-potential sand resource units throughout the Region 4 and Lower OCS Investigation Areas related to the complex geologic history of the Rio Grande Delta and its numerous cycles of growth, abandonment, and erosion related to sea-level cycles and sediment supply changes (Banfield and Anderson 2004). The units quantified here are the most promising deposits mappable at the reconnaissance-scale, but numerous archival evidence and the observed localized features indicate the opportunity for more sand-resource deposits to be located and quantified upon further investigation. The occurrence and distribution of these resources are closely linked to the regional geologic framework, with widespread sand deposition on the exposed continental shelf by ancient river and delta lobes, and subsequent erosion and reworking of many of these units into modern sand shoals and surficial sediments during sea-level rise and modern oceanographic processes. The framework presented here provides numerous specific targets for further investigation and geological ground-truth to constrain the proposed lithologies and geologic origin of these deposits.

4.4.3.10 Localized Features

Localized features are defined as features that are not continuous, nor traceable across multiple lines. These features are scattered throughout the Kenedy, Willacy, and Cameron protraction areas, within smaller channel belt type features, and some drainage/paleovalley systems. These features are normally isolated channels/sediment pockets which can be reflective of potential resources or partially preserved channel belts (Figure 57). Due to the widely spaced grid, it is not possible to determine the overall extent of these features or correlate them to the larger sand-bearing regional deposits; however, based on the observed seismic characteristics, there is potential for additional data collection to better delineate these features and determine their potential for sand. Localized features are characterized as typically having lateral accretionary deposits or transparent internal reflector packages (Figure 58 and Figure 59). There are very few features in the Lower OCS Investigation Area that can be grouped into this category due to the thickness of the TMB and acoustic blanking from high-amplitude strata. The features listed below are not exhaustive but highlight the primary localized features in the Lower OCS Investigation Area.

Figure 57: Line 211 in the Lower OCS Investigation Area.
Potential sand unit within a drainage tributary (blue dashed) underneath ~12 feet (3.7 meters) of overburden. Ravinement surface delineated in green

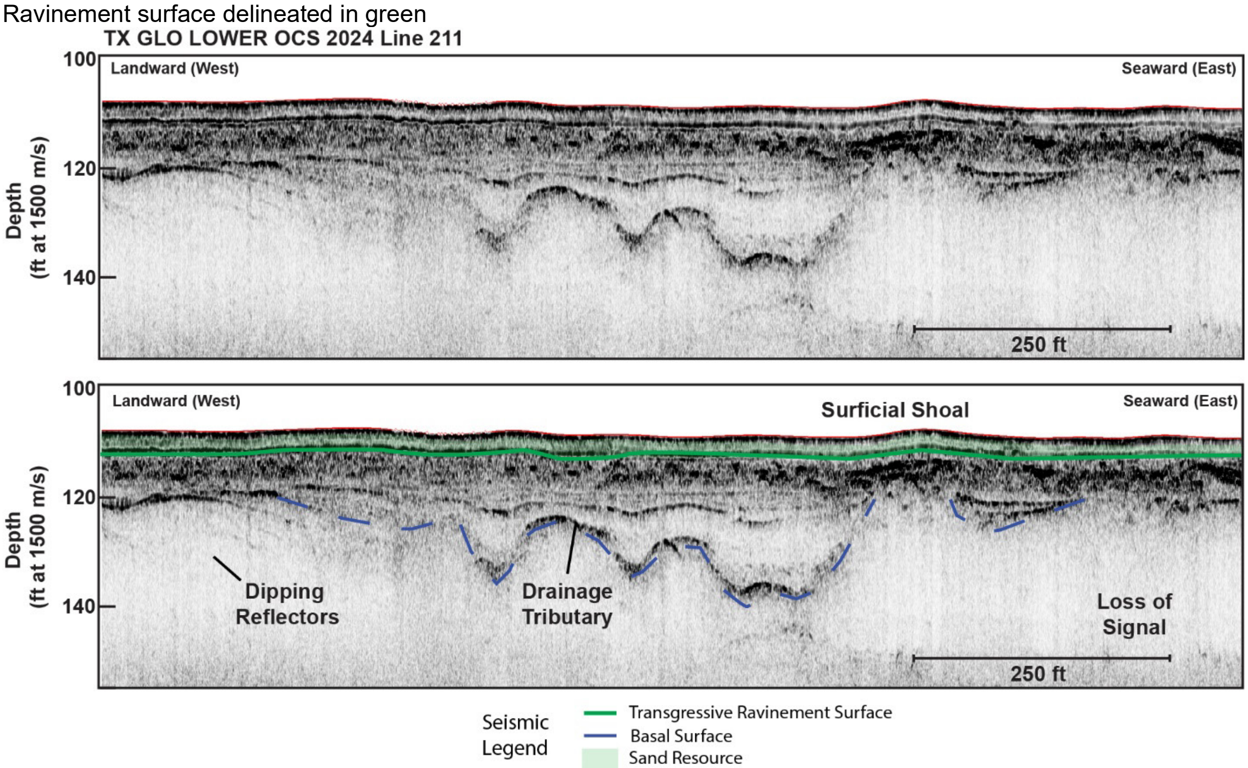


Figure 58: Line 102 in the Lower OCS Investigation Area.
Example of a channel belt (blue dashed) underneath the ravinement surface (green) with high amplitude, well-laminated ~10 feet (3 meters) channels.

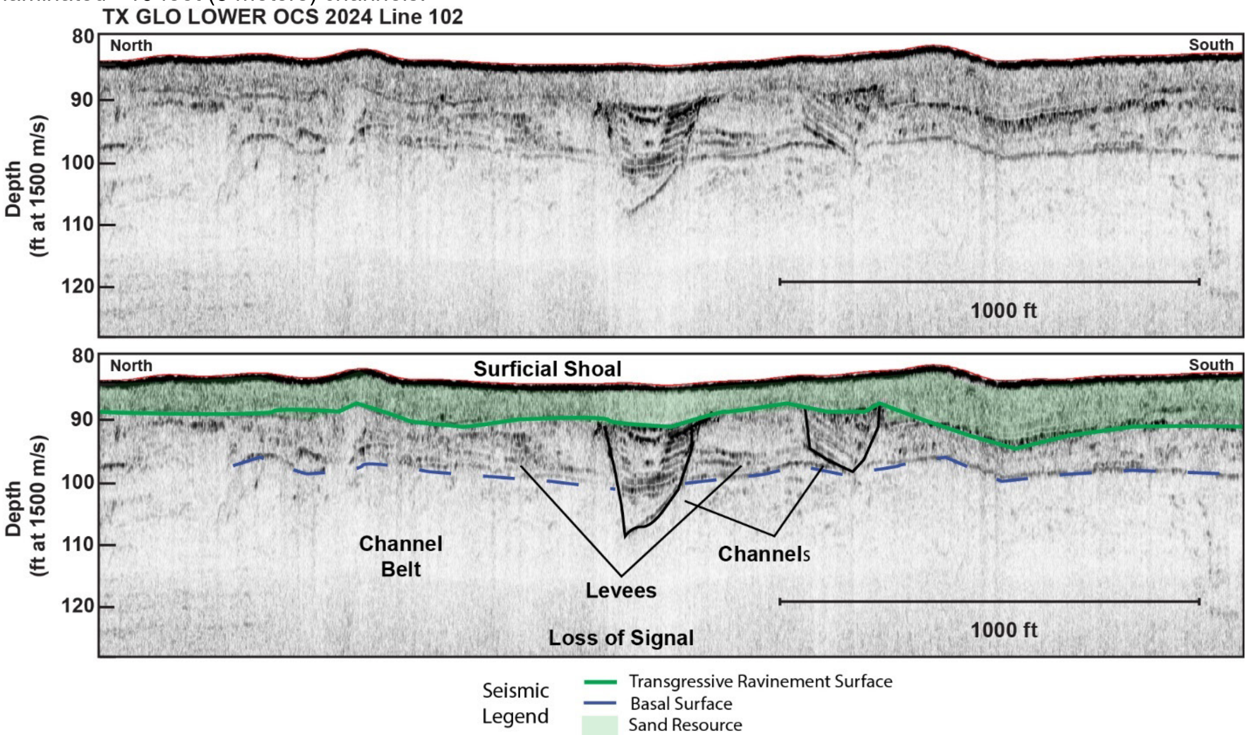
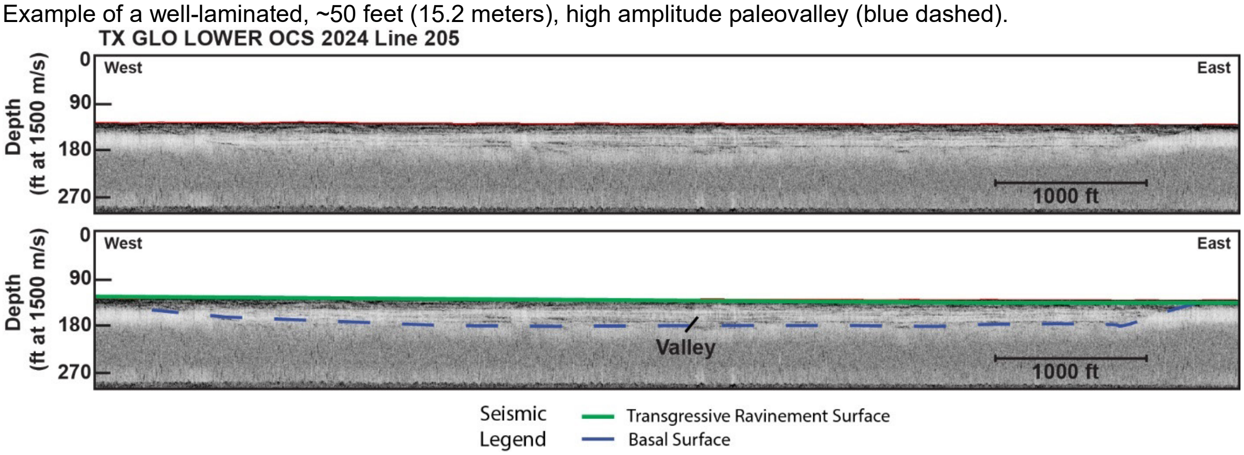


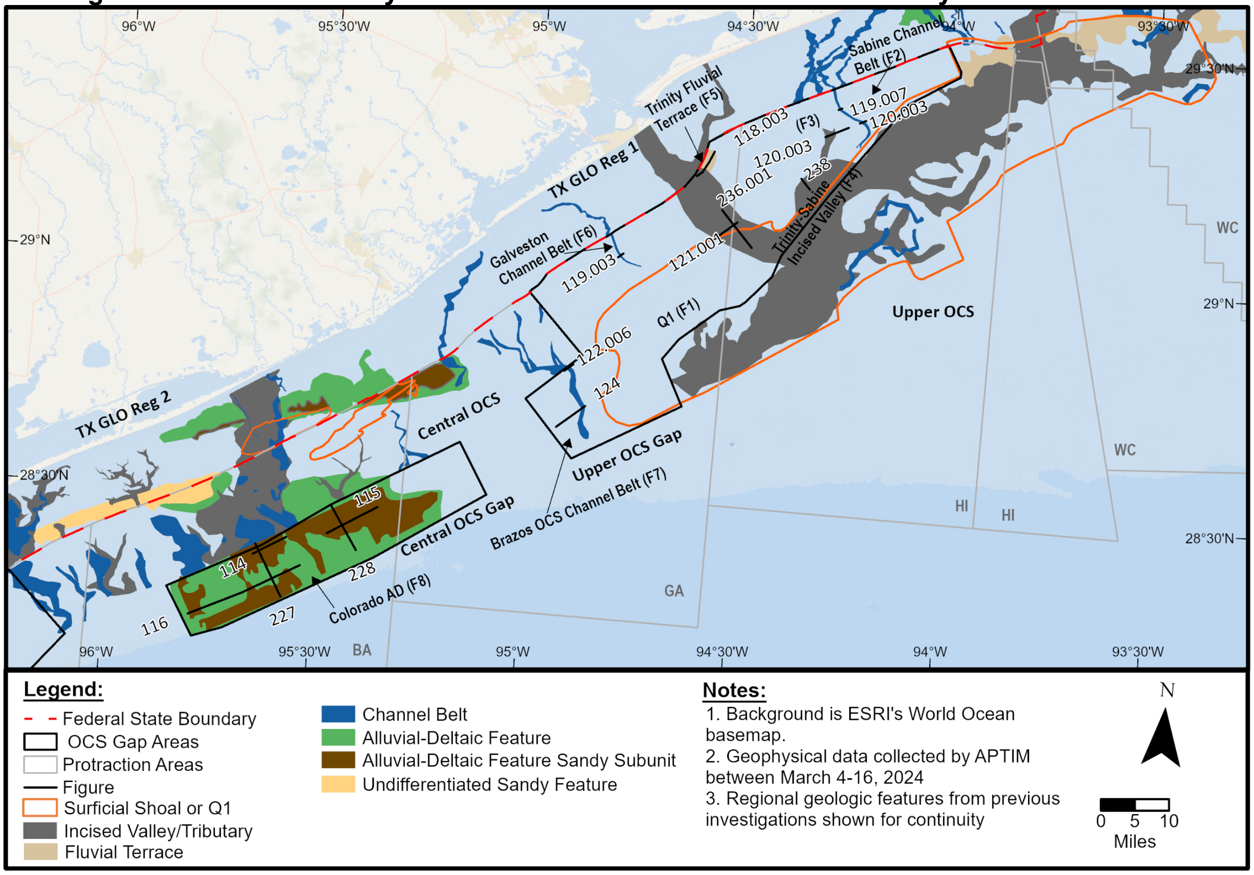
Figure 59: Line 205 in the Lower OCS Investigation Area.
Example of a well-laminated, ~50 feet (15.2 meters), high amplitude paleovalley (blue dashed).



4.4.4 Upper and Central OCS Data Gap Investigation Area

The Upper and Central OCS Data Gap Investigation Areas contain several potential sand-bearing and non sand-bearing features that are likely related to alluvial plain construction from fluvial avulsions and deposition during the Late Quaternary (Anderson et al. 2014), preserved alluvial-deltaic features of unknown age, and modern surficial shoals (Figure 60). The characteristics and initial interpretation of each identified regional geologic feature are presented below. These interpretations build upon previous results from Texas GLO Region 1 (APTIM and TWI 2021; 2025b) Upper OCS (APTIM and TWI 2022; 2025c), Regions 2 and 3 (APTIM and TWI 2024b), and Central OCS (APTIM and TWI 2024c)

Figure 60: Map of geologic features identified in the Upper and Central Coast OCS Data Gap Investigation Areas. Previously identified features are shown for continuity.

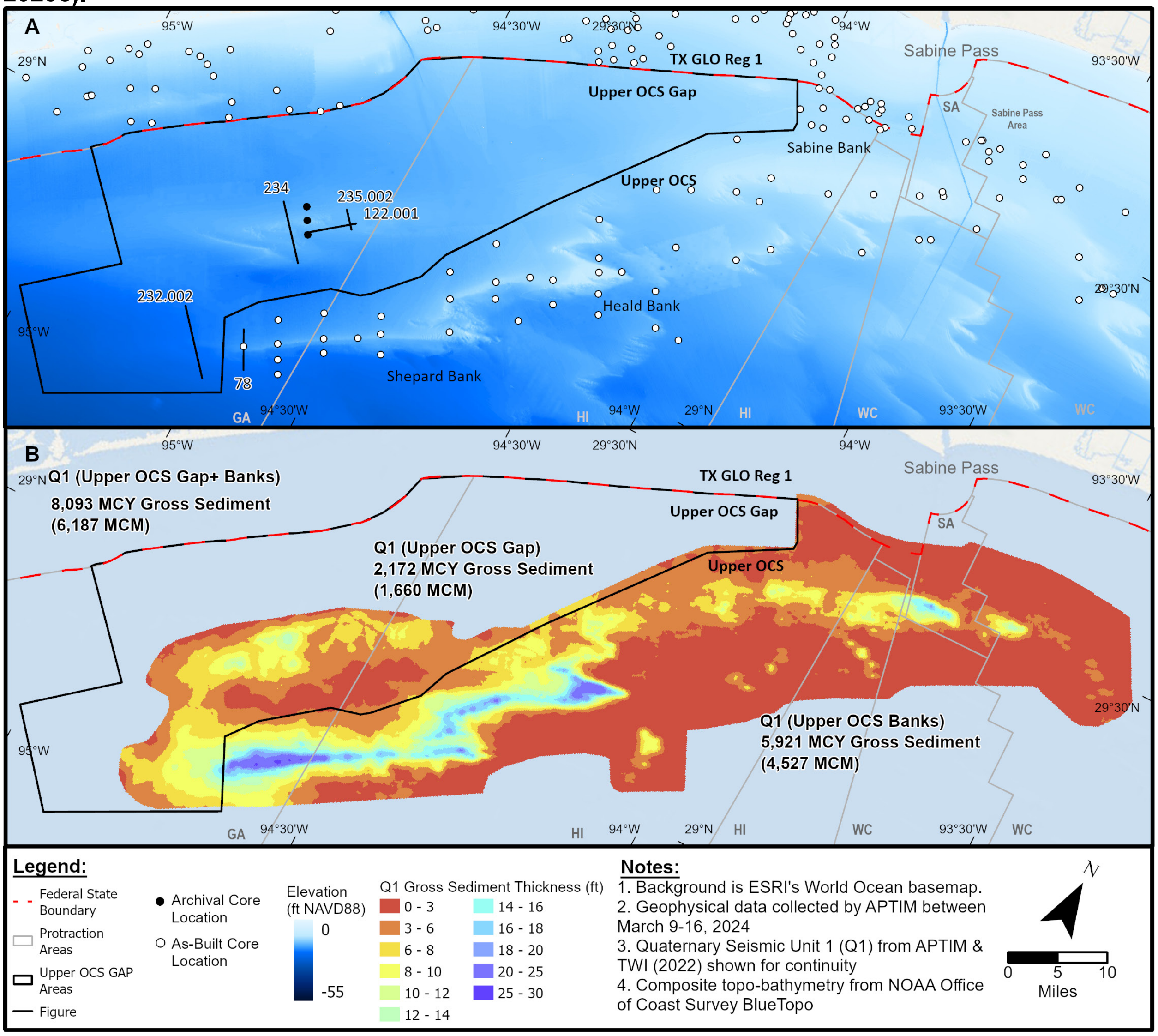


4.4.4.1 Feature 1 Seismic Quaternary Unit 1 (Q1) Extension

A correlative surficial unit, Seismic Quaternary Unit 1 (Q1) mapped in the Upper OCS Sand Banks region (APTIM and TWI 2022; 2025c) extends into the Upper OCS investigation area (Figure 61A,B). The Q1 unit was delineated as the uppermost surficial unit overlying the transgressive ravinement surface, encompassing the larger Sabine, Heald, and Shephard Banks as well as numerous smaller unnamed shoals in the Upper OCS Sand Banks Region. The general designation does not imply or specify an environment of deposition or geological interpretation, rather to refer to the uppermost regionally mappable seismic unit.

The surficial unit here, has two slight shoal bathymetric expressions, one is an unnamed shoal in the center of the investigation area and one is an extension of the named Shepard Bank further seaward (Figure 61A). In the Upper OCS Gap Investigation Area, the Q1 unit is up to 12 feet (3.7 meters) thick in both shoals and is estimated to contain 2.1 BCY (1.6 BCM) of mixed-sediment with no overburden. Combined with the Q1 unit mapped in the Upper OCS Sand Banks region, the total Q1 unit is estimated to contain 8 BCY (6.1 BCM) of mixed-sediment (Figure 61B).

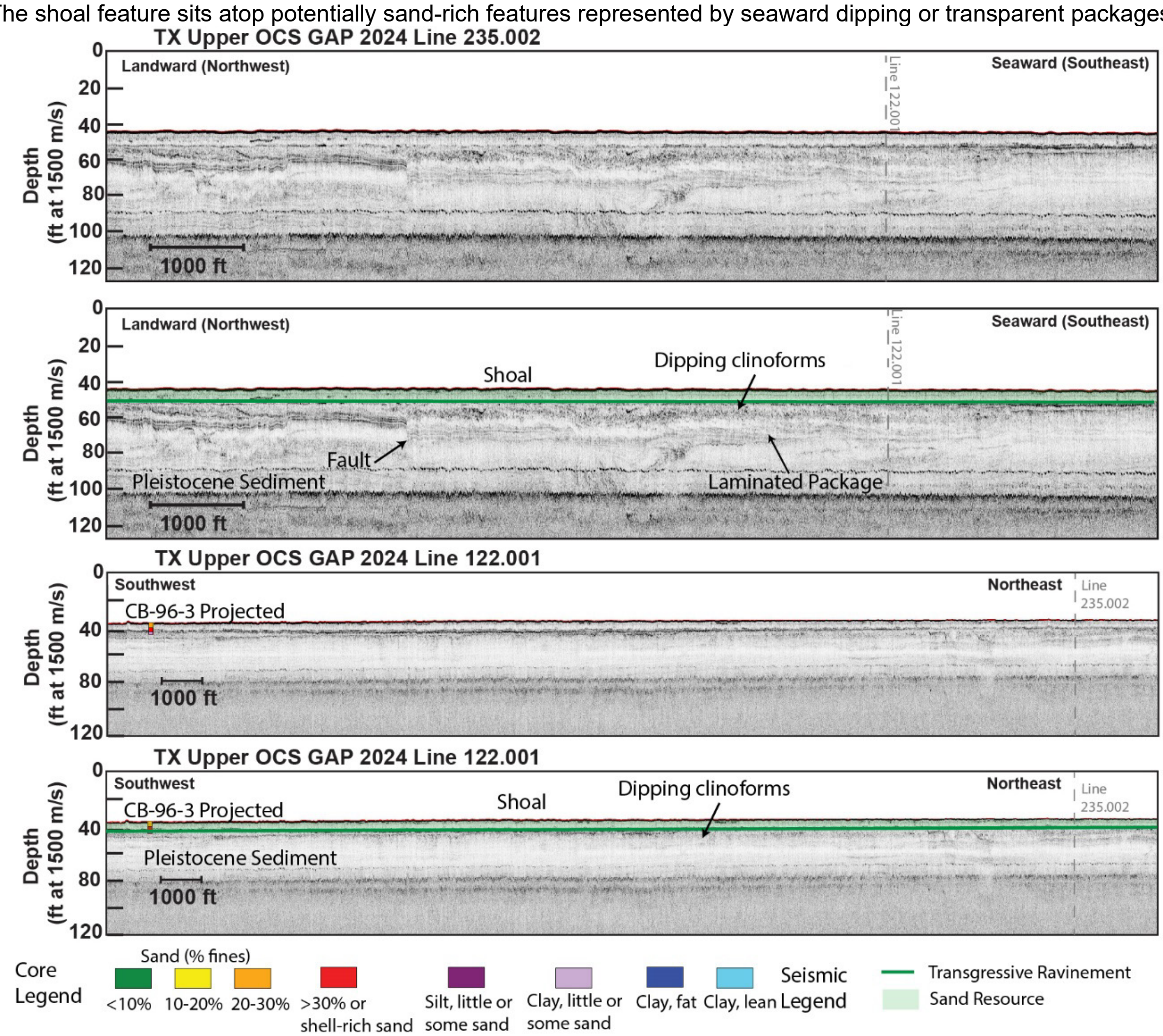
Figure 61: Map of Upper OCS Data Gap Investigation Area extension (Figure 61A) of the Quaternary Seismic Unit 1 identified in the Upper OCS Area (Figure 61B) (APTIM and TWI 2022; 2025c).



The Q1 unit is characterized by a hard top reflector that coincides with the seafloor and speckled or faintly laminated internal reflectors in seismic. The surficial unit overlies the transgressive ravinement surface with variable seismic units below. The unnammed shoal trends generally shore parallel and occurs near the Trinity and Sabine Incised Valley convergence. The unnamed shoal has a slight bathymetric expression on the interfluve and appears to fill an accommodation of the Trinity-Sabine Incised Valley, losing its bathymetric expression. The thickest surficial unit related to the unnamed shoal directly overlies a truncated, seaward dipping, transparent wedge package, inferred to contain higher sand content (Figure 62). This could be a local source of sand to the shoal as the underlying package was reworked during the transgression. Archival borings demonstrate the unnamed shoal consists of upper units of shelly sands and muddy sand up to 12 feet (3.7 meters), overlying sandy mud and Pleistocene sediment (CB96-1, 2, 3) (Rodriguez 1999).

Figure 62: Example of potential shore parallel shoal feature in the Upper OCS Data Gap Investigation Area.

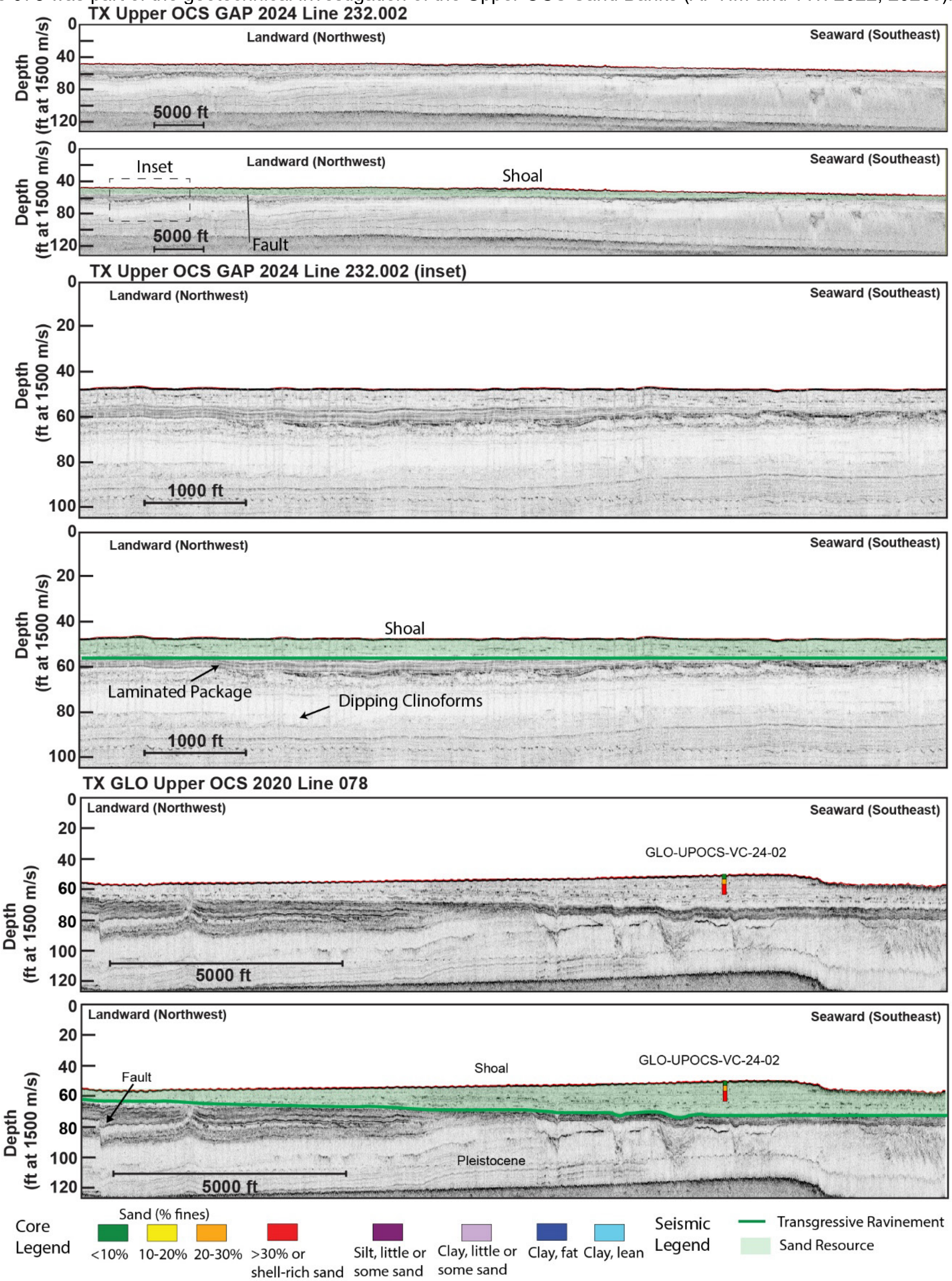
The shoal feature sits atop potentially sand-rich features represented by seaward dipping or transparent packages.



The extension of the Shepard Bank shoal has similar seismic characteristics to the unnamed shoal and the Q1 unit mapped in the Upper OCS (Figure 63). As part of the geotechnical investigation of the Upper OCS, vibracores within this Shepard Bank flank proximal to the Upper OCS Data Gap Investigation Area, show 14 feet (4.3 meters) of sand in a coarsening upwards sequence, with clay pockets and shell hash (Figure 63; Line 078). The correlative shoal extension has much less bathymetric prominence in the Upper OCS Investigation Area. Both portions of the Q1 mapped in the Upper OCS Data Gap Investigation Area contain an additional 2.1 BCY (1.6 BCM) of surfical sand and mixed-sediment resources.

Figure 63: Example of potential shoal feature that extends from the Sand Banks Upper OCS Sand Banks Area into the Upper OCS Data Gap Investigation Area.

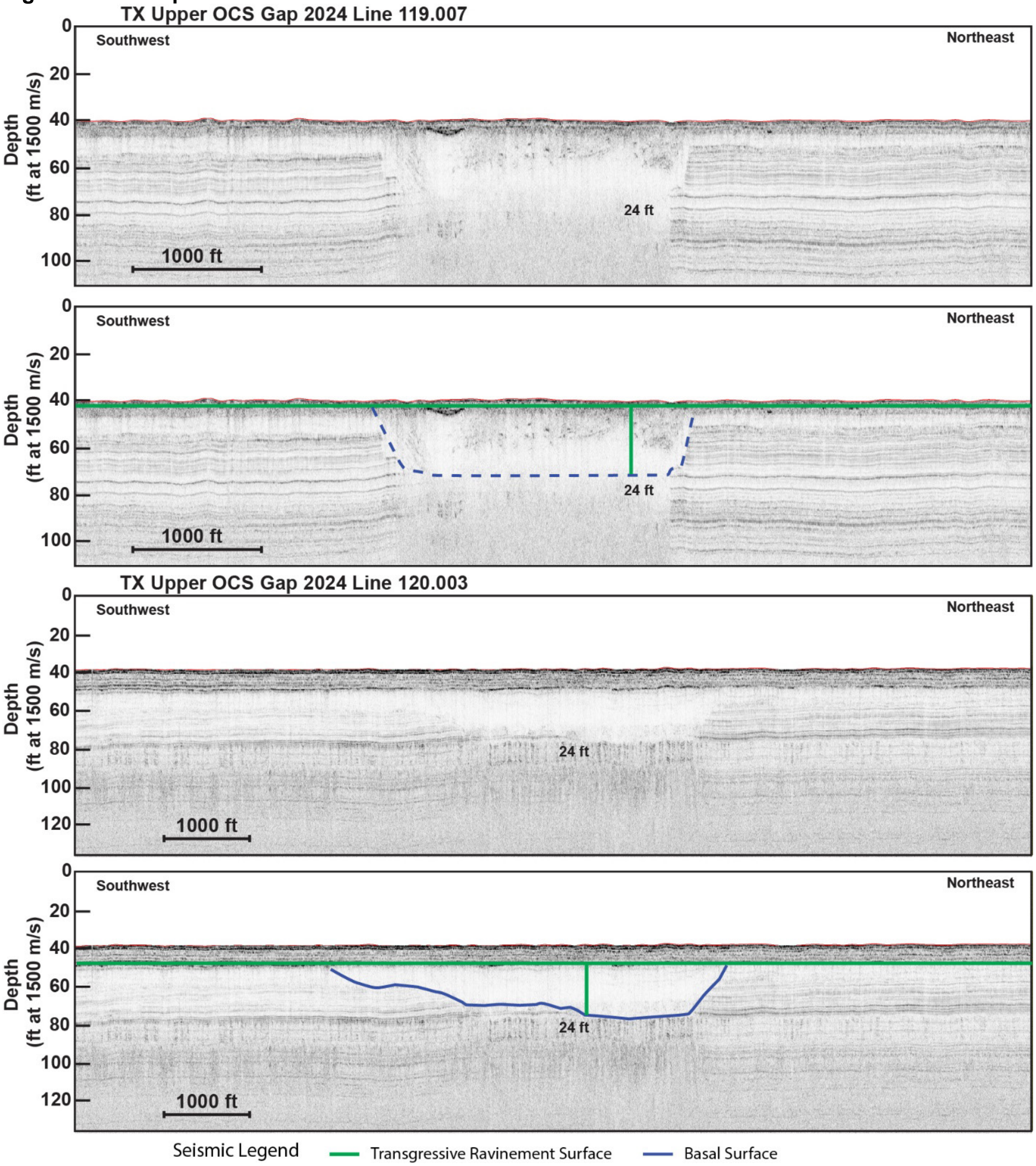
Line 078 was part of the geotechnical investigation of the Upper OCS Sand Banks (APTIM and TWI 2022; 2025c).



4.4.4.2 Feature 2 Sabine Channel Belt 10

The previously identified Sabine Channel Belt 10 (Feature 2) (APTIM and TWI 2021) is roughly 0.5 mi across and extends another 7 mi (11.3 km) into the OCS. The Pleistocene channel belt is characterized by bright, transparent to faintly dipping reflectors with an erosional base that grades laterally into an incisional channel form (Figure 64). This feature has variable amounts of overburden but generally is less than 8 feet (2.4 meters), increasing in a seaward direction and inferred as soft modern shelf deposits based on findings from Region 1 (APTIM and TWI 2025b) The 3 mi line spacing allows for general correlation of the regional feature at the reconnaissance scale that will be greatly refined with more detailed investigations. The acoustic imaging below the channel belt feature in Line 119.007 is completely lost compared to Line 120.003 where it is only slightly obscured (Figure 64) and presents a higher confidence area for sand resources from findings of channel belt features in Region 1 (APTIM and TWI 2025b).

Figure 64: Example sub-bottom of Sabine Channel Belt 10.

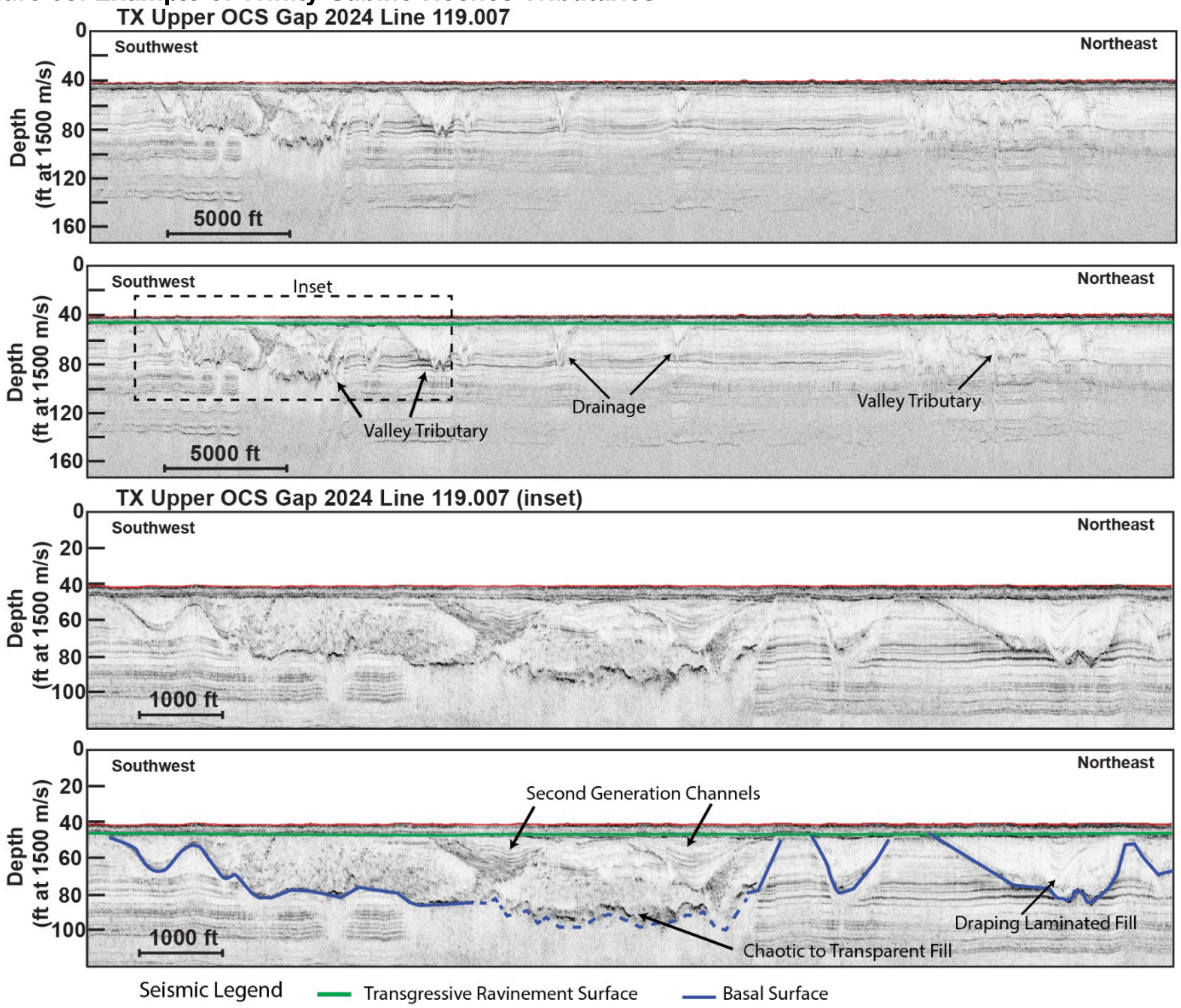


4.4.4.3 Feature 3 Trinity-Sabine-Neches Tributaries

A series of incisional features interpreted as various scale drainage features were identified in the Upper OCS Data Gap Investigation Area. These are located offshore of several fluvial systems identified in TX GLO Region 1 (APTIM and TWI 2021) but could not be confidently correlated with the current survey line spacing. The smaller scale drainage features generally have one incisional expression and a single draping fill package. The fill packages and generations of infilled channels become more complex the larger the incisional drainage feature is (Figure 65). Larger incisional tributaries, several 1000s of feet

(300s meters) wide and likely draining into the larger Sabine Incised Valley offshore, show multiple generations of channelization and variable fill packages. The base of these features sometimes contains chaotic to transparent or hazy fill near the basal portions and are typically overlain by laminated draping or slightly prograding reflector packages (Figure 65). The larger tributaries have a greater potential for sand or mixed-sediment resources compared to the simple muddy fill architecture of smaller incisions. The loss of acoustic imaging below the larger, complex features also supports the interpretation these features may contain sand-rich fill. However, due to the complexity of these cross-cutting valley tributaries and line spacing, they could not be correlated regionally, and no volume estimate was quantified.

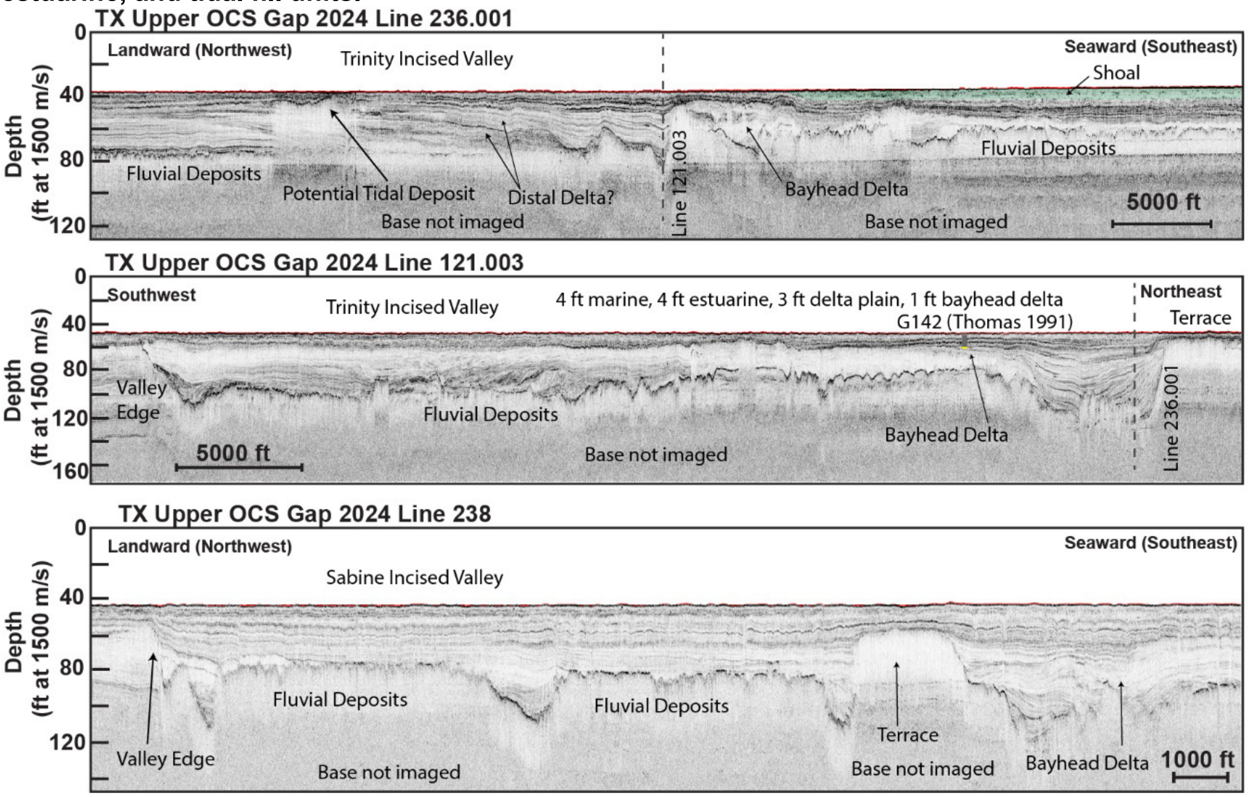
Figure 65: Example of Trinity-Sabine-Neches Tributaries



4.4.4.4 Feature 4 Trinity-Sabine Incised Valley

The Trinity-Sabine Incised Valley is a major stratigraphic feature offshore Galveston Island, extending from TX GLO Region 1 waters. The underfilled valley system in the classification of Simms et al. (2006) follows a stacked fill sequence of basal fluvial sand deposits overlain by deltaic, estuarine, and marine units. While most of the potential sand-bearing fluvial stratigraphy is buried under significant muddy overburden, that limits its accessibility as a sand resource, discrete fluvial terraces and tidal deposits within the shallow subsurface are identified in the investigation area (Figure 66). The fluvial terraces are likely related to late-stage avulsions of the Trinity and Sabine fluvial systems. Both tidal inlets and tidal deltas are regionally mapped with 2D seismic (Thomas and Anderson 1994) and in much higher resolution in 3D seismic (Swartz 2019; Swartz et al. 2023).

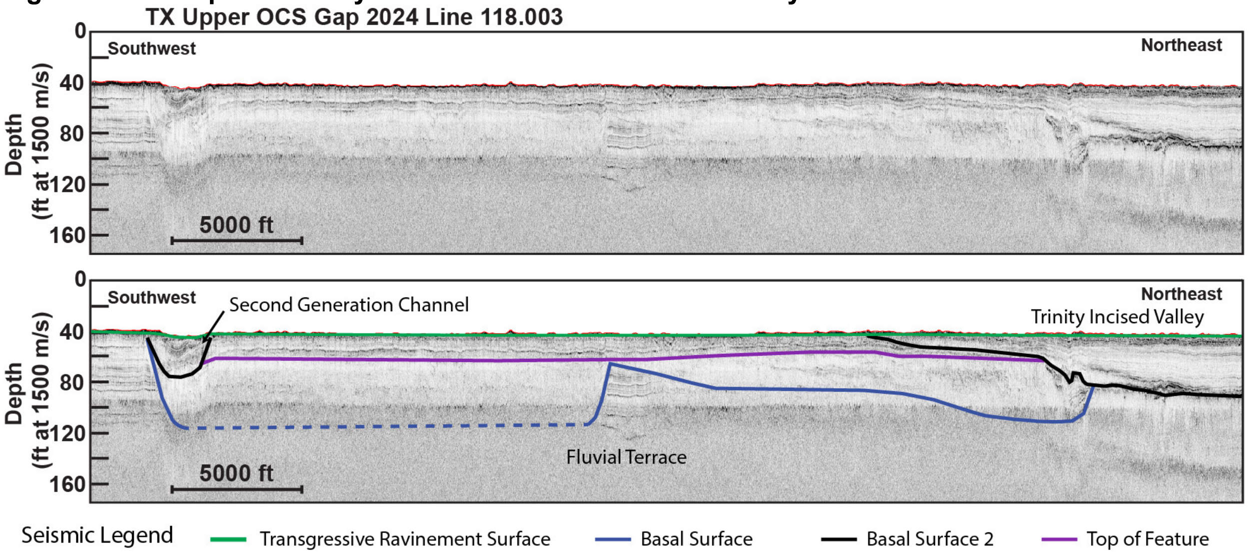
Figure 66: Examples of Trinity-Sabine Incised Valley and its corresponding fluvial, deltaic, estuarine, and tidal fill units.



4.4.4.5 Feature 5 Trinity Fluvial Terrace

A potential fluvial terrace was identified on the northern portion of the Trinity Incised Valley. The target feature is roughly 3 mi (4.8 km) across with individual features spanning nearly 1.5 mi (2.4 km) wide. The target features are characterized by transparent to faintly dipping reflectors grading into a channel form (Figure 67). These interpreted fluvial channel belts appear to be at the same stratigraphic position separated by a laminated unit and show lateral accretion in opposite directions. The fluvial terrace, and channel belt contained within, are truncated by the younger lowstand Trinity Incised Valley and associated drainage tributaries. The base of the channel belt packages is inferred in the seismic from the channel thalweg at depth. The loss of acoustic imaging below is inferred to represent sand-rich sediment. The inferred channel belt sand-rich deposits are up to 35 feet (10.7 meters) thick and are overlain by 15–20 feet (4.5–6 meters) of laminated Pleistocene reflector packages, interpreted as overburden. Previous researchers have demonstrated outcropping Pleistocene deposits in this area (Siringan and Anderson 1994; Rodriguez et al. 2004) and the presence of fluvial terraces (Thomas and Anderson 1994). The sand-rich channel belt portions of the fluvial terrace could not be correlated on nearby lines with the current line spacing of the reconnaissance survey and therefore were not quantified but could represent a significant sediment resource if better constrained.

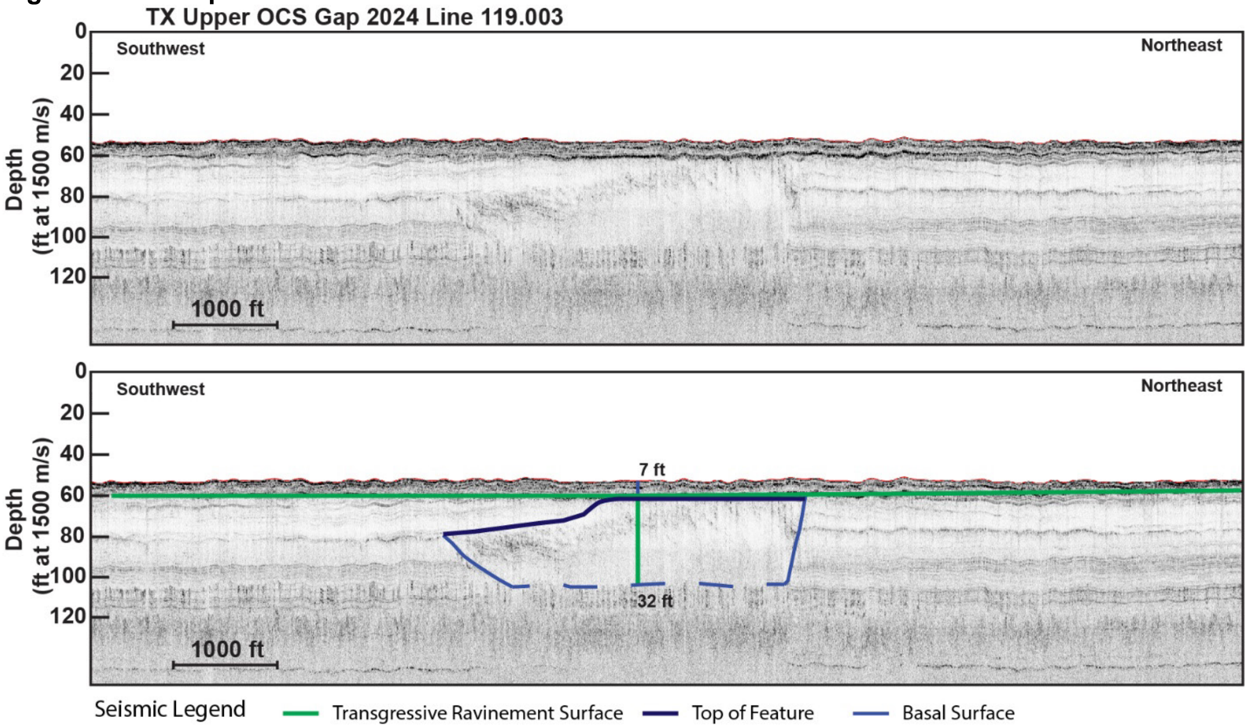
Figure 67: Example of Trinity Fluvial Terrace and Incised Valley.



4.4.4.6 Feature 6 Galveston Channel Belt 1 Extension

The Galveston Channel Belt 1 mapped in Texas GLO Region 1 (APTIM and TWI 2021; 2025b) is extended into the Upper OCS Data Gap area another 6.5 mi (10.4 km) offshore. The feature is roughly 0.3 mi (0.5 km) across, about 20–30 feet (6–9 meters) thick with about 7 feet (2.1 meters) of overburden. As in Region 1, the feature is characterized by steeply dipping clinoforms grading into an incisional channel form, all bounded by a basal erosional unconformity (Figure 68). The loss or weakening of acoustic imaging below the feature found in the OCS portions of the channel belt are interpreted to contain sand resources based on similar correlations from Region 1 (APTIM and TWI 2025b) The channel belt could not be confidently correlated across survey lines seaward of the 6.5 mi (10.4 km) extension, where identified channels at similar stratigraphic positions display a more leveed channel morphology offshore. The greatest resource potential is likely within the laterally accreting channel belt unit mapped in this investigation.

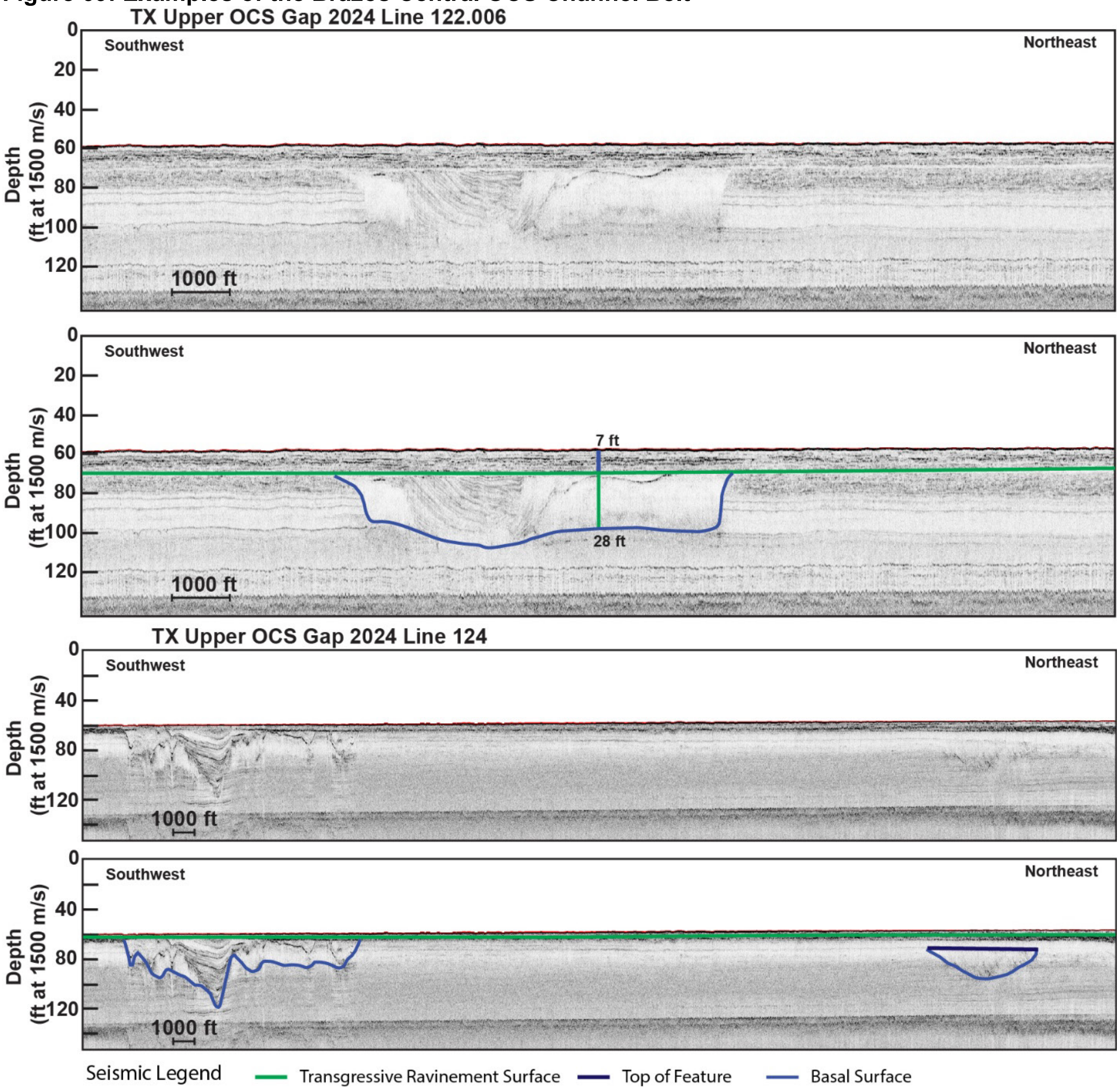
Figure 68: Example of the Galveston Channel Belt extension.



4.4.4.7 Feature 7 Brazos Central Coast OCS Channel Belt Extension

The Brazos Channel Belt system identified in the Texas Central Coast OCS(APTIM and TWI 2024c) is extended seaward an additional 9 mi (14.5 km). The overall feature demonstrates a series of complex, multi-generational channelized features. Most of the channelized features are characterized by a basal erosional unconformity, a lower basal transparent unit with a strong amplitude reflector at the top, and a series of incisions with draping or prograding fill (Figure 69). The transparent packages show a weakened acoustic image below, indicating it may contain sand-rich deposits up to 28 feet (8.5 meters) based on correlations made in Texas State waters Region 1 (APTIM and TWI 2025b), although geologic sampling is required to verify its composition and potential as a sand resource. Overburden is variable but generally less than 10 feet (3 m).

Figure 69: Examples of the Brazos Central OCS Channel Belt



4.4.4.8 Feature 8 Colorado Alluvial-Deltaic Feature and Feature 8B Sandy Subunit

The Colorado Alluvial-Deltaic feature is roughly 8 x 40 mi (12.9 x 63.3 km) and extends southwest beyond the current investigation area. The overall feature is a seaward thickening wedge with variable internal seismic facies, displaying numerous channel features, and both laminated or progradational facies. The sandy subunit (Feature 8B) identified here is up to 28 feet (8.5 meters) thick mapped in sub-bottom data, with overburden ranging 2–42 feet (0.6–42 meters). The sandy subunit is characterized by a general mounded shape made up of secondary mounds of variable scales and stacked sequences building generally offshore. The target facies is defined by a strong top reflector and an overall transparent seismic package, with restricted acoustic imaging below the thickest and most reflective intervals. (Figure 70). The target facies show numerous channel forms, some displaying laterally accreting, dipping clinoforms and others displaying a leveed morphology. The target facies grade into laminated facies below and on their peripheries. This unit is interpreted as a fluvial-deltaic deposit with numerous channels and distributary channels grading into more laminated distal delta front and prodelta sediment. It is important to note that the deltaic feature and sandy subunit are related to discrete packages or stacked lobes but are generally grouped in this investigation to quantify potential sand resource estimates. Only potentially sand-rich units with 20 feet (6 meters) or less of overburden were quantified for resource estimates.

This unit possibly correlates to transgressive Colorado deltas that were described as "sand-prone" by Snow (1998) and Abdulah (1995) (Figure 71) with sand units up to 40–50 feet (12–16 meters) thick. The two delta lobes were interpreted by previous researchers to be of a fluvial dominated delta with discrete onlapping sublobes transitioning to a wave dominated delta based on the overall shape of the deposits (Snow 1998; Abdulah et al. 2004). Just seaward of the investigation area, archival borings sampled grey, silty fine sand to sand containing shell fragments and mica, were interpreted as distributary channel sands and delta front sands that have experienced some degree of marine reworking (Snow 1998). Two archival radiocarbon dates from a *Rangia cuneata* and organic marsh sediment within these deposits provide age constraints of 10,760 years ago and 9,350 years ago, respectively (Abdulah 1995). The interpreted fluvial-deltaic deposits appear to correlate to early Holocene to Late Pleistocene transgressive distributaries and deltas of previous researchers and its potential as a sand resource is relatively high. The potential sand unit's overburden varies significantly within the investigation area.

Figure 70: Example of the Colorado Alluvial-Deltaic Feature Sandy Subunit in the southwest.

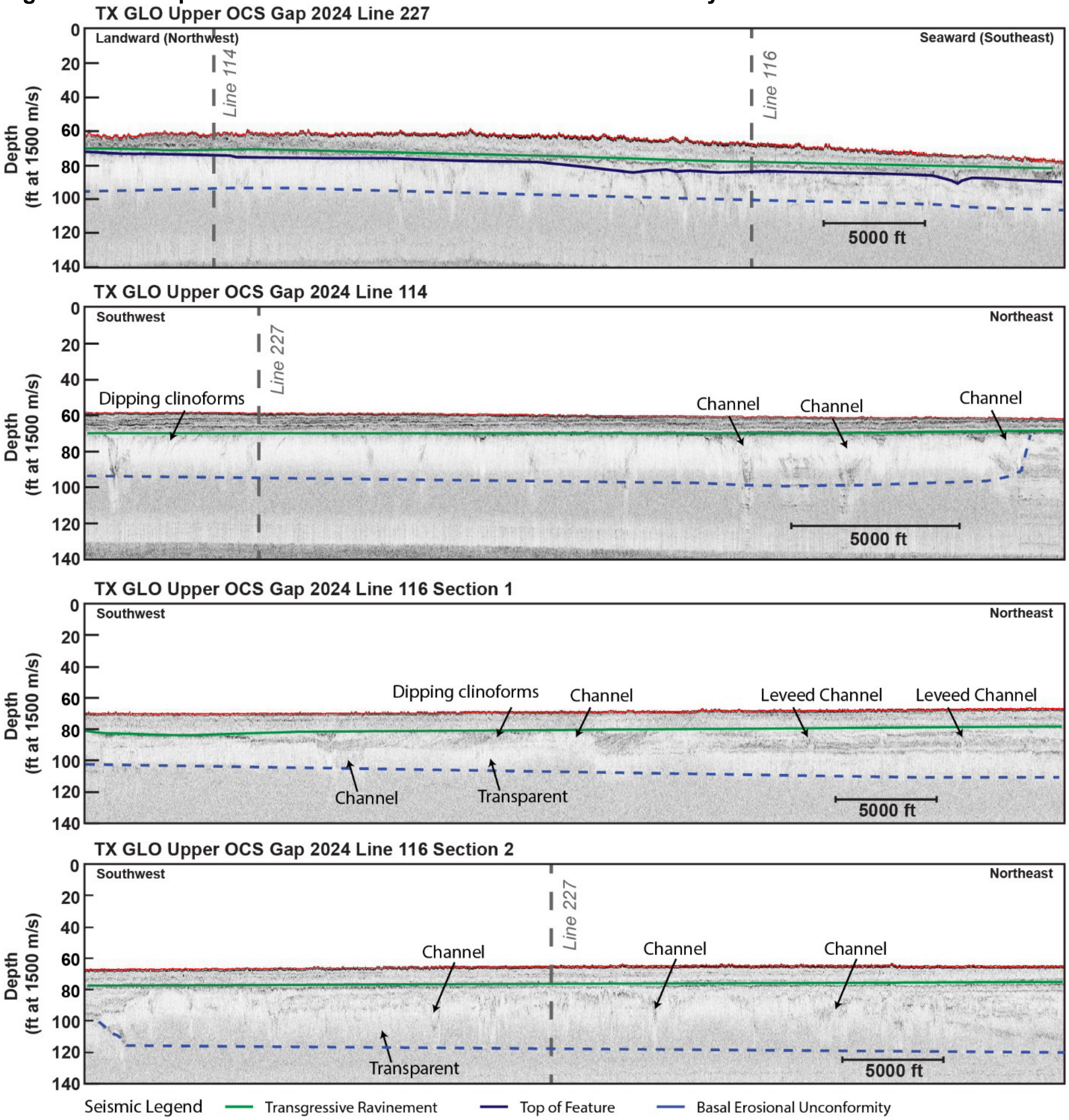
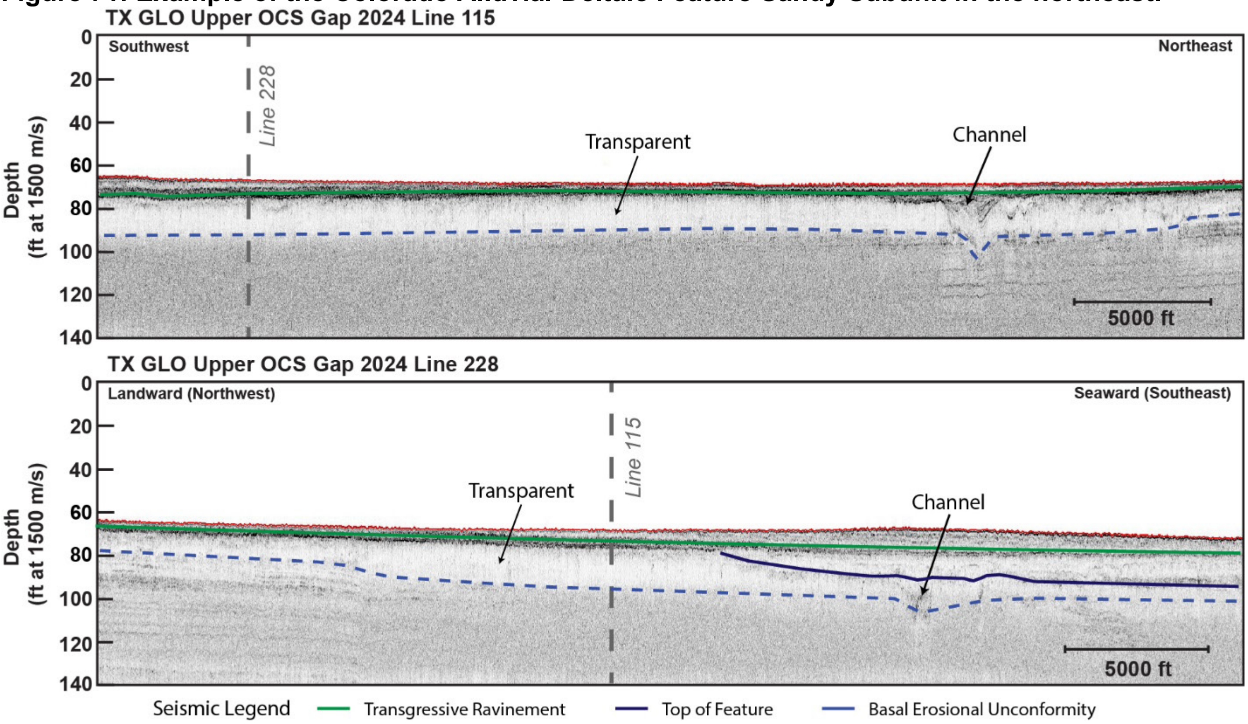


Figure 71: Example of the Colorado Alluvial-Deltaic Feature Sandy Subunit in the northeast.



Although the Colorado Incised Valley was delineated in the Central OCS (APTIM and TWI 2024c) the valley edges are not clearly delineated in the Upper OCS Data Gap lines further seaward using chirp sub-bottom. The presence of thick transparent packages occurring below the transgressive ravinement surface are likely obscuring acoustic imaging of the incised valley edges at depth. The transparent packages are interpreted as sand-rich deltaic deposits outlined in the previous section. Based on previous literature the Colorado Incised Valley continues to the shelf edge to lowstand fan deposits roughly 20,000 years ago (Anderson et al. 2004).

4.4.4.9 Potential Sediment Resource Quantity Estimates

Sand resource targets such as, surficial shoal units, fluvial channel belt, and alluvial-deltaic sandy subunit deposits containing an estimated 4.61 BCY (3.52 BCM) of sand-rich sediment (Figure 72). Other geologic subsurface features were potentially sand bearing but were excluded in resource quantification estimates due to their amount of overburden (the overlying non-compatible sediment between the potential sandy deposit and the seafloor). In other instances, subsurface features were summarized in previous sections for their significance to the geologic framework understanding but their fine-grained sediment composition excludes them from inclusions as potential sand resources. To be considered viable, a sediment resource must be at least 5 feet (1.5 meters) thick in the subsurface with less than 20 feet (6 meters) of overburden. All resource volumes presented are first order estimates and will be greatly refined with geologic sampling and future more detailed survey spacing.

The surficial Seismic Quaternary Unit (Q1) comprises both bathymetric shoals and other surficial units above the transgressive ravinement surface. The originally delineated Q1 unit of APTIM and TWI (2022) was expanded into the Upper OCS Data Gap Investigation Area, with the thickest portions related to an extension of the Shepard Bank and an unnamed shoal. This sediment resource is estimated to contain 2.17 BCY (1.66 BCM) of sand-rich sediment within the Upper OCS Data Gap Investigation Area and verified by archival sediment cores in discrete locations.

The previously identified Sabine Channel Belt 10 and Galveston Channel Belt 3 (APTIM and TWI 2021), which are verified to contain large quantities of sand-rich sediment in state waters (APTIM and TWI 2025b) were extended several miles in the Upper OCS Data Gap area in this investigation. The fluvial channel belts are characterized by a transparent to faintly dipping reflector package grading into an incisional channel form. The portions of the channel belts mapped in the OCS have a loss of acoustic signal below the target deposit which has correlated to contain higher sand content in state waters (APTIM and TWI 2025b) The two channel belt extensions in the OCS are estimated to contain 18 and 15 MCY (13.8 and 11.5 MCM), respectively.

The last, high confidence, regional sand resource target is related to the sandy subunit of an alluvial-deltaic feature offshore of the Colorado Incised Valley mapped in the Central OCS Investigation Area (APTIM and TWI 2024a). This overall mounded feature is characterized by stacked transparent packages with faintly dipping reflector packages and numerous channel features. Only the potentially highest sand content portions of the alluvial-deltaic feature are quantified and estimated to contain 3.11 BCY (2.38 BCM). This feature potentially correlates to a deltaic feature identified by previous researchers that have verified high sand content further offshore of the investigation area (Snow 1998).

Several localized features that could not be correlated regionally could also present as sediment resources if further constrained with increased survey density and geological sampling to verify its composition. These features are found throughout the investigation area and are likely related to fluvial deposits in the subsurface.

Figure 72: Map of viable potential sand resource targets within the investigation area.

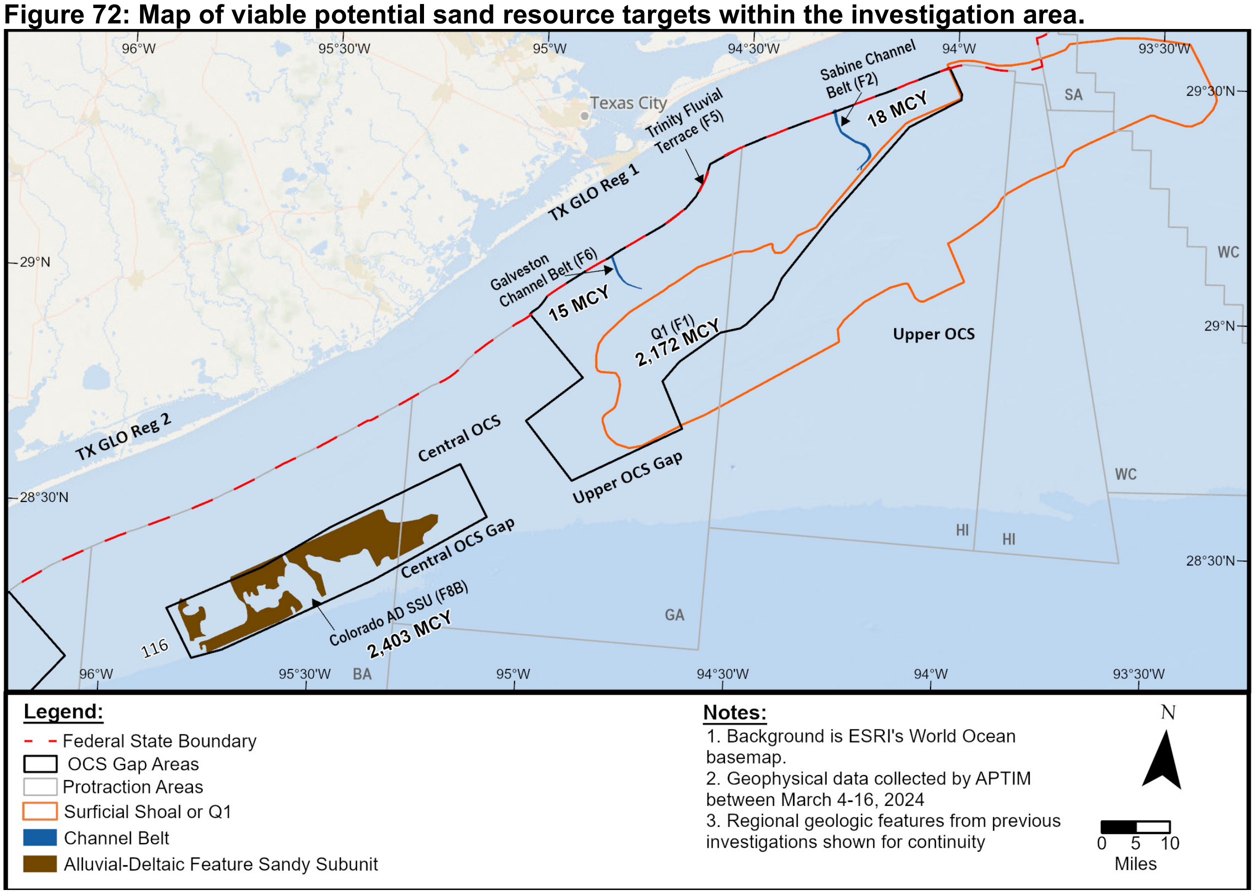


Table 6: Summary of regional geologic features in Upper and Central OCS Data Gap Investigation Areas and quantified viable potential mixed sediment resources with less than 20 feet (6.096 meters) overburden.

Total gross sediment volume totals 4,068 MCY (3,110 MCM)

Feature Number	Protraction Area	Viable Resource (Yes/No/ Potential)	Preliminary Interpretation	Area sq ft x 10^6 (sq m x 10^6)	Average Stratigraphic Unit Thickness ft (m)	Average Overburden Thickness ft (m)	Gross Sediment Volume MCY (MCM)	Example Data Figure No.
1	Galveston Area, High Island Area, High Island Area (East Addition), West Cameron Area (West Addition)	Yes	Surficial Shoal (Q1)	10,396 (965.8)	5.5 (1.7)	0 (0)	2,172 (1,660)	Figure 62
2	High Island Area	Yes	Sabine Channel Belt 10	40 (3.71)	11.5 (3.5)	8.7 (2.7)	18 (14)	Figure 64
3	Galveston Area	Potential	Trinity-Sabine-Neches Valley Tributaries	NA	NA	NA	NA	Figure 67
4	Galveston Area, High Island Area	No	Trinity-Sabine Incised Valley	NA	NA	NA	NA	Figure 65
5	High Island Area	Potential	Trinity Fluvial Terrace	NA	NA	NA	NA	Figure 66
6	Galveston Area	Yes	Galveston Channel Belt	30 (2.78)	12.5 (3.8)	8 (2.4)	15 (11)	Figure 68
7	Galveston Area	Potential	Brazos OCS Channel Belt	NA	NA	NA	NA	Figure 69
8	Brazos Area, Galveston Area	No	Colorado Alluvial-Deltaic Feature	NA	NA	NA	NA	N/A
8B	Brazos Area, Galveston Area	Yes	Colorado Alluvial-Deltaic Feature Sandy Subunit	6,230 (578)	14	15 (4.5)	2,403 (1,837)	Figure 70 Figure 71

Note sq f- square feet, sq m- square meters, ft-feet, m-meters, MCY- Million Cubic Yards, MCM- Million Cubic Meters,
*Gross volume estimates for the Colorado incised valley are for viable channel belt complexes where able to correlate with less than 20 feet (6.096 m) overburden, this should be considered a very conservative estimate. **Features not considered potential viable sand resource targets due to the amount of overburden and are presented for regional geologic framework understanding only. Note the reported volumes do not include volume of overburden, just the sand-bearing unit of interest. Volumes and feature numbers correlate with Figure 72.

4.4.4.10 Regional Geologic Summary

The Central and Upper OCS Data Gap Investigation Areas fills data gaps and was designed to potentially extend previously mapped features spanning from offshore of Sabine Pass to the Colorado-Brazos River and a few areas offshore of San Antonio Bay. This investigation area contains several discrete sand resources within regional scale geologic systems such as surficial shoal units, channel belts, alluvial-deltaic features. These interpretations are based on geophysical data and any available archival sediment boring or core data. Discrete sediment resources quantity and composition within these systems will be refined with future investigations of increased geophysical and geological survey density. Outside of the mapped regional features, there are localized features that are not easily correlated across the reconnaissance line spacing of the survey, related to fluvial stratigraphy and tidal deposits, likely contain sand resources.

Only a brief summary is presented here, for further detailed descriptions and visualizations see previous TX GLO Region 1 (APTIM and TWI 2025b), TX GLO Region 2 and 3 (APTIM and TWI 2024b), Central Coast OCS (APTIM and TWI 2024c), and Upper Coast Sand Banks (APTIM and TWI 2025c) reports. The Q1 surficial unit in the Upper OCS Data Gap area directly overlies reworked Pleistocene deposits or in some cases, overlies incisional tributary or the main Trinity Incised Valley. The accommodation from consolidation of fine-grained fill within the incisional valleys and tributaries provided storage for the thicker Q1 deposits. In other areas the thickest portions of the surficial shoals overlie sand-rich Pleistocene deposits. Overall, the Shepard Bank extension and the unnamed shoal are expanded from the Upper OCS (APTIM and TWI Forthcoming) connected by a sheet of sediment above the transgressive ravinement surface.

Some of the Pleistocene fluvial stratigraphy identified in TX GLO Region 1 were confidently extended offshore and displays similar seismic signatures of verified sand-rich facies in state waters (APTIM and TWI 2025b). The Galveston and Sabine Channel Belts displayed lateral accretion several miles offshore on the OCS, transitioning to more leveed channel morphology indicating potentially higher vertical sediment aggradation and potential proximity to major depocenters.

The alluvial-deltaic feature and its sandy subunits offshore of the Colorado identified in the Central OCS Data Gap area extends from fluvial stratigraphy of the ancestral Colorado River system. The identified geologic feature likely contains fluvial channel belt and delta front sand of various stacked delta lobes. This feature potentially correlates to a Colorado delta system deposited as sea-levels rose during the last transgression (Abdulah 1995; Snow 1998) verified to contain significant silty sand and sand deposits through archival borings. An increasing amount of fine-grained sediment related to the Texas Mud Blanket overlie this geologic feature and fluvial features identified to the south.

4.4.4.11 Localized Features

Localized features are not continuous or traceable across multiple lines at the current reconnaissance survey line spacing. These features are scattered throughout the protraction areas, within smaller channel belt type features and some drainage/paleovalley systems. These features are normally isolated channels/sediment pockets which can be reflective of potential resources or partially preserved channel belts (Figure 73). Features with overburden that exceed 21 feet (6.1 meters) are not targeted as potential resources due to accessibility but are included due to the value they bring to better understanding the geologic framework of the area (Figure 74). Due to the widely spaced grid, it is not possible to determine the overall extent of these features or correlate them to the larger sand-bearing regional deposits; however, based on the observed seismic characteristics, there is potential for additional data collection to better delineate these features and determine their potential for sand. Localized features are characterized as typically having lateral accretionary deposits or transparent internal reflector packages (Figure 75). The features listed below are not exhaustive but highlight the primary localized features in the Upper and Central Coast OCS Data Gap Investigation Area.

Figure 73: Line 115 in the Upper OCS Data Gap Investigation Area.
Example of a semi-transparent, chaotic channel belt (blue dashed) with steeply dipping reflectors incised by a transparent, ~ 8 feet (2.4 meters) channel. Overlaying the channel belt is the most recent Holocene ravinement, ~4 feet (1.2 meters) thick (green).

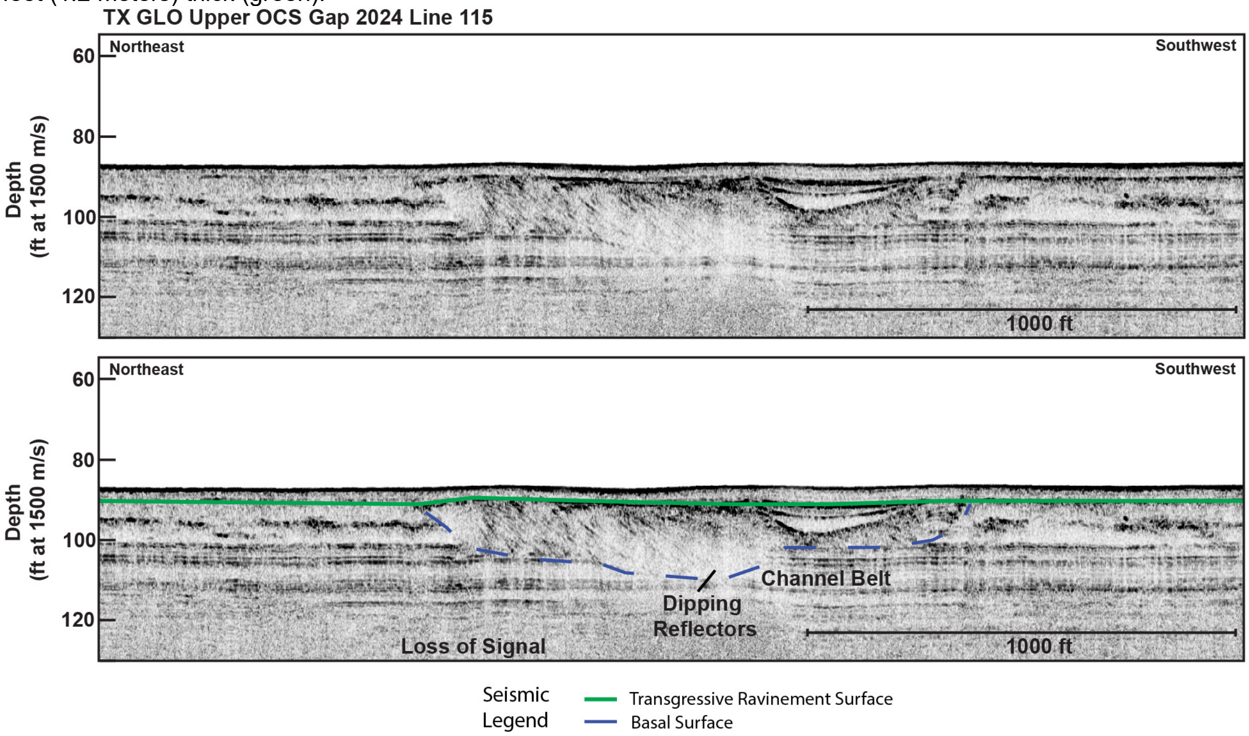


Figure 74: Line 111 in the Central Coast OCS Data Gap Area.
Example of high-frequency reflectors (black) downlapping at a low angle (1–5 degrees) beneath the TMB with ~50 feet (15.2 meters) of overburden. Ravinement thickness delineated in green shade. Valley bounded in green.

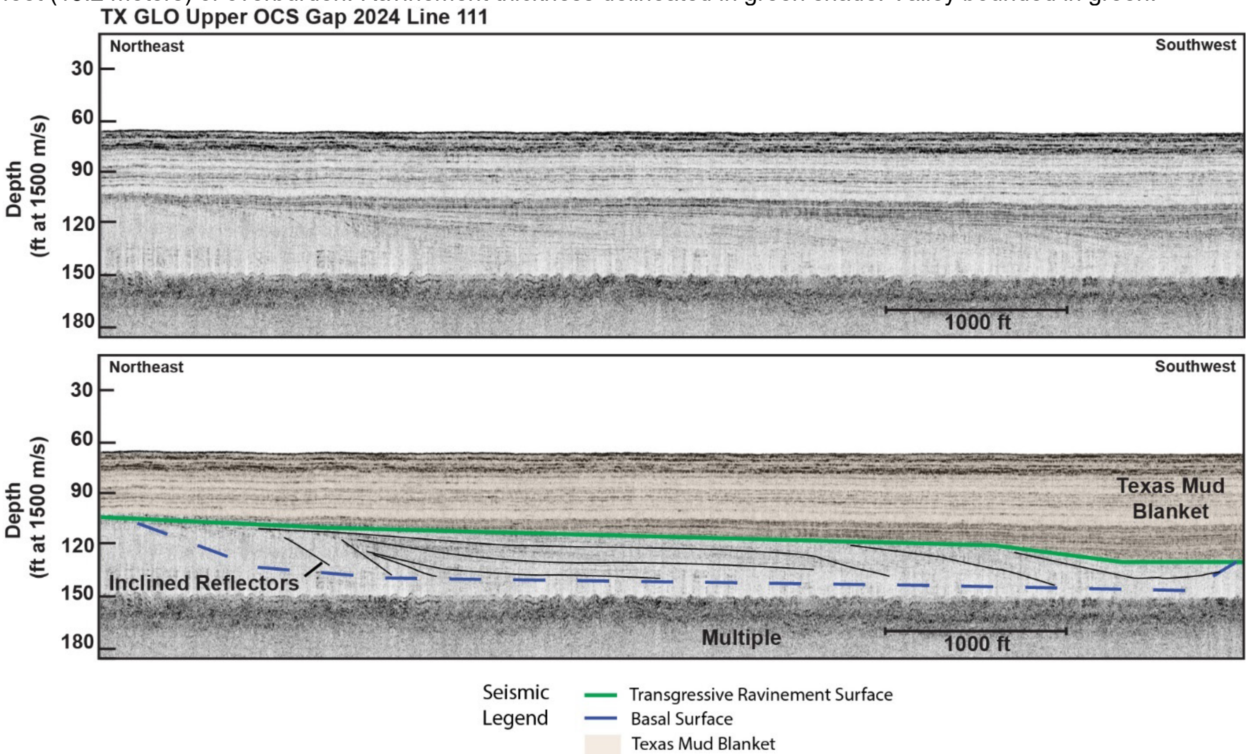
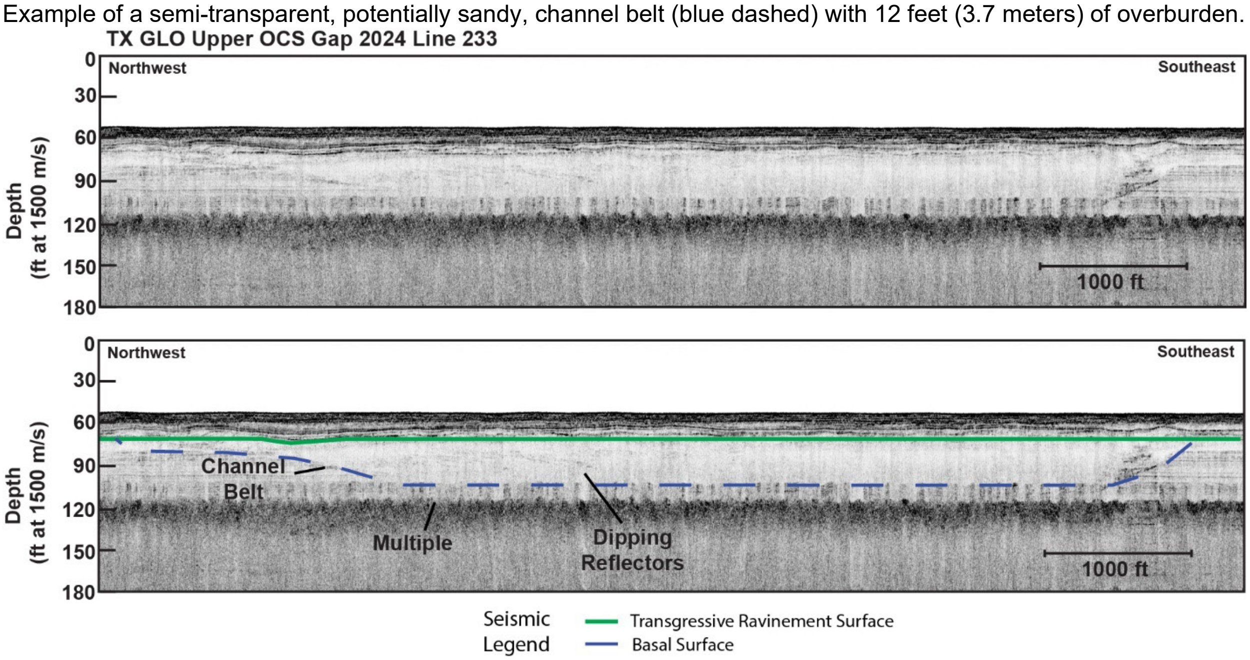


Figure 75: Line 233 in the Upper OCS Data Gap Area.
Example of a semi-transparent, potentially sandy, channel belt (blue dashed) with 12 feet (3.7 meters) of overburden.



4.4.5 Texas Mud Blanket

This investigation identifies and delineates a regional unit that extends across GLO Regions 2 and 3 (APTIM and TWI 2024b), the Central OCS (APTIM and TWI 2024c), and into GLO Region 4 and the

Lower OCS (APTIM and TWI 2025a). The TMB is defined here as the uppermost depositional unit resolved in the chirp data. The TMB is bounded by the transgressive ravinement surface and the modern seafloor, except where overlain by modern coastal deposits (lower shoreface or tidal deltas). The full spatial extent of these features are not constrained by the data collected during this investigation, as it extends to the west-southwest according to archival studies (Weight et al. 2011). The seismic character is defined by draping, horizontally laminated, to slightly wavy, laterally continuous reflectors of varying amplitudes, and is interpreted as a fine-grained deposit. The reflector sets downlap seaward and onlap landward. This unit thickens up to 100 feet (30.5 meters) seaward and to the southwest within the investigation area (Figure 76). The TMB is described as being Holocene age based on radiocarbon samples presented in Weight et al. (2011) and others (Figure 77).

Figure 76: Line 104. Example of the gas escaping in the Texas Mud Blanket.
Gas presents itself in the seismic profile as parabolas. Ravinement surface delineated in green.

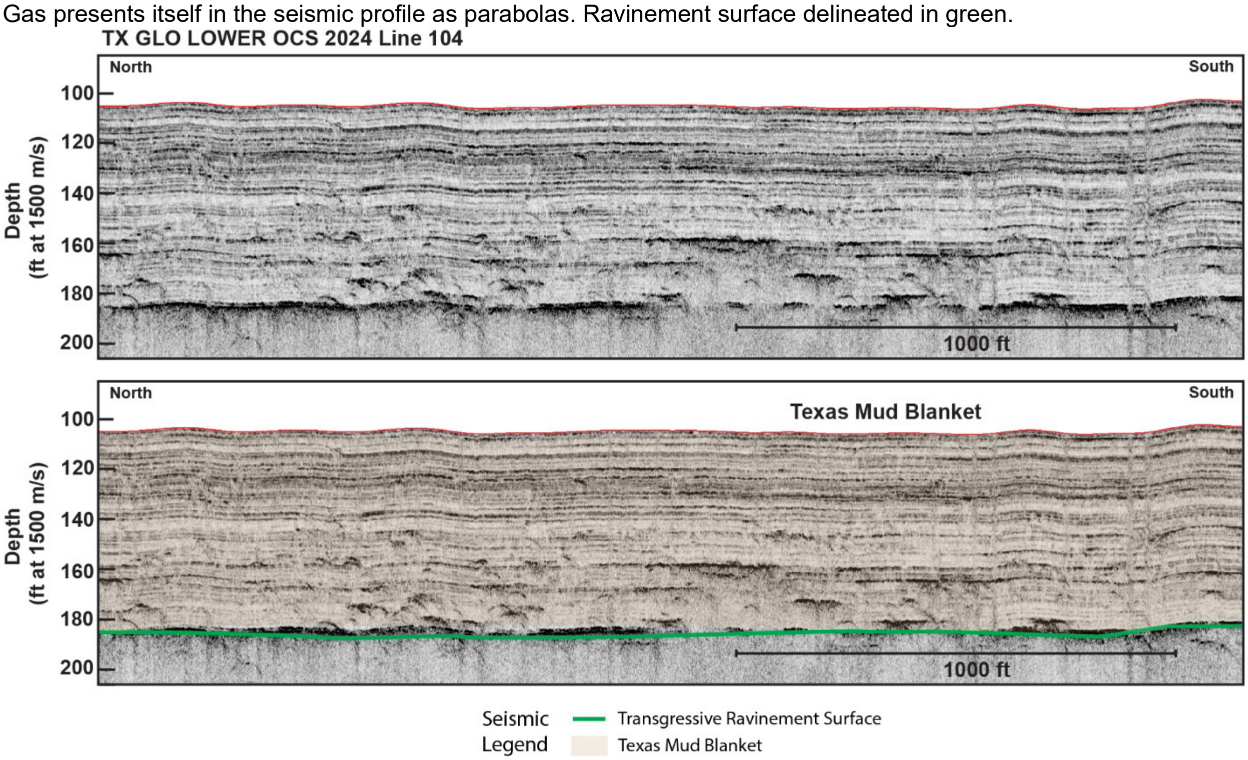
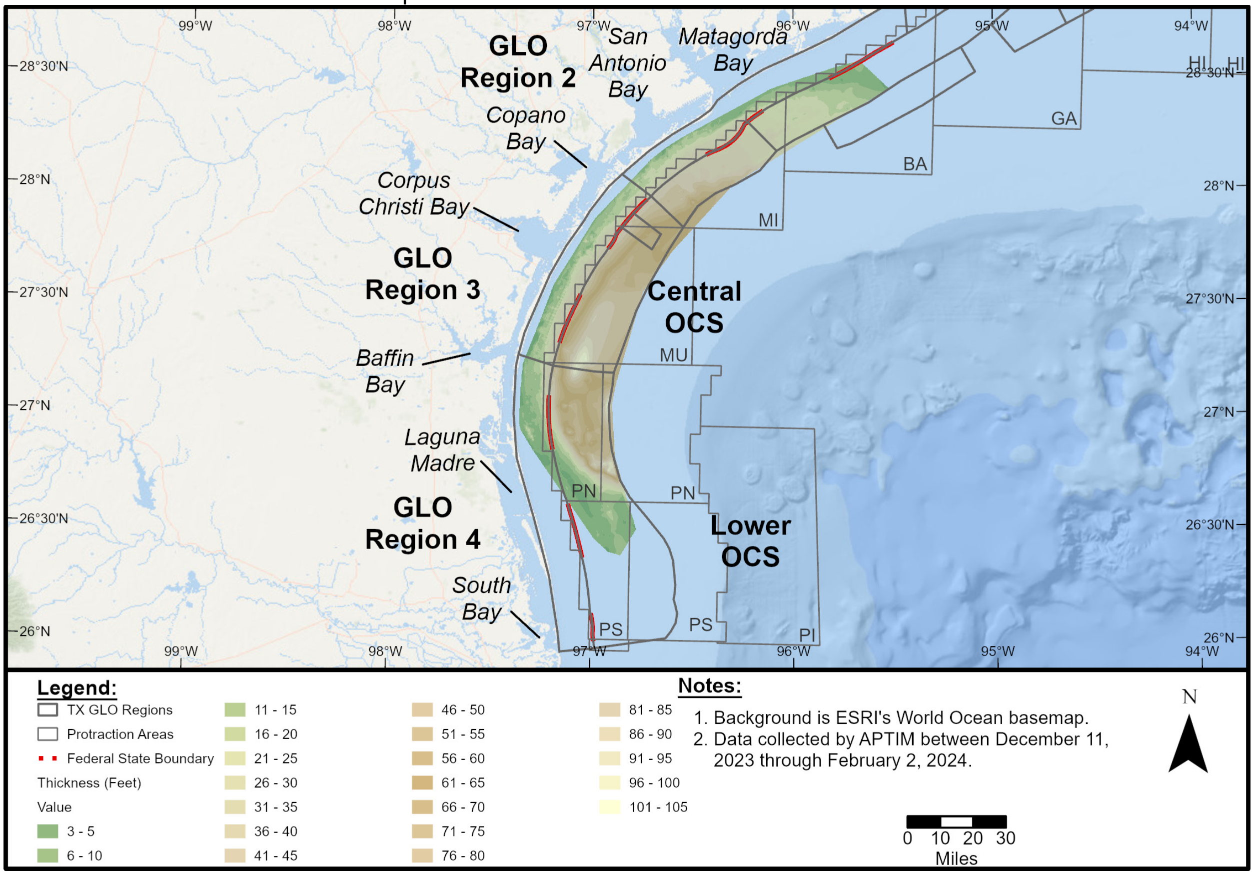


Figure 77: Map of Texas Mud Blanket (TMB) distribution and thickness.
Note that the TMB is classified as overburden to any underlying potential sand-bearing geologic features. An overburden threshold of 20 feet (6 meters) is used to characterize viable and non-viable sand-bearing features from reconnaissance-level sand resource quantification.



The TMB represents river plume fine-grained material as well as locally reworked shelf edge delta material that accumulated in the central Texas shelf embayment during the last transgression (Weight et al. 2011). Based on seismic data from this investigation it is a highly continuous feature. Historical geological data show grey to red clays and interbedded clays and silts with sand lenses and shelly mud intervals (Weight et al. 2011). Depositional ages range from 9,000 years ago to present, representing both terrestrial to marine sedimentation (Weight et al. 2011).

The TMB does not represent a potential sand resource but understanding its distribution is critical to identifying the limiting overburden that may constrain the utility of any underlying potential sand-bearing sediment resources. This investigation uses a threshold of 20 feet (6 meters) or greater of TMB to exclude underlying features from consideration as a viable sand resource target. However, these excluded features are identified and mapped due to their importance for the regional geologic framework. Potential sand-bearing deposits displaying massive or transparent acoustic facies were found in much of the central portion of the investigation below the TMB and transgressive ravinement surface but were not mapped due to poor seismic imaging at depth. This could correlate to a preserved MIS3 coastal shoreline or wave dominated delta 80,000 years old underlying the TMB identified in previous research (Anderson et al. 2004; Eckles et al. 2004). However, these coastal deposits are overlain by greater than 20 feet (6 meters) of TMB overburden and were excluded as a potential sand resource.

4.4.6 Ravinement

One of the tasks for this investigation was to identify the most recent transgressive ravinement surface evident throughout the investigation areas. The ravinement surface is indicative of an erosional unconformity, where the dominant force was either wave or tidal scouring which caused the removal of the antecedent deposits as the gulf shoreline migrated across the shelf leaving behind coastal, estuarine, and marine stratigraphic units above the ravinement.

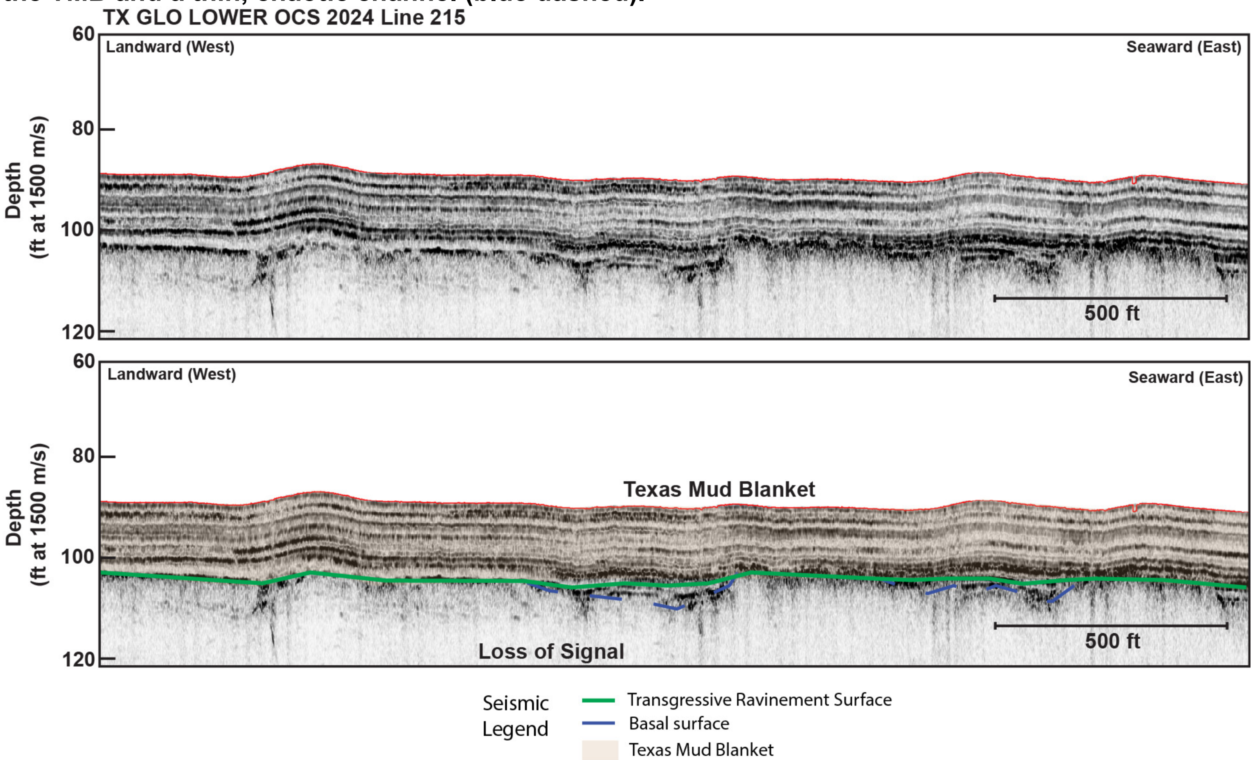
The most recent Holocene/Pleistocene unconformity ravinement was mapped throughout the entire investigation areas. In some locations the most recent ravinement is absent above pre-existing Pleistocene deposits indicating that the modern seafloor is coincident with the ravinement surface. This stratigraphic reflector was digitized manually identifying this reflector within SonarWiz to create a color-coded boundary. This boundary (where visible) was used within SonarWiz to compute the thickness from the bottom of the most recent depositional unit (i.e., erosional surface) to the seafloor to generate an isopach of the most recent sediment wedge. The thickness (xyz) of this sediment unit was imported into Surfer 23 and gridded to create an interpolated surface depicting the general trend of deposits above the ravinement surface within the area (Appendix A and Appendix C). This area's ravinement was then compared to the ravinement in GLO Regions 1, 2, 3, and 4 as well as previously mapped areas in Central and Upper OCS.

In the Upper OCS Data Gap Investigation Area, the ravinement surface is relatively shallow with respect to the seafloor. In the northeast part of the area, close to Sabine Bank, the most recent Holocene ravinement is roughly 2 to 6 feet (0.6 to 1.8 meters) thick (Appendix A Map 7a–7c) and gradually thickens to 8 feet (2.3 meters) moving offshore. Offshore High Island and Galveston, the ravinement surface is 1 to 2 feet (0.3 to 0.6 meters) thick with discrete areas existing at ~6 feet (~1.8 meters).

In the Central OCS Data Gap Investigation Area, the ravinement surface generally thickens from 29 feet (8.8 meters) in the northeast to 38 feet (11.6 meters) in the southwest offshore Calhoun County. The ravinement surface south of East Matagorda Bay is roughly 42 feet (12.8 meters) and thickens to 60 feet (18 meters) offshore of San Antonio Bay.

In the Lower OCS Investigation Area, an abrupt shoaling of the ravinement surface is found to coincide with the southerly edge of the modern Texas Mud Blanket. The surface is deeper than 40 feet (12.2 meters) in the north part of this investigation area, shallowing to under 10 feet (3 meters) offshore Willacy County (Figure 78). It continues to shallow to the south, where it exists 3 feet (0.9 meters) below the seafloor offshore Cameron County.

Figure 78: Line 215 in the Lower OCS Investigation Area. Ravinement surface (green) bounded by the TMB and a thin, chaotic channel (blue dashed).



5 Conclusions

This sand source reconnaissance geophysical investigation followed sequential survey procedures developed by APTIM. This report details the resource exploration results of two investigation areas: 1) the Lower OCS, 2) Upper and Central OCS Data Gap Investigation Areas.

During Phase I, a review of historical data found limited geologic data for marine sand resources offshore Regions 4 and Lower OCS to the Texas federal/state boundary along Kenedy, Willacy, and Cameron Counties. Along the Central and Upper OCS regions, APTIM, TWI, the GLO, and BOEM reviewed the geophysical data collected in 2020 and 2022 (APTIM and TWI 2022; 2024c) and identified specific areas that would benefit from additional data collection to further assist in the understanding of the geologic framework and constrain potential resources. Based on this review, Phase II involved the collection of reconnaissance geophysical investigation at a roughly 3 nm (5.6 km) square grid within the Lower OCS Investigation Area. Within the Central OCS Data Gap area, 362.8 nm (671.9 km) of geophysical data were collected to help constrain previously identified features from Phase I. Within the Upper OCS Data Gap area, 572.8 nm (1,060.8 km) of geophysical data were collected fill to the gap area between the Region 1 and Upper OCS Sand Banks areas.

Interpretation of the reconnaissance geophysical survey data were used to identify major regional stratigraphic features located within the OCS investigation areas and correlated to results from previous and concurrent state waters investigations, as well as develop a regional geologic framework of major depositional systems that have the potential to contain accessible sand resources. Throughout Lower OCS and Upper and Central OCS Data Gap Investigation Areas researched as part of this investigation, an additional 16 regional features were identified, of which seven likely contain viable potential sand resource.

In the Lower OCS Investigation Area, the surficial sand units (Feature 1) consist of two shore-parallel trends of surficial units found at 100 feet (30 meters) and 165 feet (50 meters) water depths. The eight identified surficial units have variable bathymetric expressions, some units show prominence while others appear to fill accommodations created by underlying deposits. Each sand unit correlates to high intensity returns in the analyzed sidescan sonar. These units are characterized by fuzzy to transparent seismic packages bounded by a strong to hazy surficial reflector and the transgressive ravinement surface with variable underlying reflectors. The surficial units are up to 12 feet (3.7 meters) thick and estimated to contain 813 MCY (621 MCM) of sand-rich sediment with no overburden.

Delta Front Sand deposits (Feature 2) are an extension from TX GLO Region 4 state waters into the Lower OCS Investigation Area. Feature 2 underlies surficial shoal units and has an average thickness of 8 feet (2.4 meters). With additional geotechnical sampling to verify its sand composition, the surficial sand units and delta front could be considered a combined resource. It is estimated that the Delta Front Sand deposits (Feature 2) contain 529 MCY (404 MCM) of sand-rich sediment. Most of the "overburden" is associated with additional sand resources related to surficial sand units.

In the Lower OCS, Shelf Delta Front Sand systems (Feature 4) mark major depocenters nearing the shelf slope. The Shelf Delta Front Sand is made up of individual lobes of various ages but are generally grouped for this investigation. Feature 4 occurs in water depths of 130–180 feet (40–55 meters). It is characterized by mounded features of opposite dipping reflectors, transparent packages, and faint seaward dipping reflector packages. The base of these deposits identified here are likely conservative estimates as there may be areas of stacked sand packages not resolvable in chirp sub-bottom, at depth. Again, these features underly surficial sand units in some locations in the southern portions of the Lower OCS. Fine-grained overburden related to the TMB increases to the north. It is estimated that the Shelf Delta Front Sand deposit (Feature 4) contains 3.78 BCY (2.89 BCM) of sand-rich sediment. The presented volume is clipped to areas of 20 feet (6 meters) or less of overburden, additional sand resources were excluded where the TMB overburden was above this threshold.

In the Upper OCS Data Gap Investigation Area, the surficial Seismic Quaternary Unit (Q1) comprises both bathymetric shoals and other surficial units above the transgressive ravinement surface. The originally delineated Q1 unit of the Upper OCS (APTIM and TWI 2022) was further expanded into the Upper OCS Data Gap, with the thickest portions related to an extension of the Shepard Bank and an unnamed shoal. This sediment resource is estimated to contain 2.17 BCY (1.66 BCM) of sand-rich sediment within the Upper OCS Data Gap Investigation Area and verified by archival sediment cores in discrete locations.

The previously identified Sabine Channel Belt 10 and Galveston Channel Belt 3 of GLO Region 1 (APTIM and TWI 2021), were extended several miles in the Upper OCS Data Gap Investigation Area. These channel belts were verified to contain large quantities of sand-rich sediment in state waters (APTIM and TWI 2025c). The fluvial channel belts are characterized by a transparent to faintly dipping reflector package grading into an incisional channel form. The extensions of the channel belts mapped in the Upper OCS Data Gap area have a loss of acoustic signal below the target deposit which was correlated to contain higher sand content in state waters (APTIM and TWI 2025c) The two channel belt extensions in the Upper OCS Data Gap are estimated to contain 18 and 15 MCY (13.8 and 11.5 MCM), respectively.

In the Central OCS Data Gap Investigation Area, a potentially sandy subunit of an alluvial-deltaic feature extends offshore of the mapped Colorado Incised Valley in previous investigations (APTIM and TWI 2024c) The overall mounded alluvial-deltaic sandy subunit feature is characterized by stacked transparent packages with faintly dipping reflector packages and numerous channel features. Only the potentially highest sand content portions of the alluvial-deltaic feature are quantified and estimated to contain 3.11

BCY (2.38 BCM). This feature potentially correlates to a deltaic feature identified by previous researchers that have verified high sand content further offshore of the investigation area (Snow 1998).

This investigation expanded the Texas Mud Blanket delineation, a regional feature found in GLO Region 2 and 3 and the Central OCS Data Gap Investigation Area, extending to Region 4 and the Lower OCS Investigation Area. This feature has been extensively researched in prior studies (Weight et al. 2011). Its seismic character includes draping, horizontally laminated, to slightly wavy, laterally continuous reflectors of varying amplitudes. The reflector sets downlap seaward and onlap landward. The unit thickens seaward and to the southwest, up to 100 feet (30.48 meters) thick. This muddy, to sandy mud unit does not represent a potential sand resource but understanding its distribution was critical to identifying the limiting overburden that may constrain the utility of any underlying potential sand-bearing sediment resources.

In addition to the large regional units, smaller, isolated features were also identified during data processing. These localized features are observed throughout the OCS, and many are potentially sand-bearing deposits but are not observed on adjacent geophysical lines, making characterization and quantification of potential sand resources impossible at this resolution. These smaller features are normally isolated channels or sediment pockets, which are indicative of sand or mixed sediments.

The 16 features identified in this investigation are not exhaustive or inclusive of all potential sand-bearing stratigraphy within the region, but rather represent systems that are sufficiently regionally extensive and contiguous to be confidently interpreted across the variably spaced reconnaissance survey grid. The major geologic systems observed represent a cumulative gross volume of ~9.2 BCY (~7 BCM) of sand and mixed sediments. The precise composition of these deposits is likely highly variable and requires more detailed geological investigation. Some of these large, depositional systems have never been previously observed and help to constrain areas of fluvial-deltaic activity of the Texas coastal rivers and reorganization by coastal processes throughout the Pleistocene and Holocene. The precise composition of these deposits is likely highly variable and requires more detailed geological investigation.

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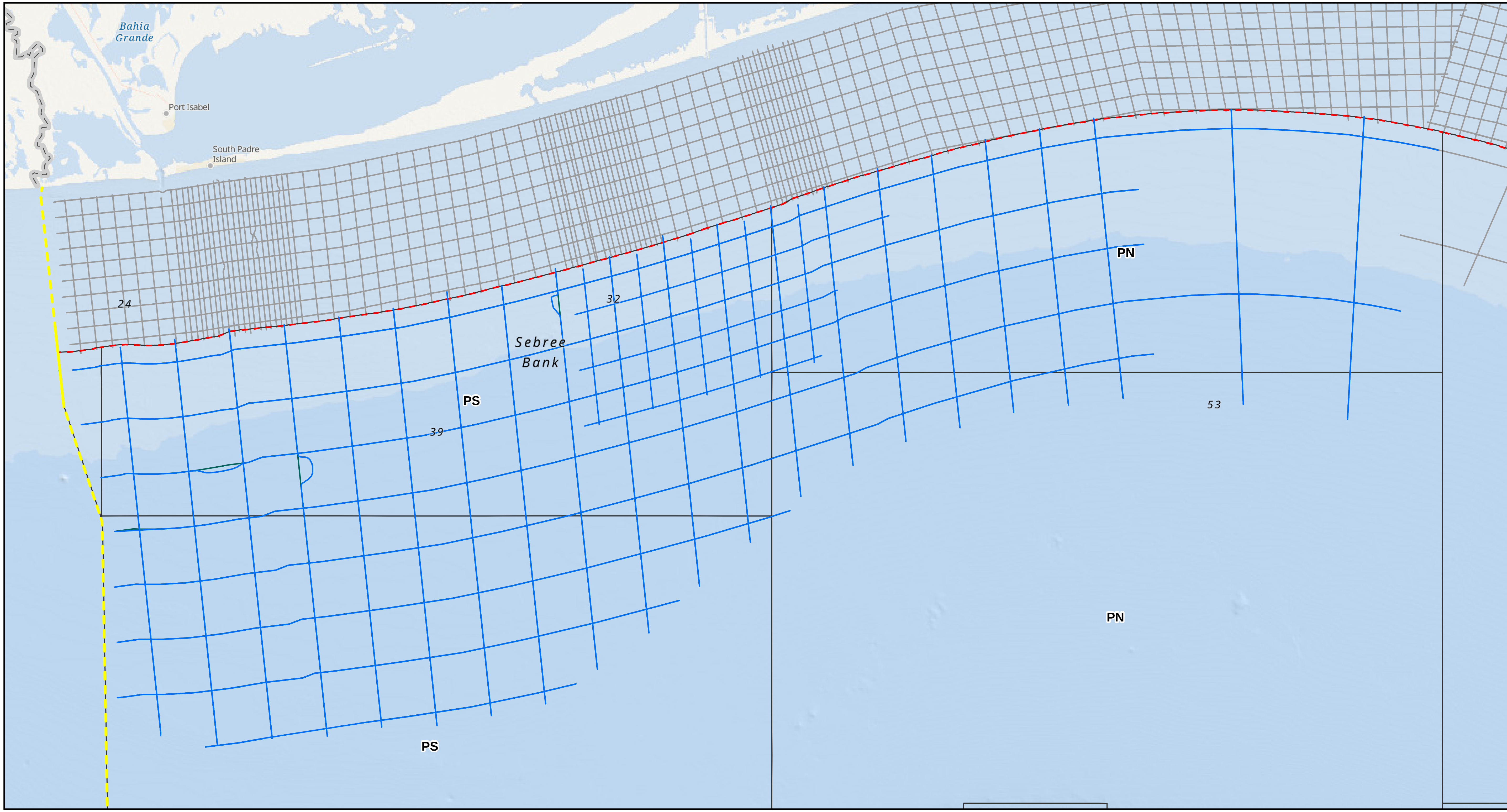
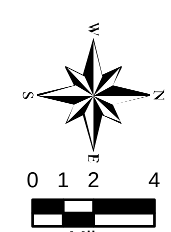
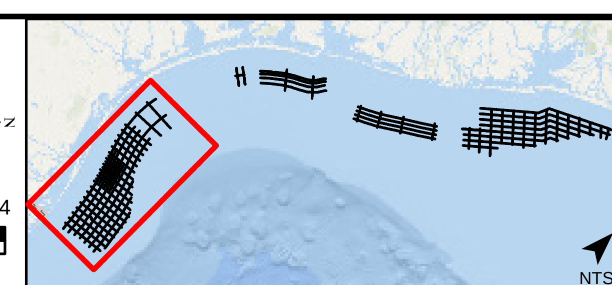
Appendix A: Maps



Notes:
1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:
- As-Run Tracklines
- GLO Region and OCS As Run Tracklines
- Federal/State Boundary
- U.S Mexico Border
- BOEM OCS Protraction Diagrams Areas

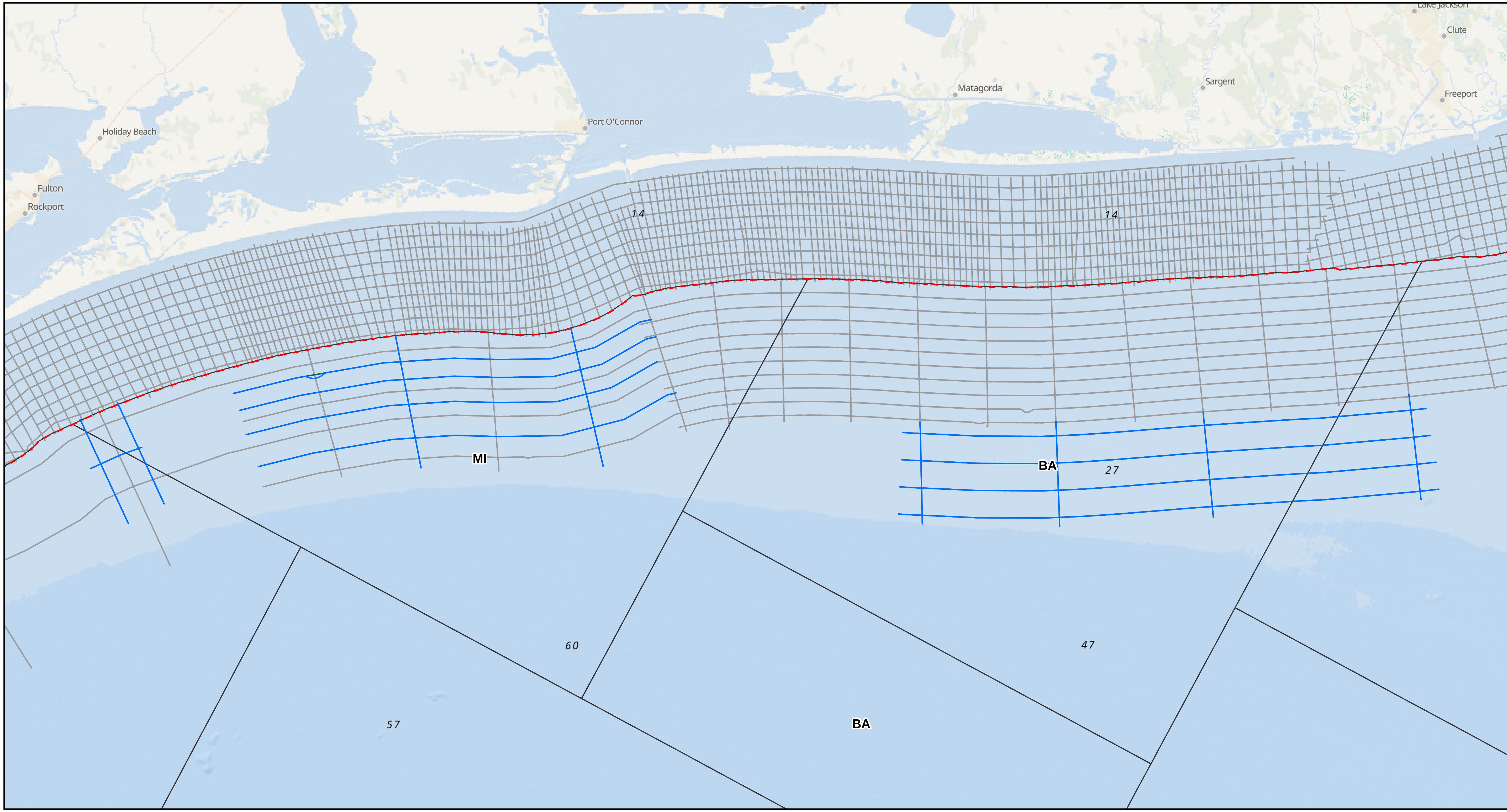




Title:
Texas General Land Office Lower Coast OCS Sand Source Survey
As Run Geophysical Tracklines

APTIM
725 US Highway 301 S
Tampa, FL 33619
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 1a



Notes:

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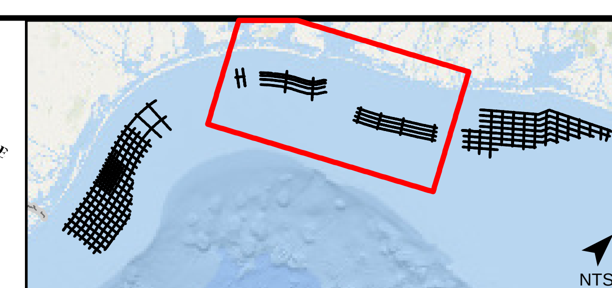
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- As-Run Tracklines
- GLO Region and OCS As Run Tracklines
- Federal/State Boundary
- BOEM OCS Protraction Diagrams Areas



Title:

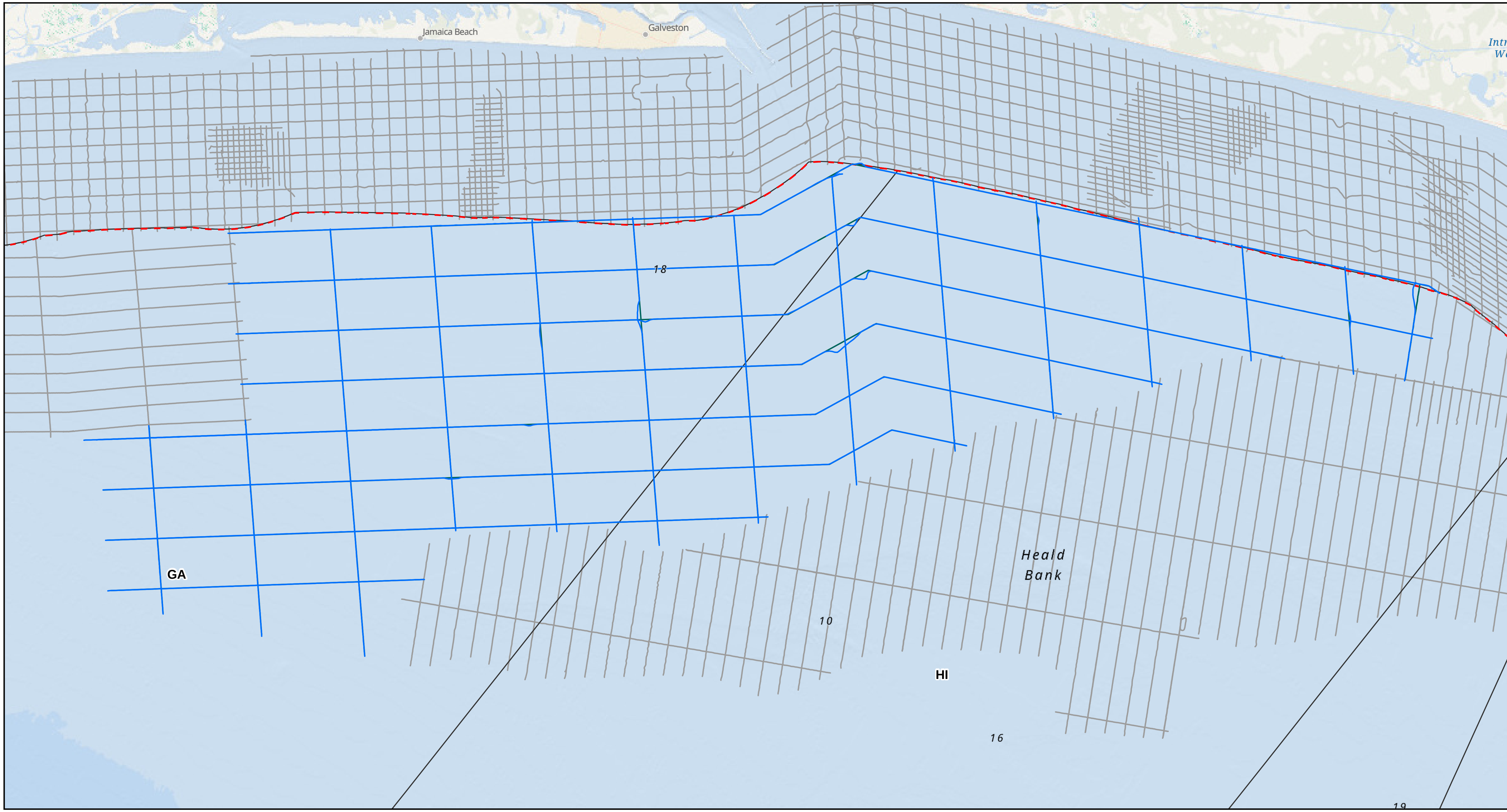
Texas General Land Office Lower Coast OCS Sand Source Survey

As Run Geophysical Tracklines

APTIM

725 US Highway 301 S
Tampa, FL 33619
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 1b



Notes:
1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

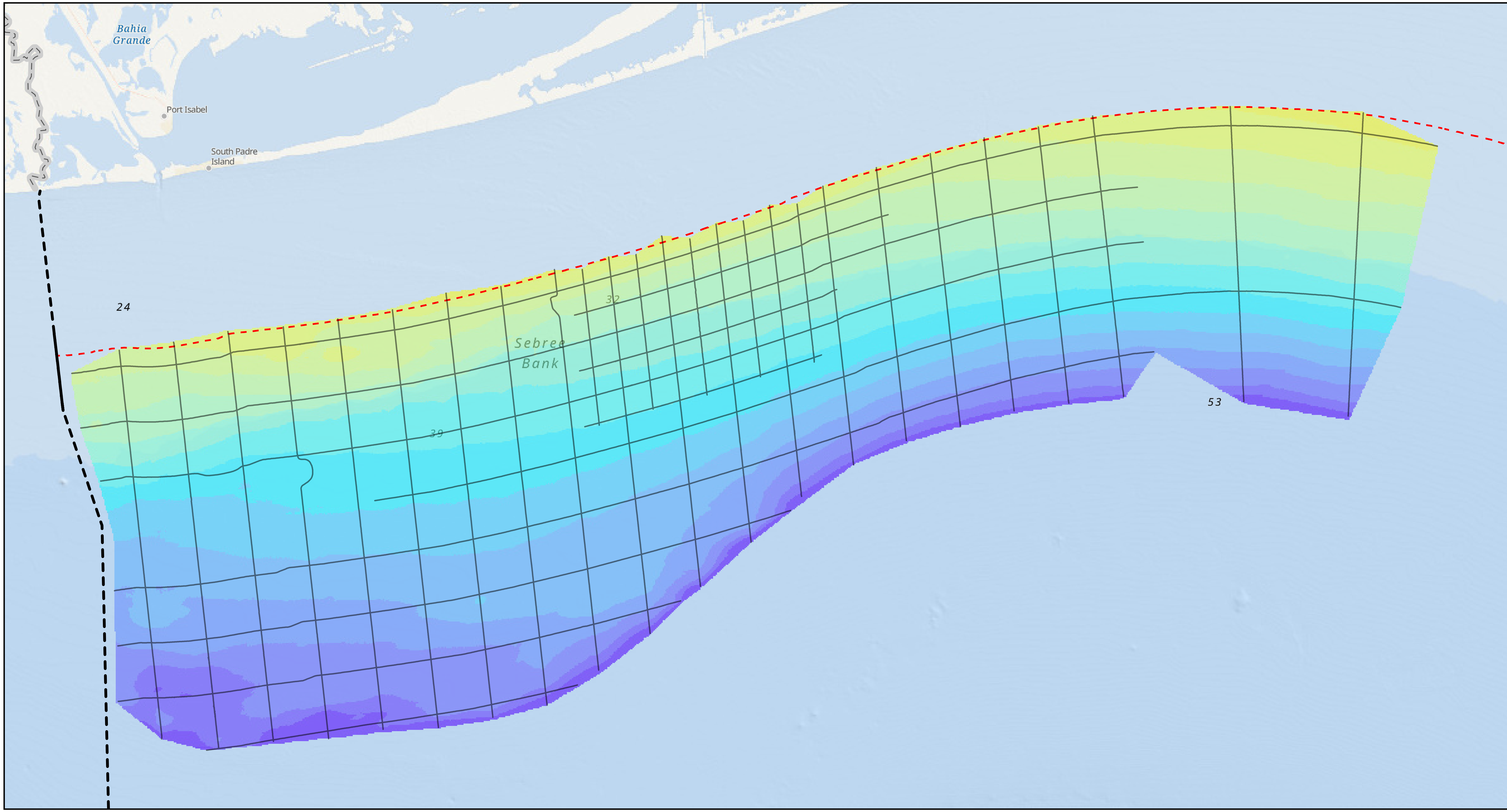
Legend:
- As-Run Tracklines
- GLO Region and OCS As Run Tracklines
- Federal/State Boundary
- BOEM OCS Protraction Diagrams Areas

0 1 2 4
Miles

Title:
Texas General Land Office Lower Coast OCS Sand Source Survey
As Run Geophysical Tracklines

APTIM
725 US Highway 301 S
Tampa, FL 33619
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 1c



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Elevation (ft, NAVD88)

-45 - -38	-80 - -73	-115 - -108	-150 - -143
-52 - -45	-87 - -80	-122 - -115	-157 - -150
-59 - -52	-94 - -87	-129 - -122	-164 - -157
-66 - -59	-101 - -94	-136 - -129	-168 - -164
-73 - -66	-108 - -101	-143 - -136	-174 - -168

0 1 2 4
Miles

Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Single Beam Bathymetry Surface

APTIM

725 US Highway 301 S
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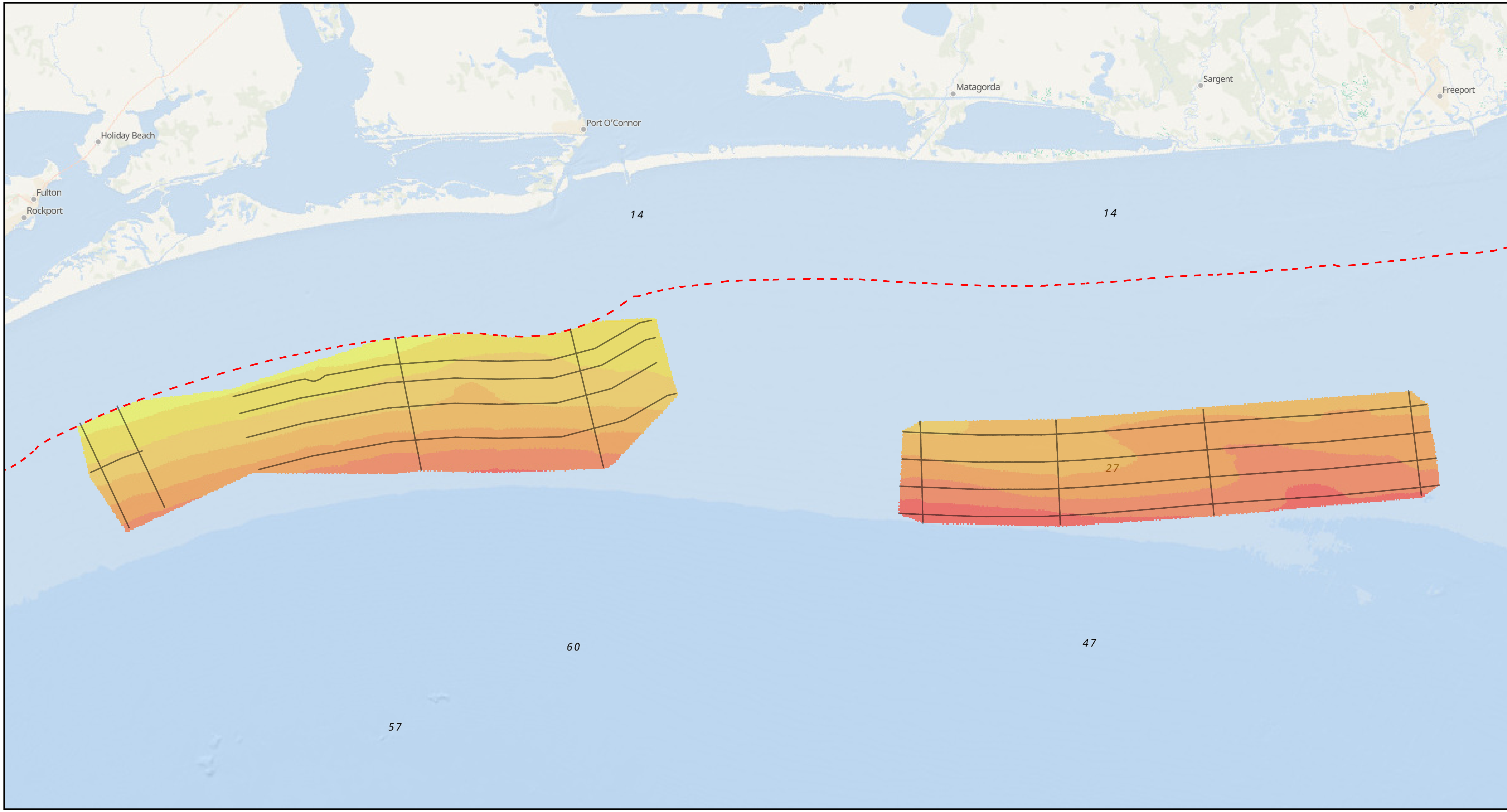
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 2a



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

— As-Run Tracklines

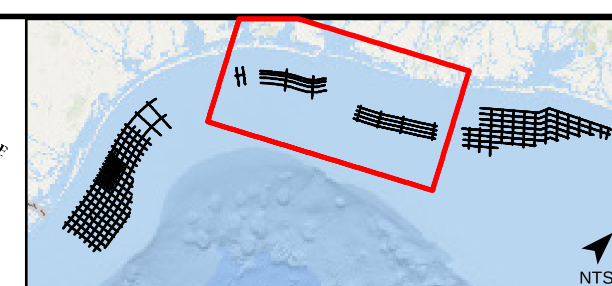
- - Federal/State Boundary

Elevation (ft, NAVD88)

-45 - -38	-80 - -73	-115 - -108	-150 - -143
-52 - -45	-87 - -80	-122 - -115	-157 - -150
-59 - -52	-94 - -87	-129 - -122	-164 - -157
-66 - -59	-101 - -94	-136 - -129	-168 - -164
-73 - -66	-108 - -101	-143 - -136	-174 - -168

0 1 2 4

Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Single Beam Bathymetry Surface

APTIM

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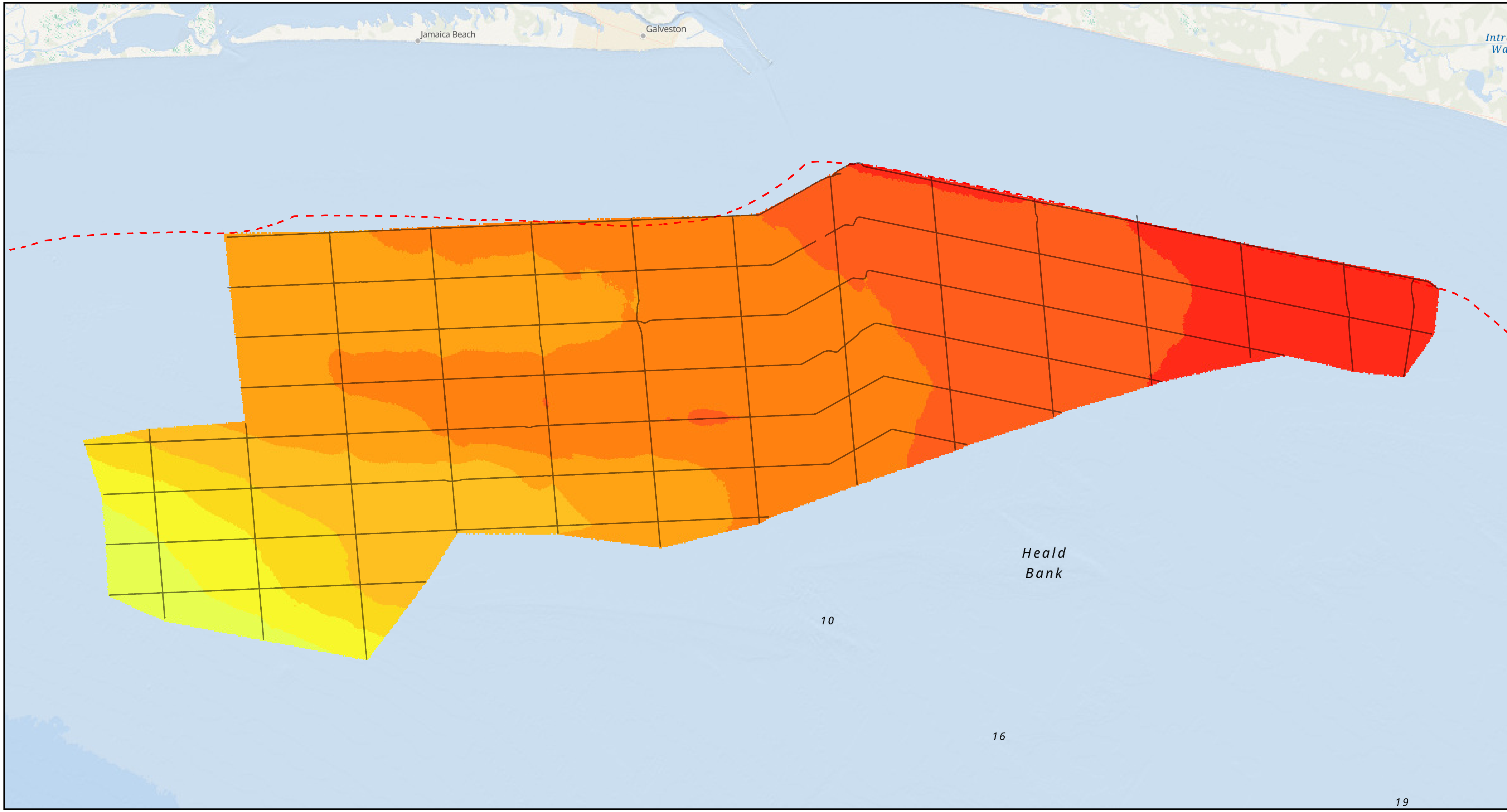
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 2b



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

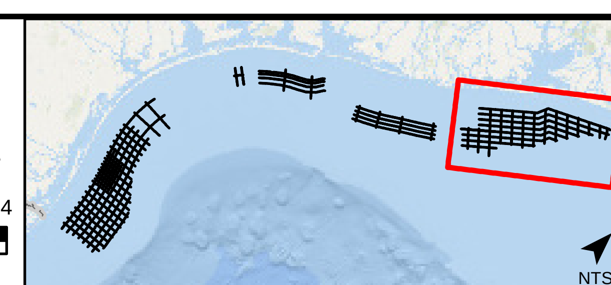
Legend:

— As-Run Tracklines
- - Federal/State Boundary

Elevation (ft, NAVD88)

-45 - -38	-80 - -73	-115 - -108	-150 - -143
-52 - -45	-87 - -80	-122 - -115	-157 - -150
-59 - -52	-94 - -87	-129 - -122	-164 - -157
-66 - -59	-101 - -94	-136 - -129	-168 - -164
-73 - -66	-108 - -101	-143 - -136	-174 - -168

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Single Beam Bathymetry Surface

APTIM

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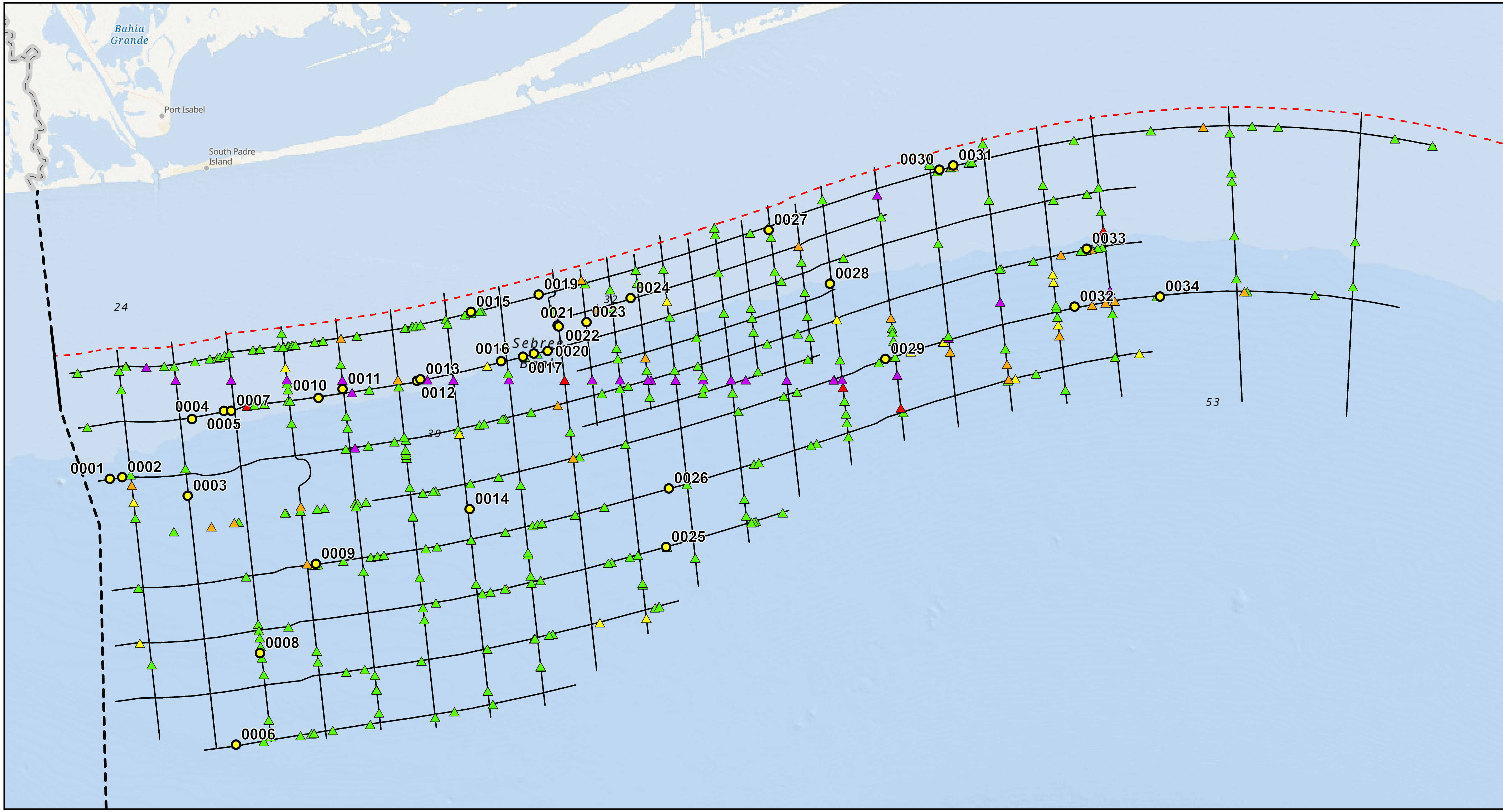
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 2c



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

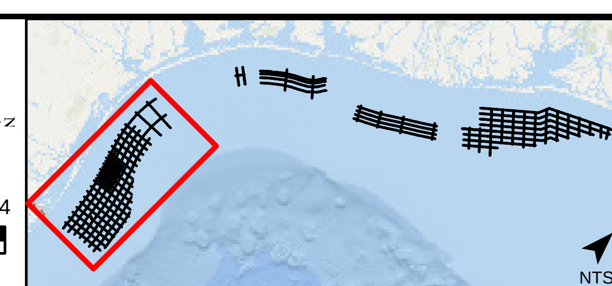
Legend:

- Sidescan Sonar Contacts
- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Magnetic Anomalies Amplitude (nT)

- 0 - 50
- 51 - 100
- 101 - 500
- 501 - 1000
- 1001+

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Sidescan Sonar Contacts and Magnetometer Anomalies

APTIM

725 US Highway 301 S
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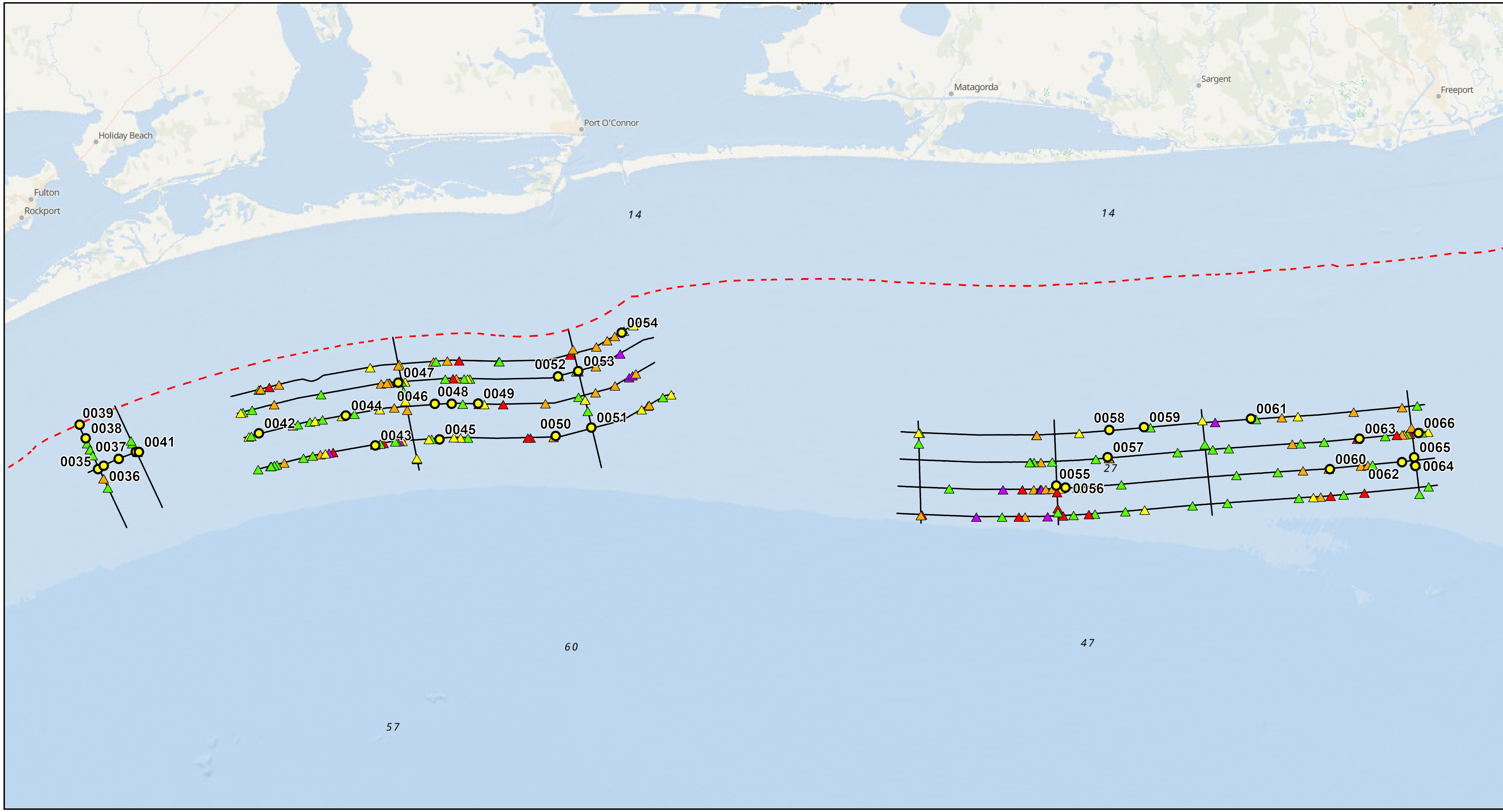
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 3a



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

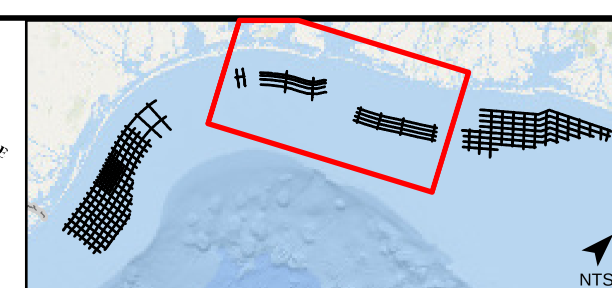
Legend:

- Sidescan Sonar Contacts
- As-Run Tracklines
- Federal/State Boundary

Magnetic Anomalies Amplitude (nT)

- 0 - 50
- 51 - 100
- 101 - 500
- 501 - 1000
- 1001+

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Sidescan Sonar Contacts and Magnetometer Anomalies

APTIM

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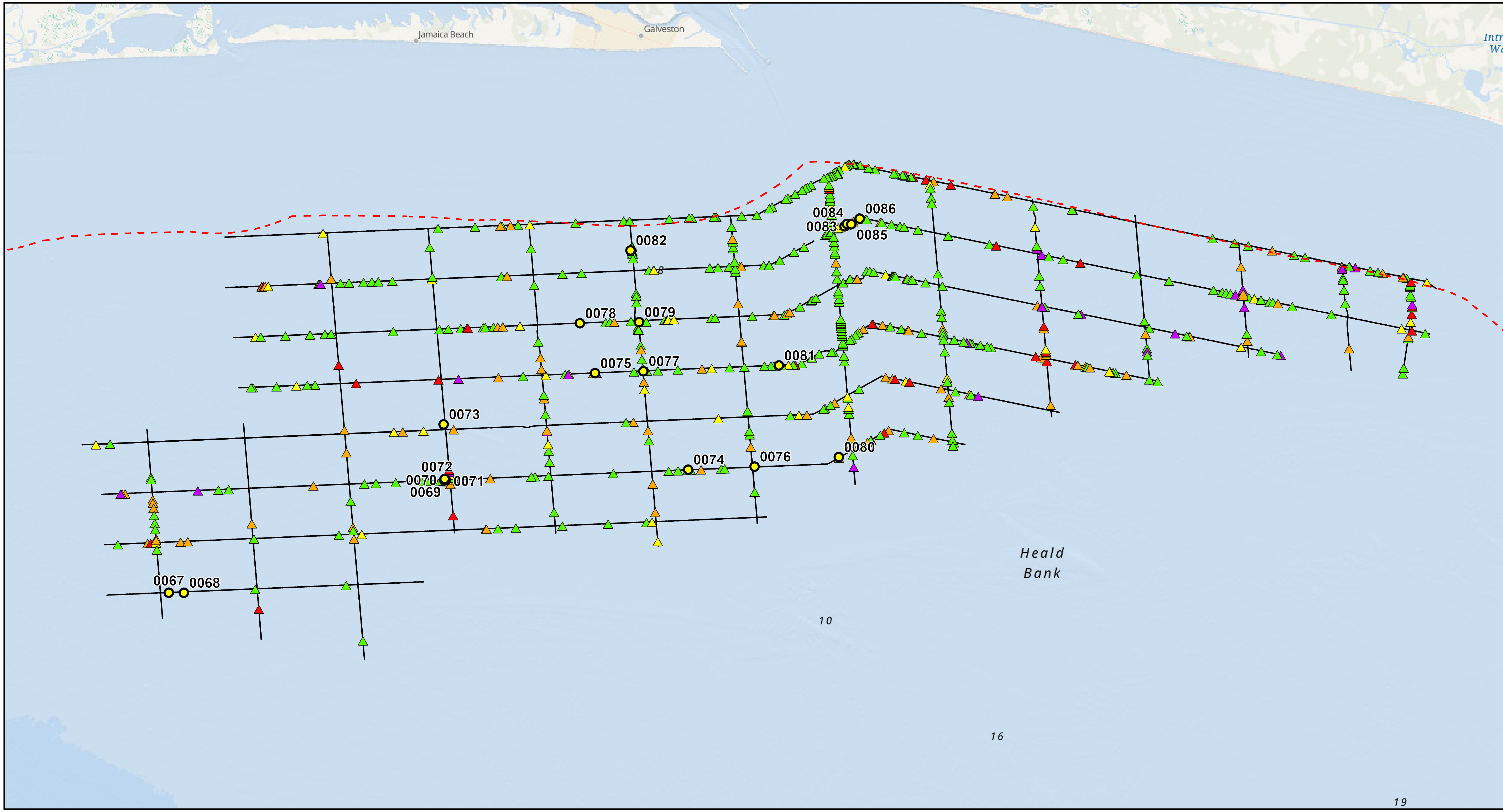
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 3b



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

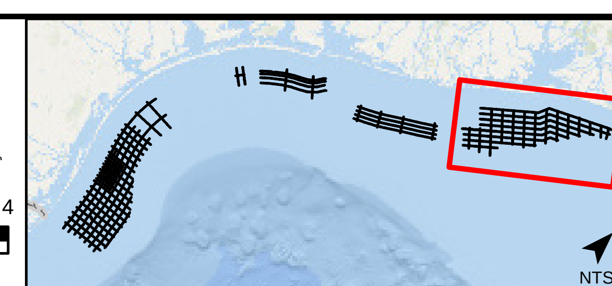
Legend:

- Sidescan Sonar Contacts
- As-Run Tracklines
- Federal/State Boundary

Magnetic Anomalies Amplitude (nT)

- 0 - 50
- 51 - 100
- 101 - 500
- 501 - 1000
- 1001+

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Sidescan Sonar Contacts and Magnetometer Anomalies

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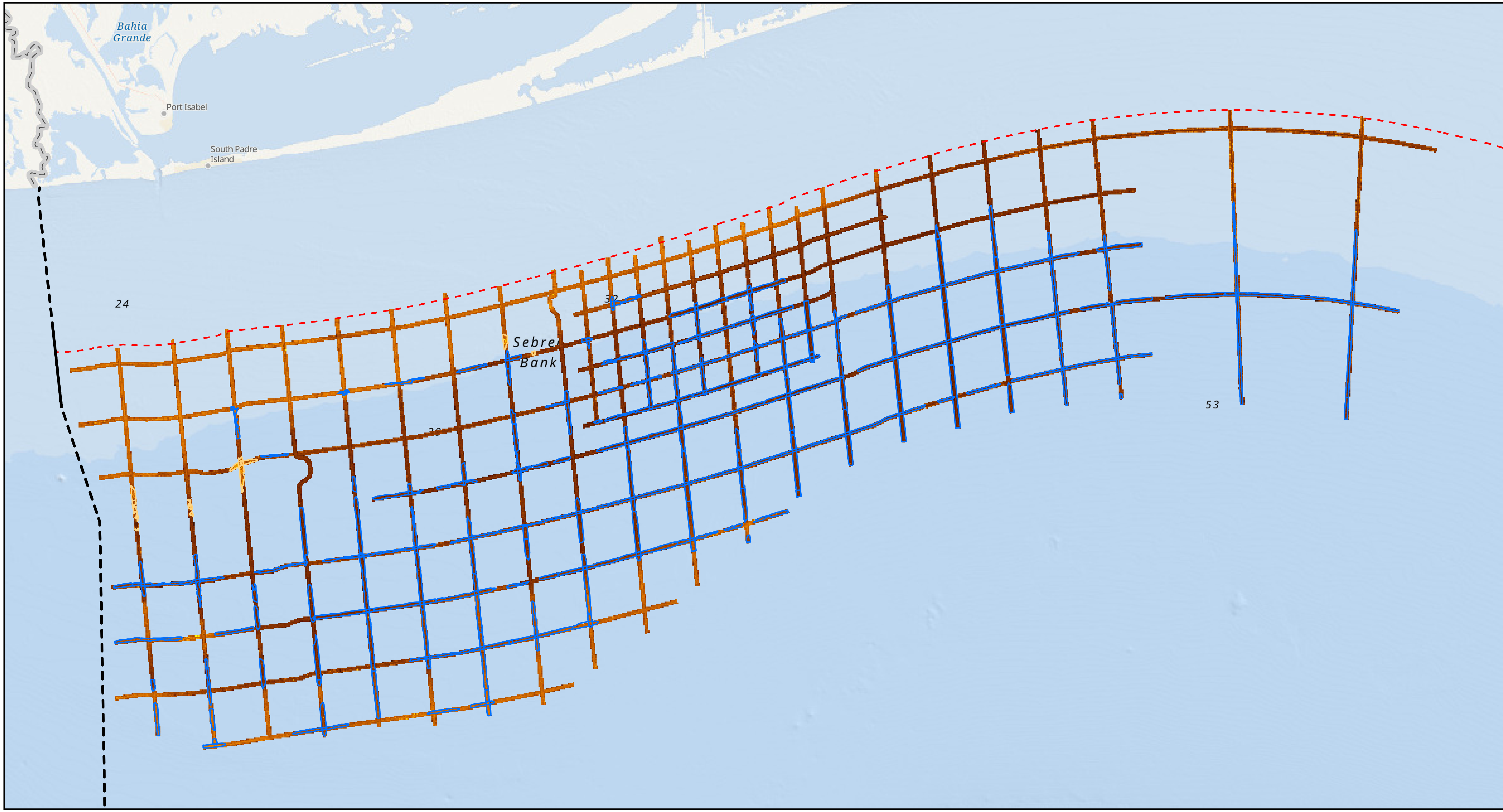
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 3c



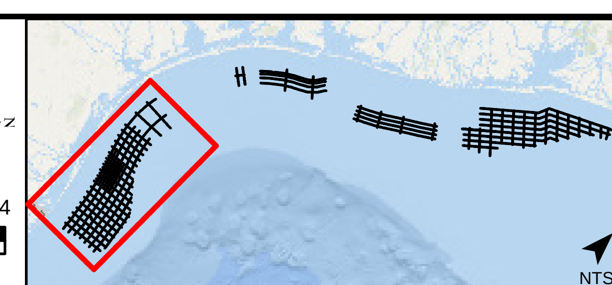
Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend

- Pockmark Field
- Hardbottom
- Federal/State Boundary
- U.S Mexico Border

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Sidescan Sonar Mosaic and Digitized Features

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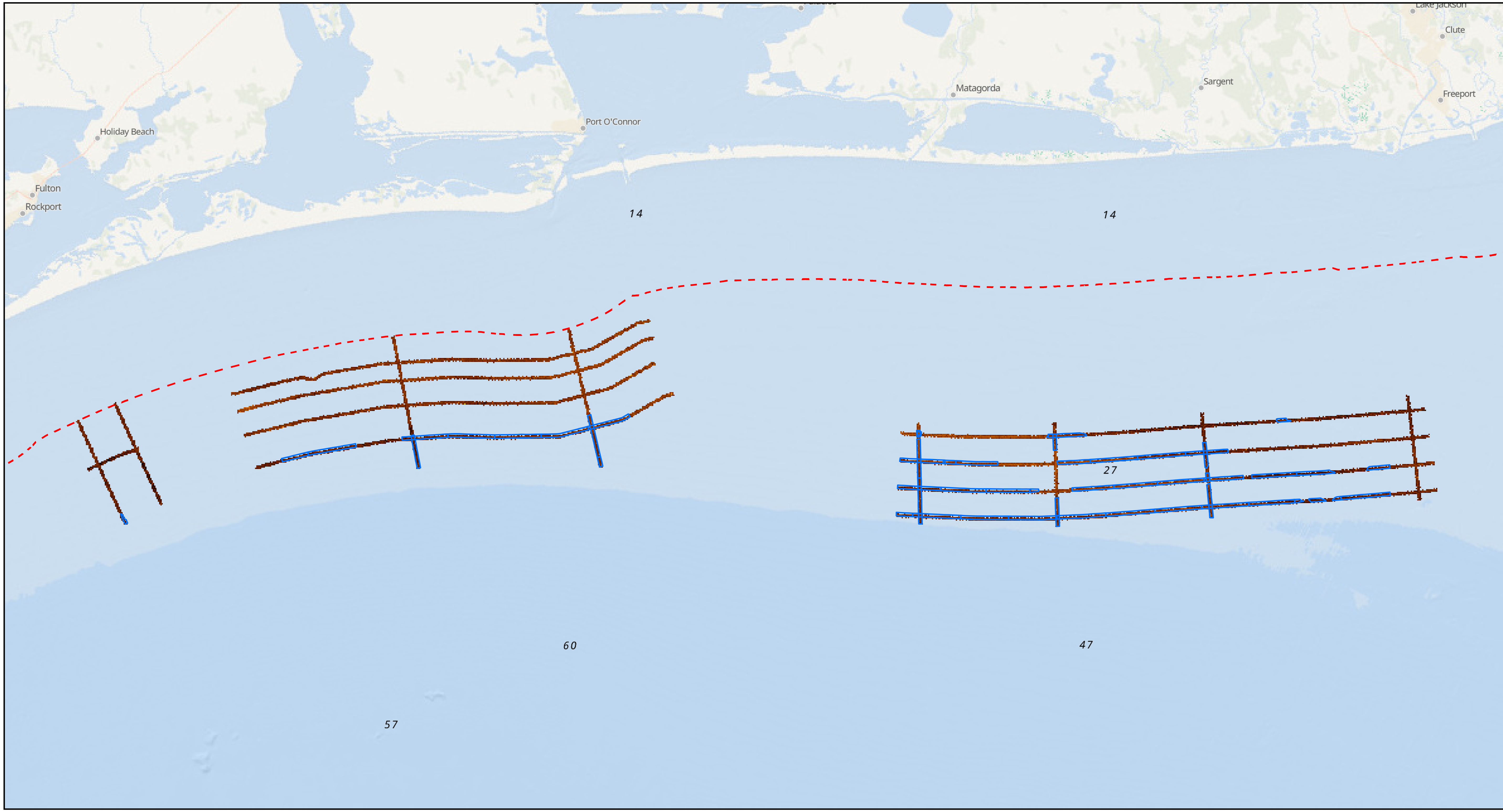
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 4a

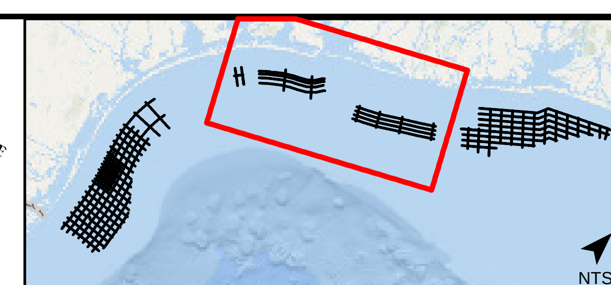


Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend

- Pockmark Field
- Hardbottom
- Federal/State Boundary



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Sidescan Sonar Mosaic and Digitized Features

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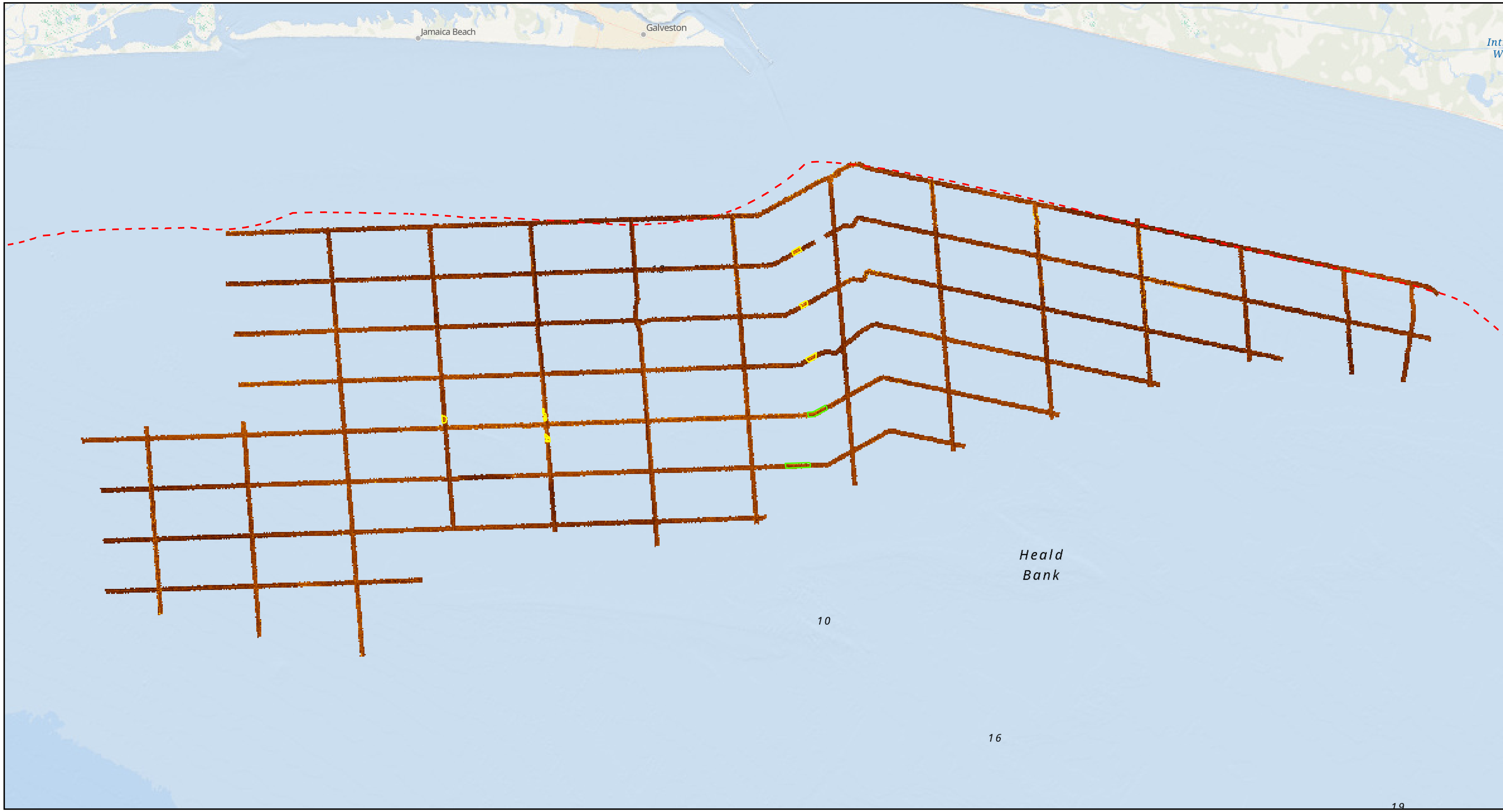
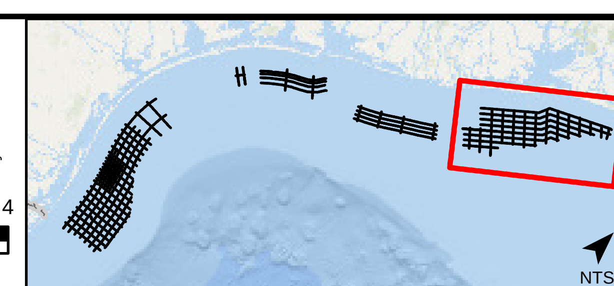
Tampa, FL 33619
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 4b





Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend

- Sand Waves
- Sand
- Pockmark Field
- Hardbottom
- Federal/State Boundary

0 1 2 4
Miles

NTS

Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Sidescan Sonar Mosaic and Digitized Features

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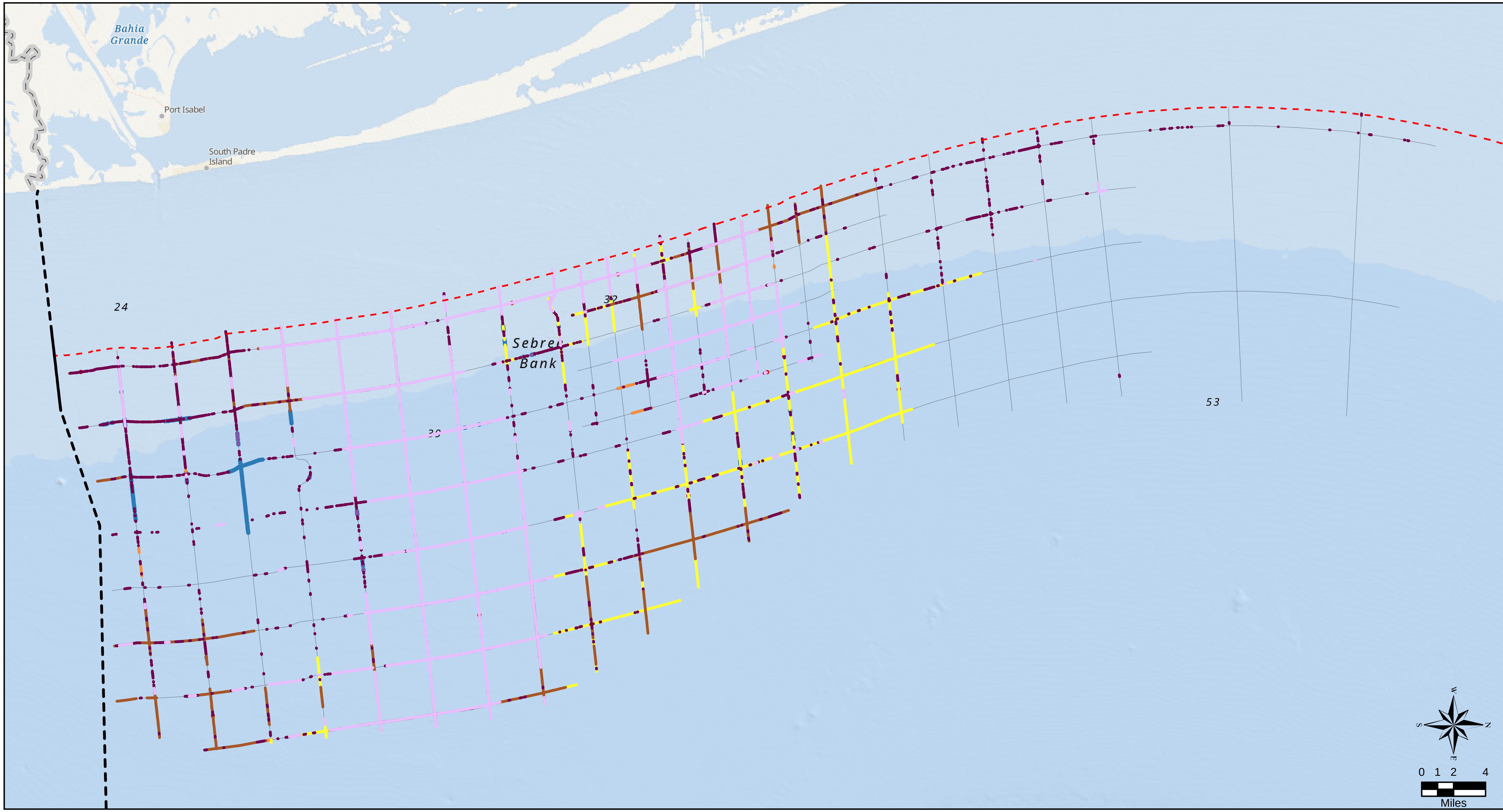
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 4c

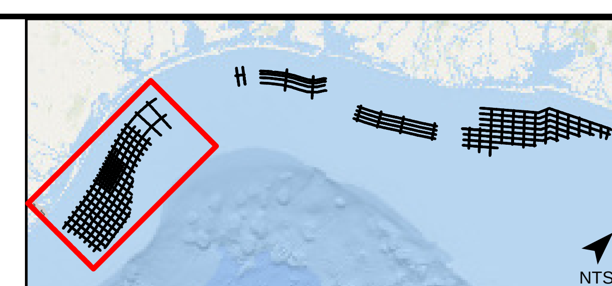


Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- Fault
- Consolidated Sediment
- Localized Feature
- Outcrop
- Prograding Surface
- Shelf Delta Front Sands
- Surficial Sand Unit Base
- Channels
- Valleys
- As-Run Tracklines
- U.S Mexico Border
- Federal/State Boundary



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Seismic Sub-bottom Digitized Features

APTIM

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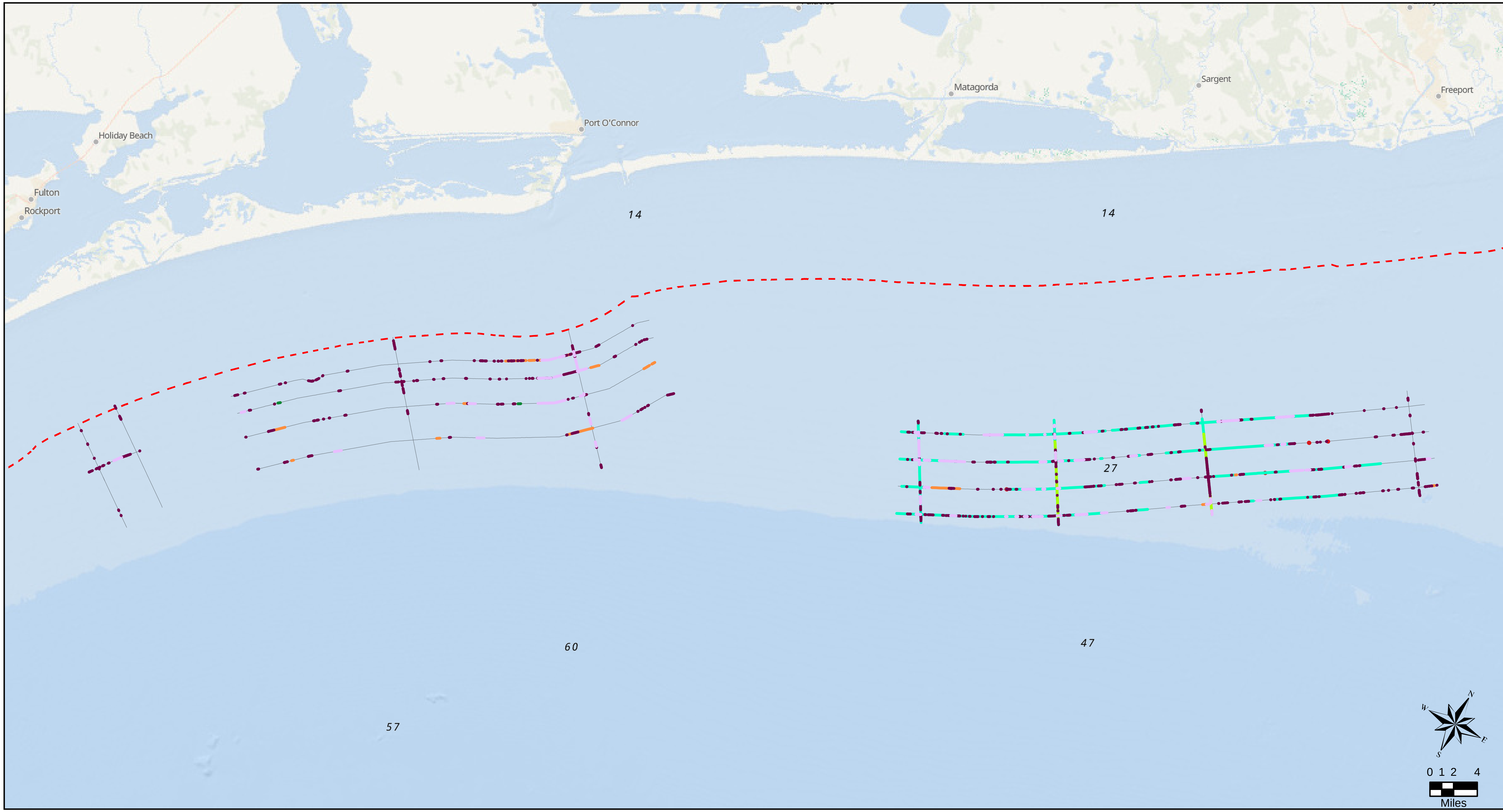
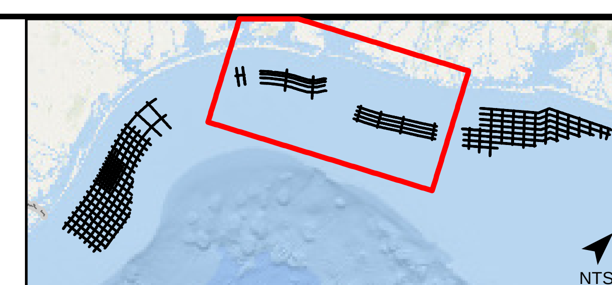
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 5a





Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- Fault
- Colorado Alluvial-Deltaic Sandy Subunit
- Downlapping
- Inclined Reflectors
- Localized Feature
- Prograding Surface
- Shoal
- Channels
- Valley
- As-Run Tracklines
- Federal/State Boundary

Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Seismic Sub-bottom Digitized Features

APTIM

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Tampa, FL 33619
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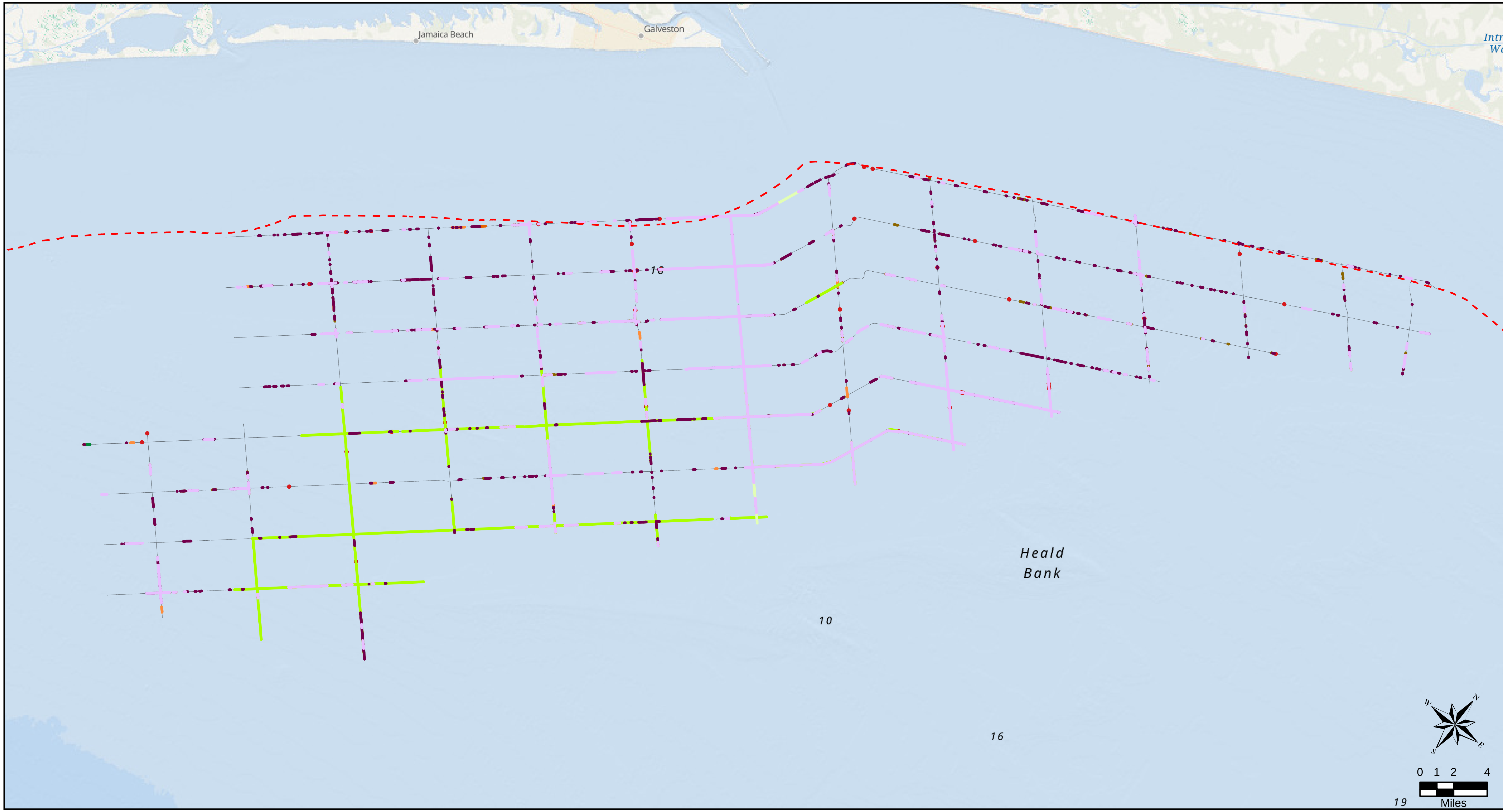
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 5b



Notes:
1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:
- Fault
- Downlapping
- Drainage
- Inclined Reflectors
- Localized Feature
- Potential Sand Unit
- Prograding Surface
- Shoal
- Terrace
- Channels
- Valley
- As-Run Tracklines
- Federal/State Boundary

Title:
Texas General Land Office Lower Coast OCS Sand Source Survey
Seismic Sub-bottom Digitized Features

APTIM
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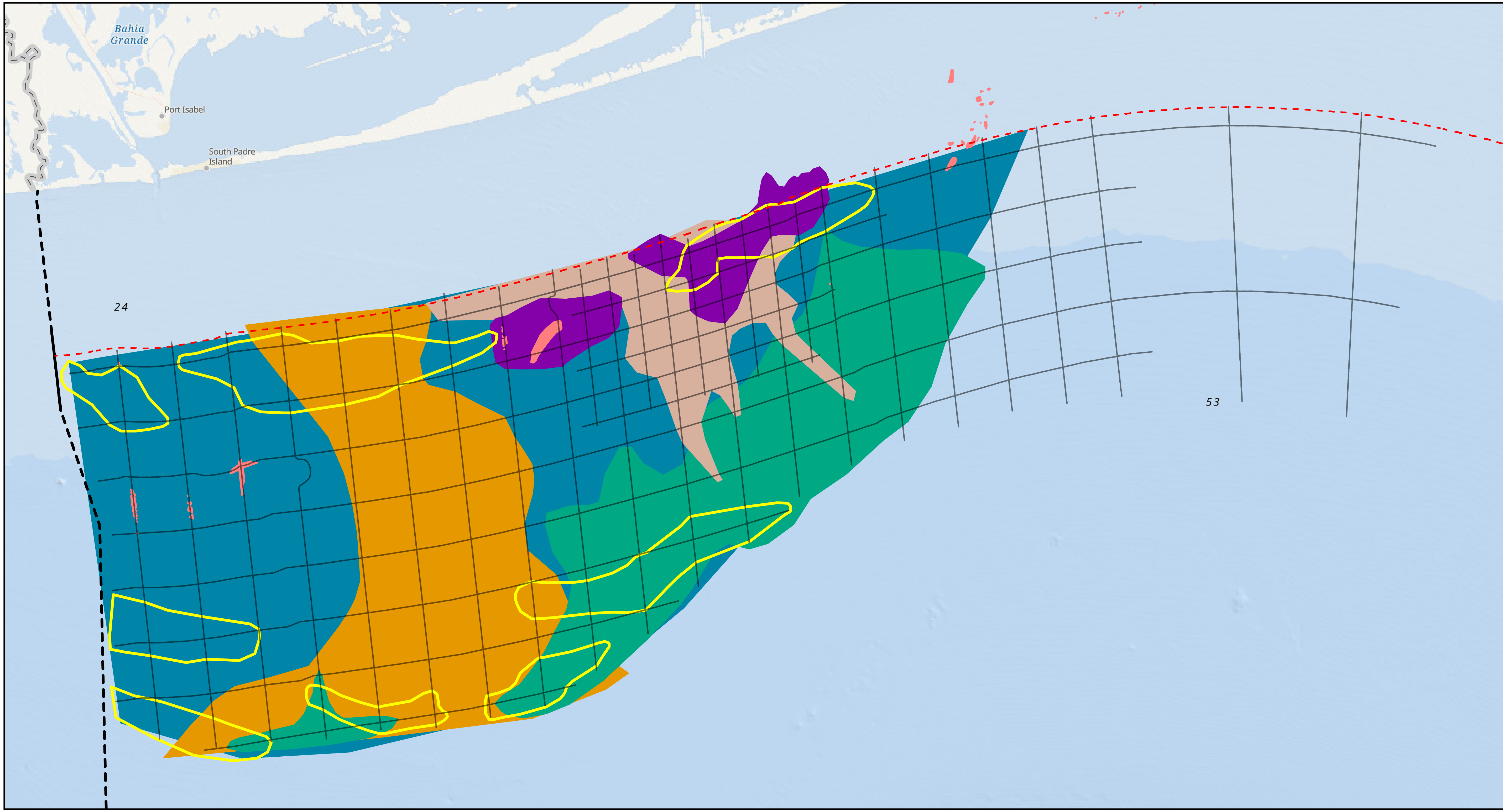
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 5c



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- Consolidated Sediment
- Surficial Sand
- Delta Front Sands
- Rio Grande Incised Valley Fill 2
- Shelf Edge Delta Front Sands
- Rio Grande Incised Valley Fill 1
- Undifferentiated Delta Plain
- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

0 1 2 4
Miles

Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Geophysical Interpretation/Analysis Results

APTIM

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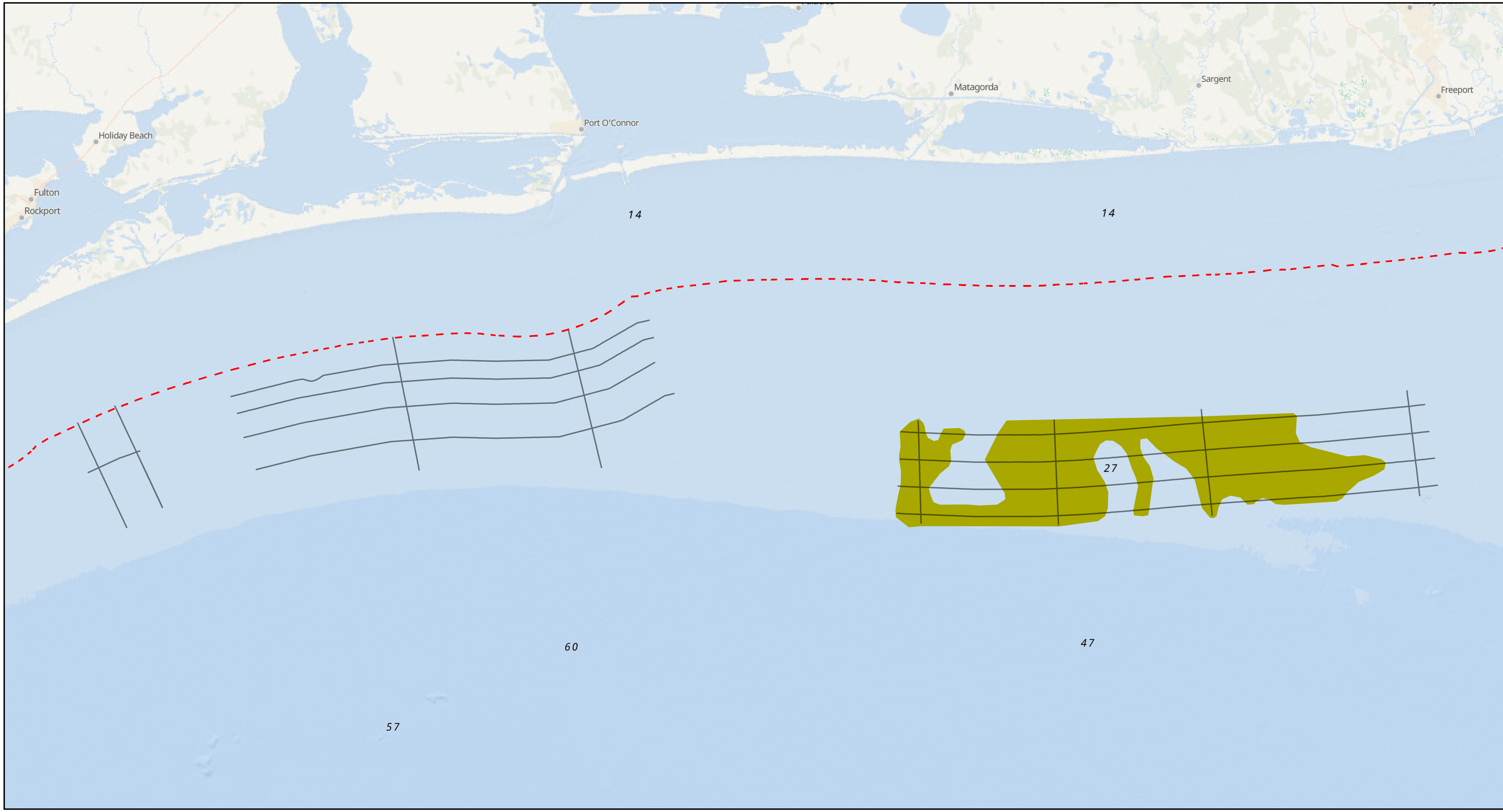
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 6a



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

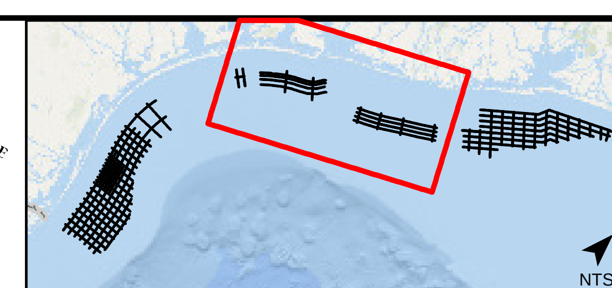
Legend:

- Colorado Alluvial-Delatic Sandy Subunit
- As-Run Tracklines
- Federal/State Boundary

N E S W

0 1 2 4

Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Geophysical Interpretation/Analysis Results

APTIM

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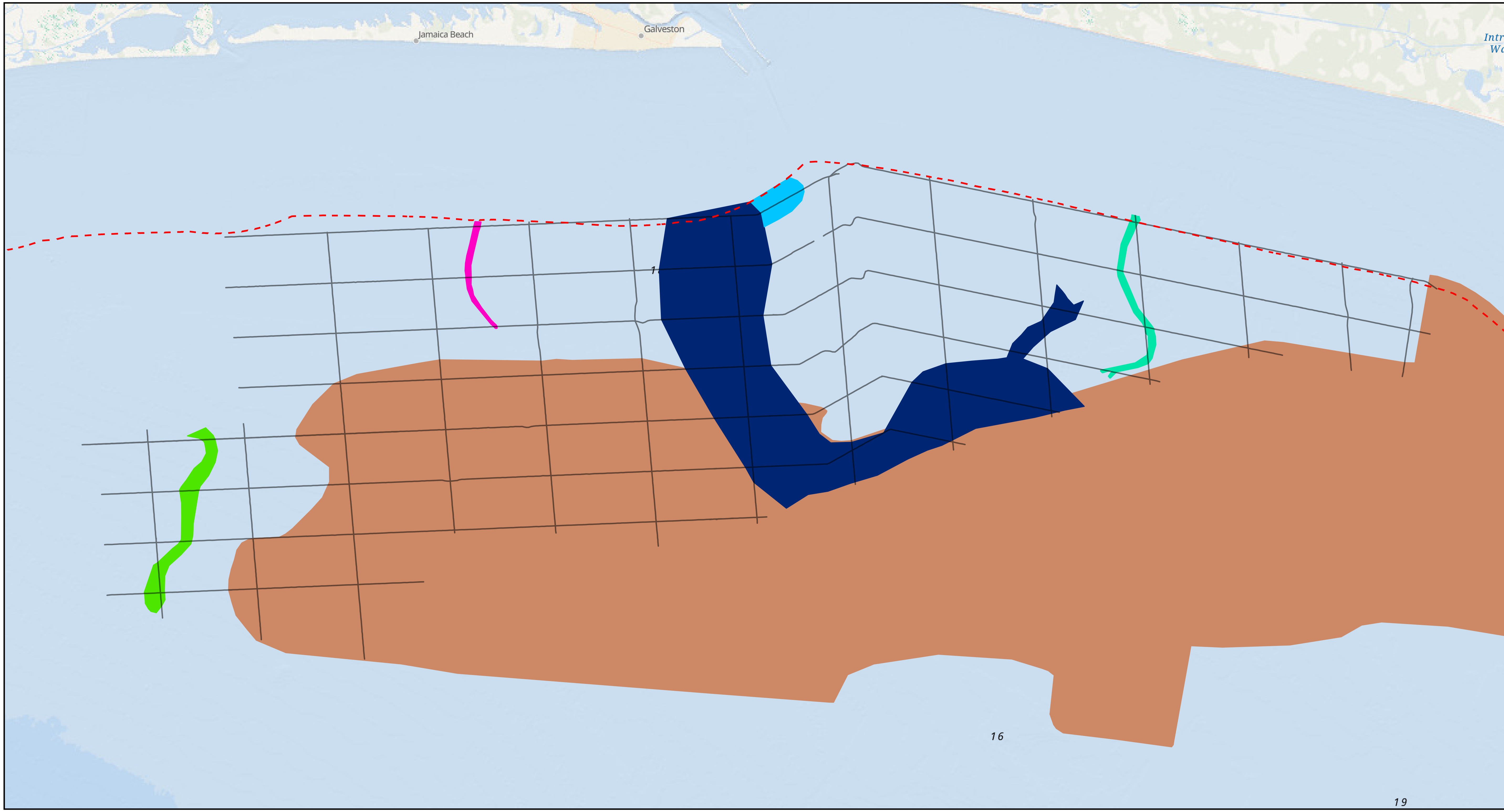
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 6b



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- Galveston Channel Belt
- Fluvial Terrace
- Trinity-Sabine Incised Valley
- Sabine Channel Belt 10
- Channel Belt
- Shoal Q1
- As-Run Tracklines
- Federal/State Boundary

0 1 2 4
Miles

Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Geophysical Interpretation/Analysis Results

APTIM

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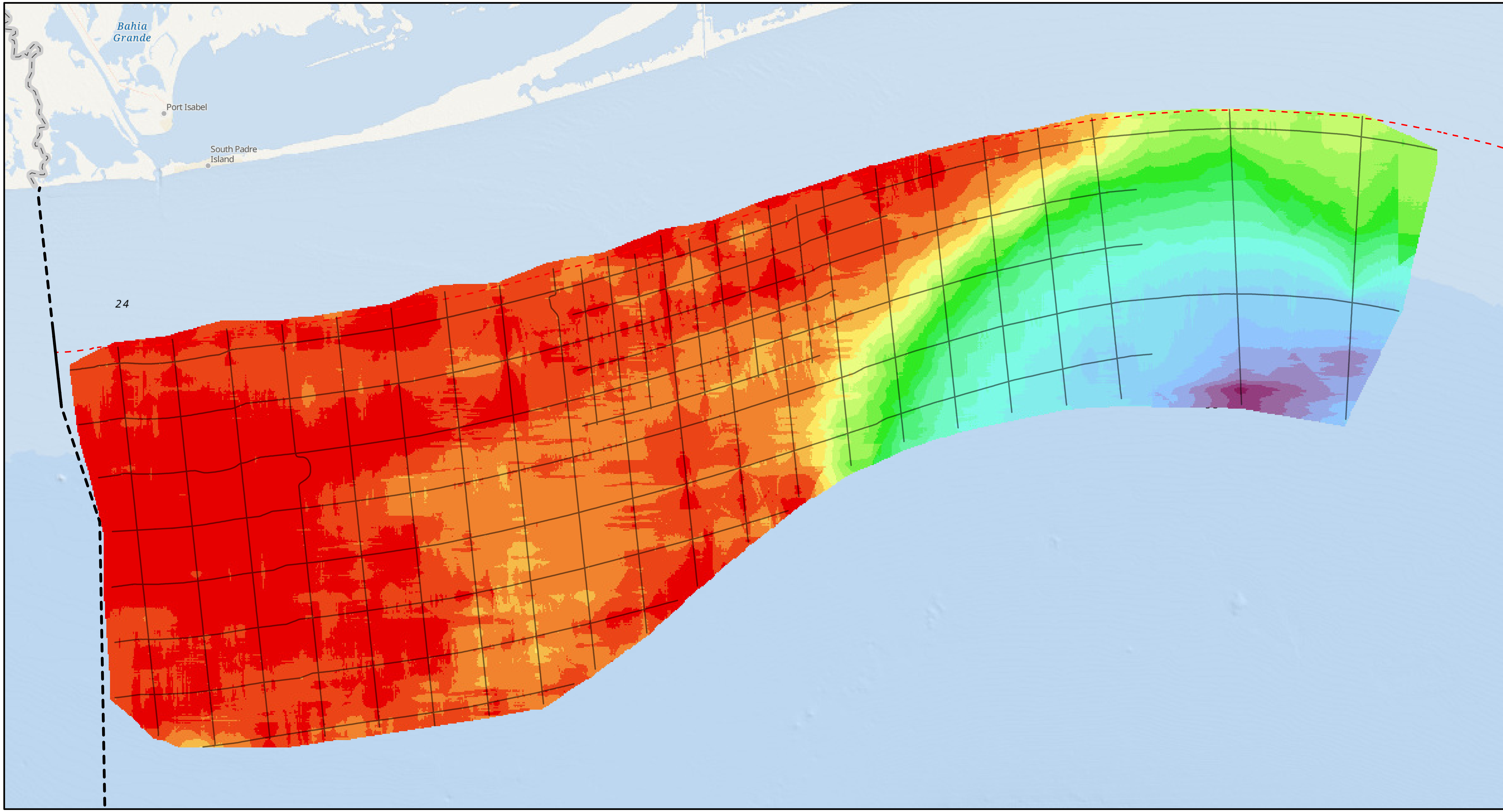
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 6c



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

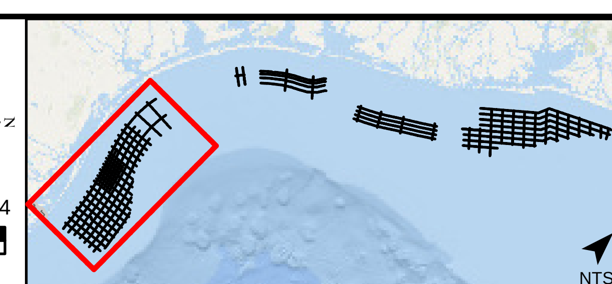
Legend:

— As-Run Tracklines
- - - Federal/State Boundary
— — U.S Mexico Border

Ravinement Thickness (ft)

0 - 5	25 - 30	50 - 55	75 - 80	100 - 105
5 - 10	30 - 35	55 - 60	80 - 85	105 - 110
10 - 15	35 - 40	60 - 65	85 - 90	110 - 115
15 - 20	40 - 45	65 - 70	90 - 95	115 - 120
20 - 25	45 - 50	70 - 75	95 - 100	

0 1 2 4
Miles



Title:

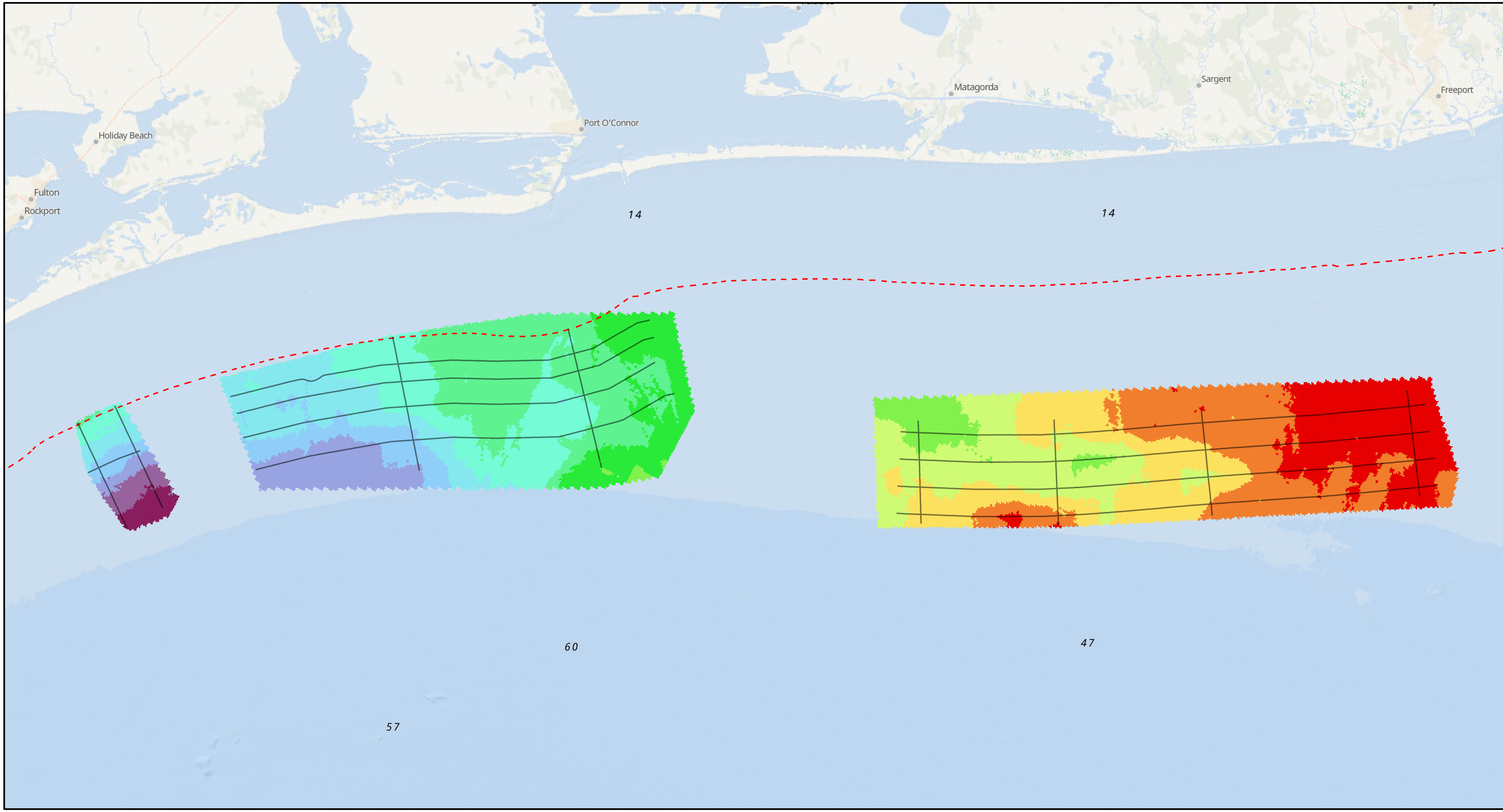
Texas General Land Office Lower Coast OCS Sand Source Survey

Seismic Ravinement Surface

APTIM

725 US Highway 301 S
Tampa, FL 33619
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 7a



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

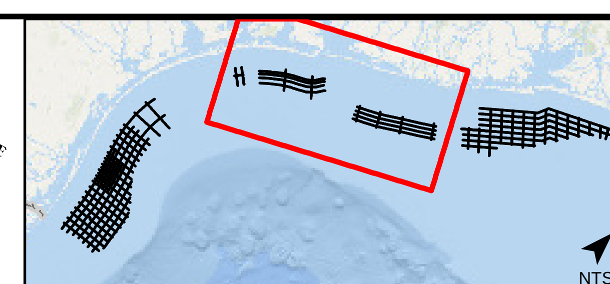
As-Run Tracklines

Federal/State Boundary

Ravinement Thickness (ft)

0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
85 - 90
90 - 95
95 - 100
100 - 105
105 - 110
110 - 115
115 - 120

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Seismic Ravinement Surface

APTIM

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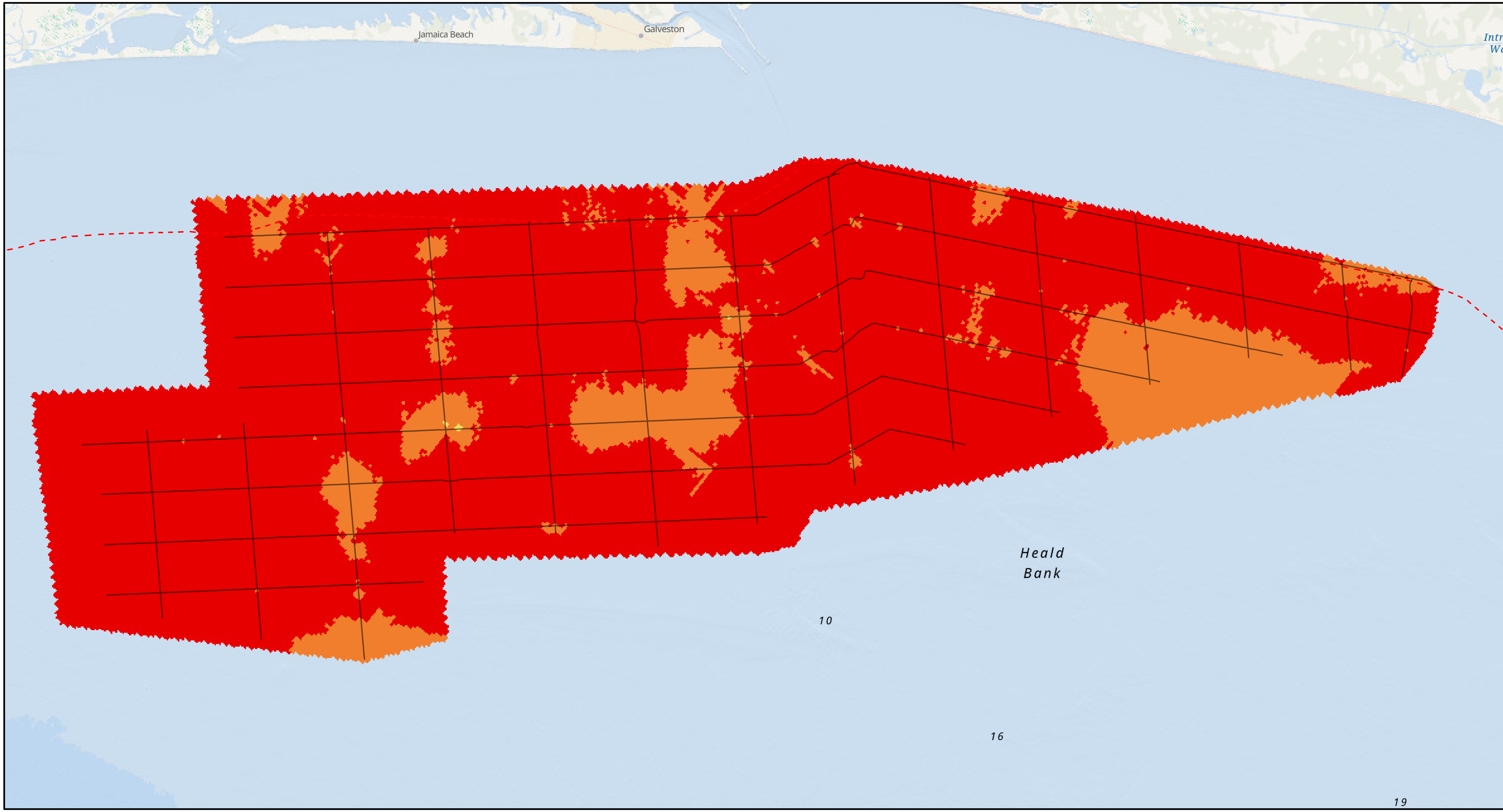
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 7b



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

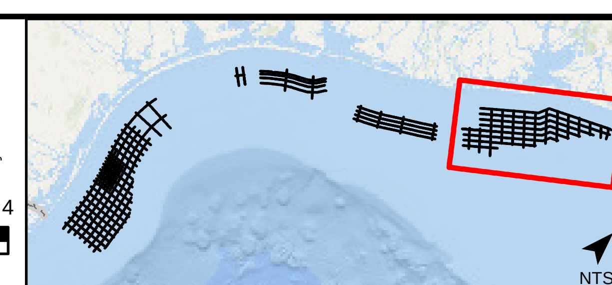
Legend:

— As-Run Tracklines
- - - Federal/State Boundary

Ravinement Thickness (ft)

0 - 5	25 - 30	50 - 55	75 - 80	100 - 105
5 - 10	30 - 35	55 - 60	80 - 85	105 - 110
10 - 15	35 - 40	60 - 65	85 - 90	110 - 115
15 - 20	40 - 45	65 - 70	90 - 95	115 - 120
20 - 25	45 - 50	70 - 75	95 - 100	

0 1 2 4
Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey
Seismic Ravinement Surface

APTIM

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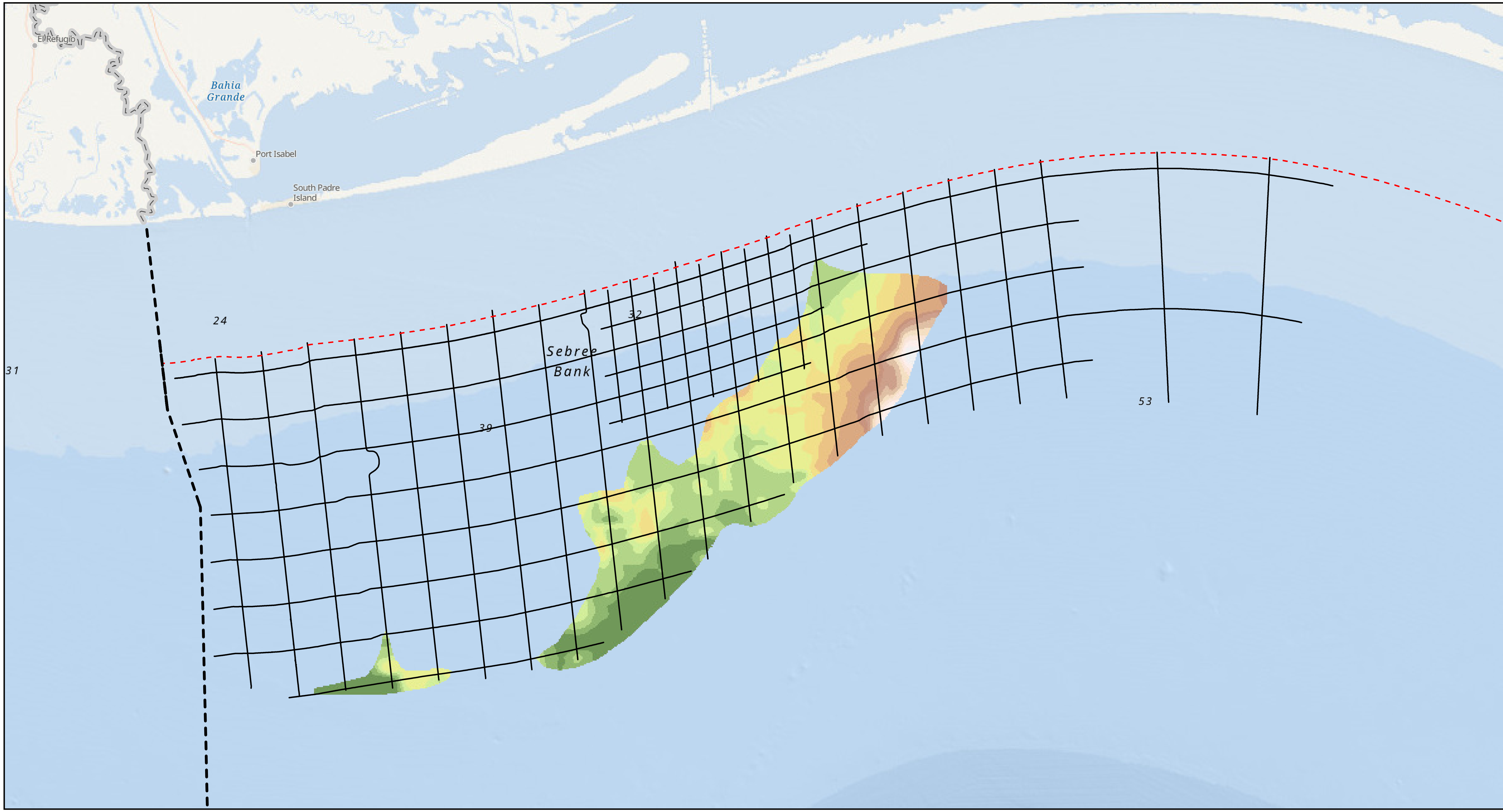
APTIM.com

Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 7c



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Overburden Thickness (ft)

2 - 5	15 - 20	48 - 52	71 - 76
6 - 8	21 - 27	53 - 58	77 - 84
9 - 11	28 - 36	59 - 64	85 - 91
12 - 14	37 - 47	65 - 70	

0 1 2 4 Miles

NTS

Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Overburden Thickness

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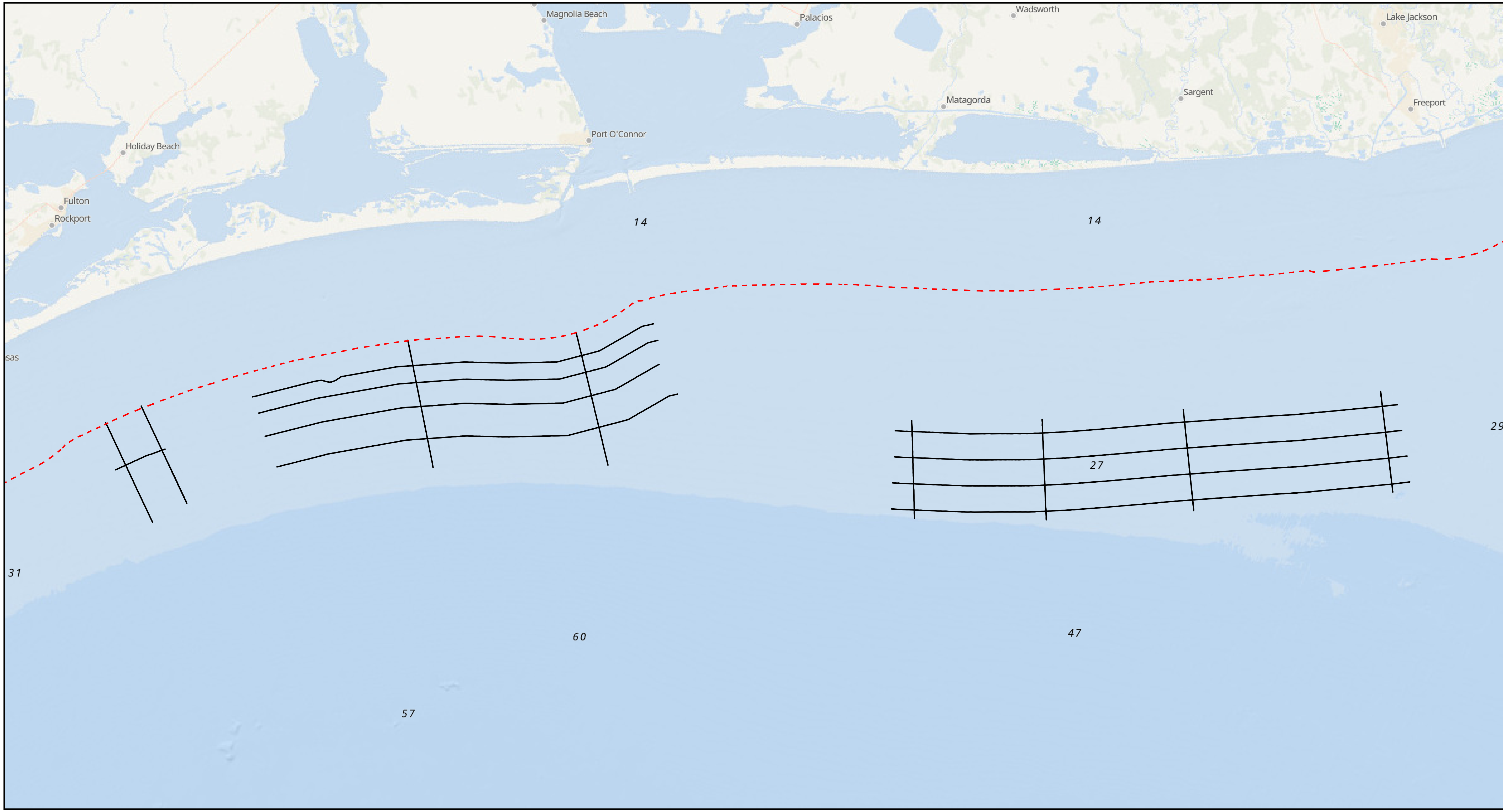
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 8a



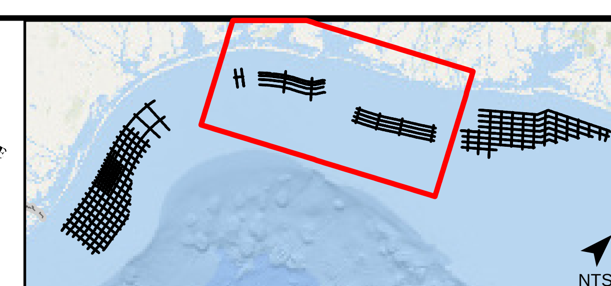
Notes:
1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:
- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Overburden Thickness (ft)

2 - 5	15 - 20	48 - 52	71 - 76
6 - 8	21 - 27	53 - 58	77 - 84
9 - 11	28 - 36	59 - 64	85 - 91
12 - 14	37 - 47	65 - 70	

0 1 2 4
Miles



Title:
Texas General Land Office Lower Coast OCS Sand Source Survey
Overburden Thickness

APTIM

725 US Highway 301 S
Tampa, FL 33619
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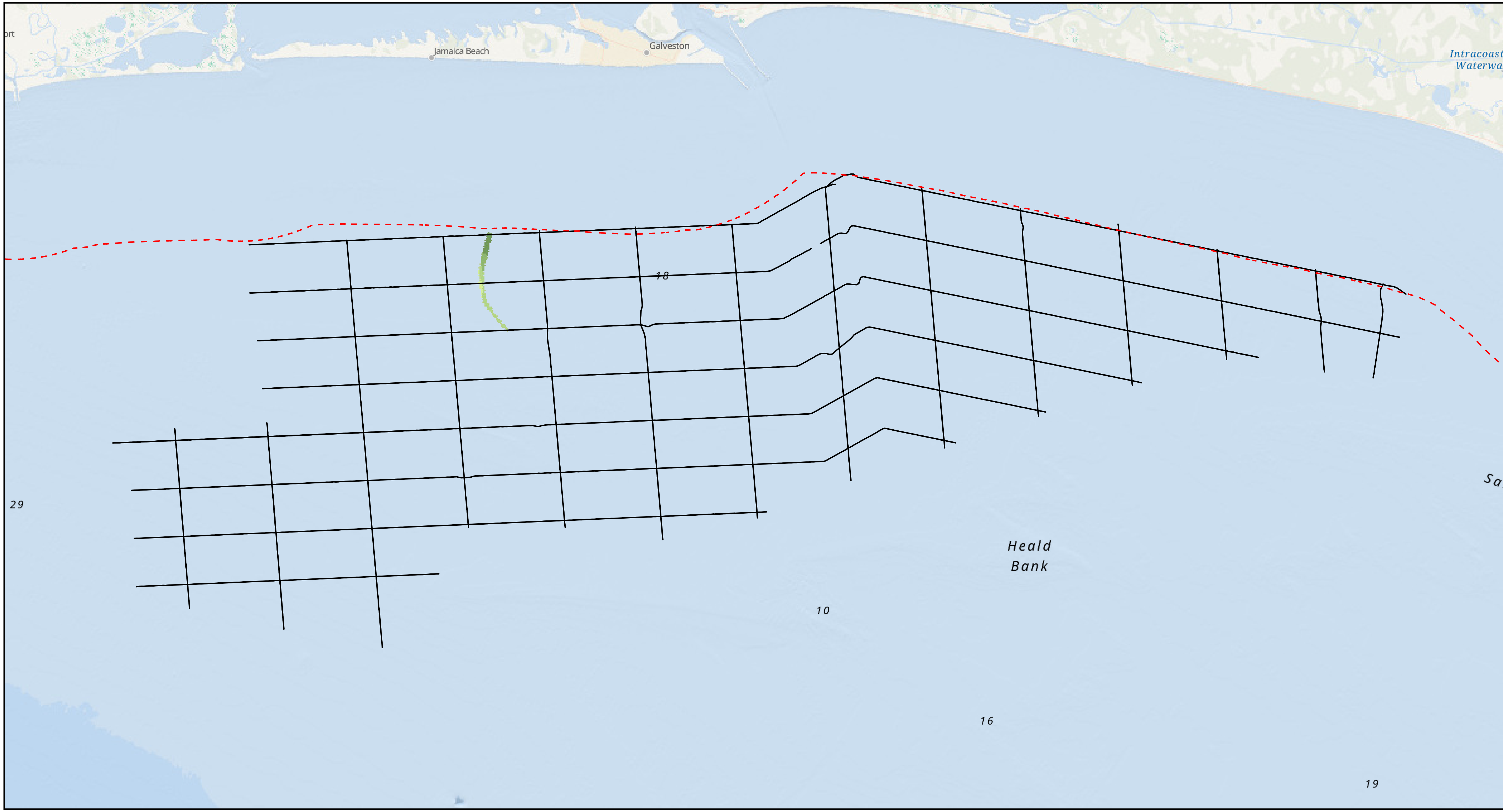
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 8b



Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

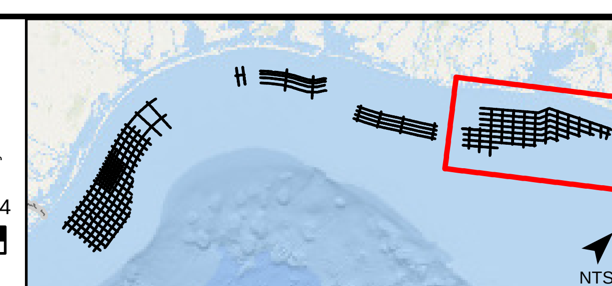
Legend:

- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Overburden Thickness (ft)

2 - 5, 6 - 8, 9 - 11, 12 - 14, 15 - 20, 21 - 27, 28 - 36, 37 - 47, 48 - 52, 53 - 58, 59 - 64, 65 - 70, 71 - 76, 77 - 84, 85 - 91

0 1 2 4 Miles



Title:

Texas General Land Office Lower Coast OCS Sand Source Survey
Overburden Thickness

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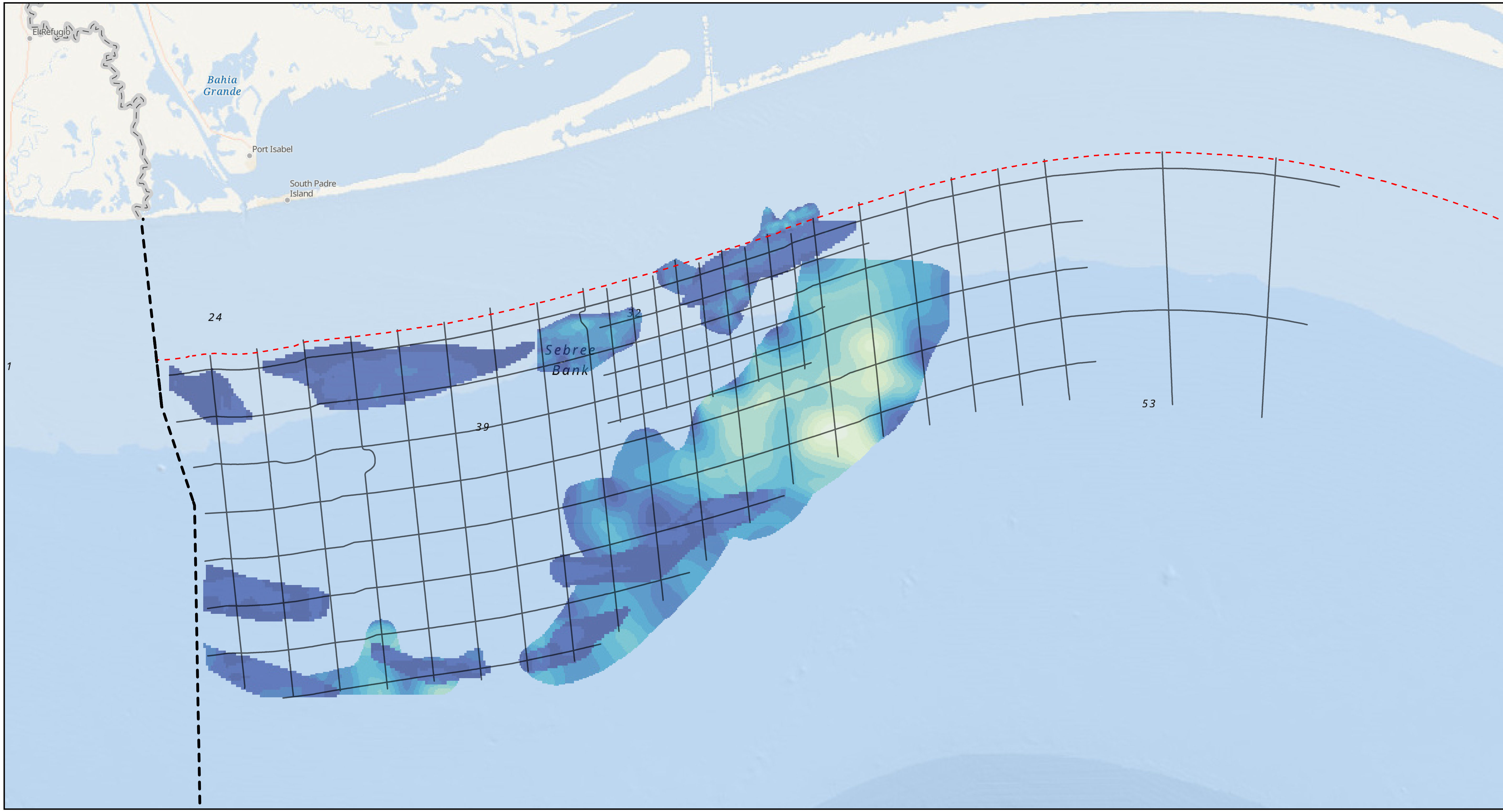
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 8c



Notes:

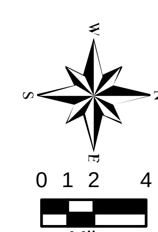
1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

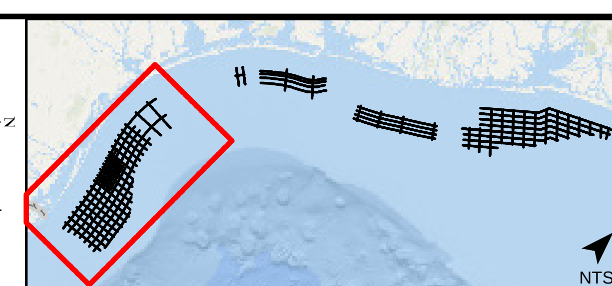
Legend:

- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Sand Deposit Thickness (ft)

0 - 3	15 - 18	30 - 33
3 - 6	18 - 21	33 - 36
6 - 9	21 - 24	36 - 39
9 - 12	24 - 27	
12 - 15	27 - 30	





Title:

Texas General Land Office Lower Coast OCS Sand Source Survey

Mixed Sediment Thickness

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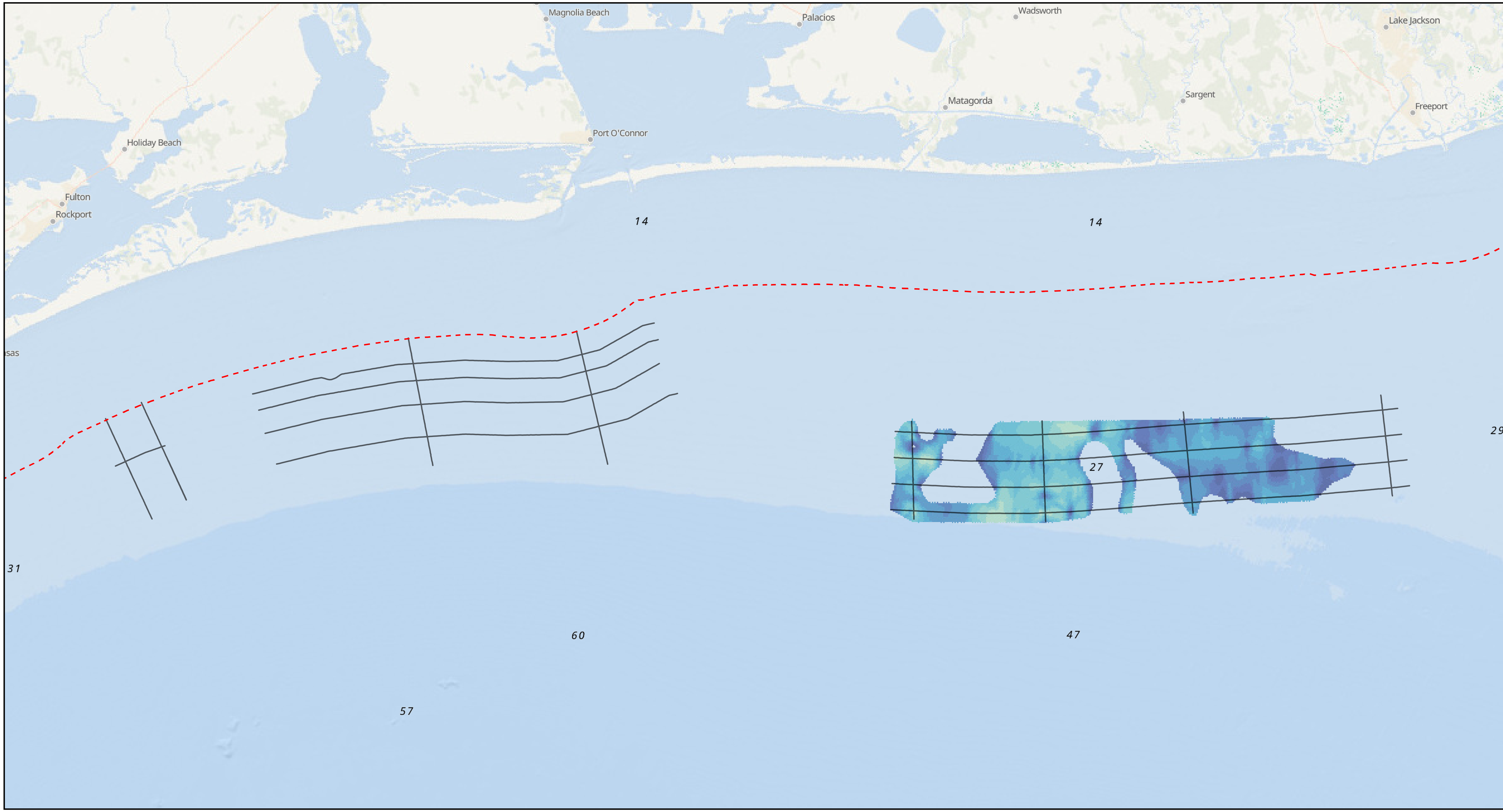
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 9a



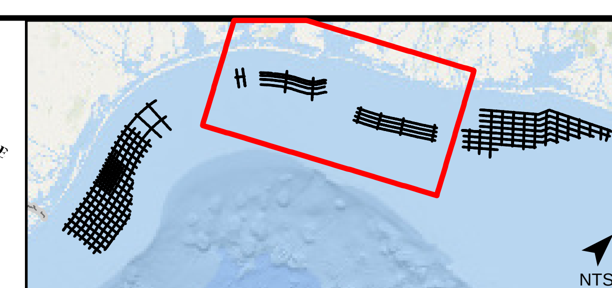
Notes:
1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:
- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Sand Deposit Thickness (ft)

0 - 3	15 - 18	30 - 33
3 - 6	18 - 21	33 - 36
6 - 9	21 - 24	36 - 39
9 - 12	24 - 27	
12 - 15	27 - 30	

0 1 2 4
Miles



Title:
Texas General Land Office Lower Coast OCS
Sand Source Survey
Mixed Sediment Thickness

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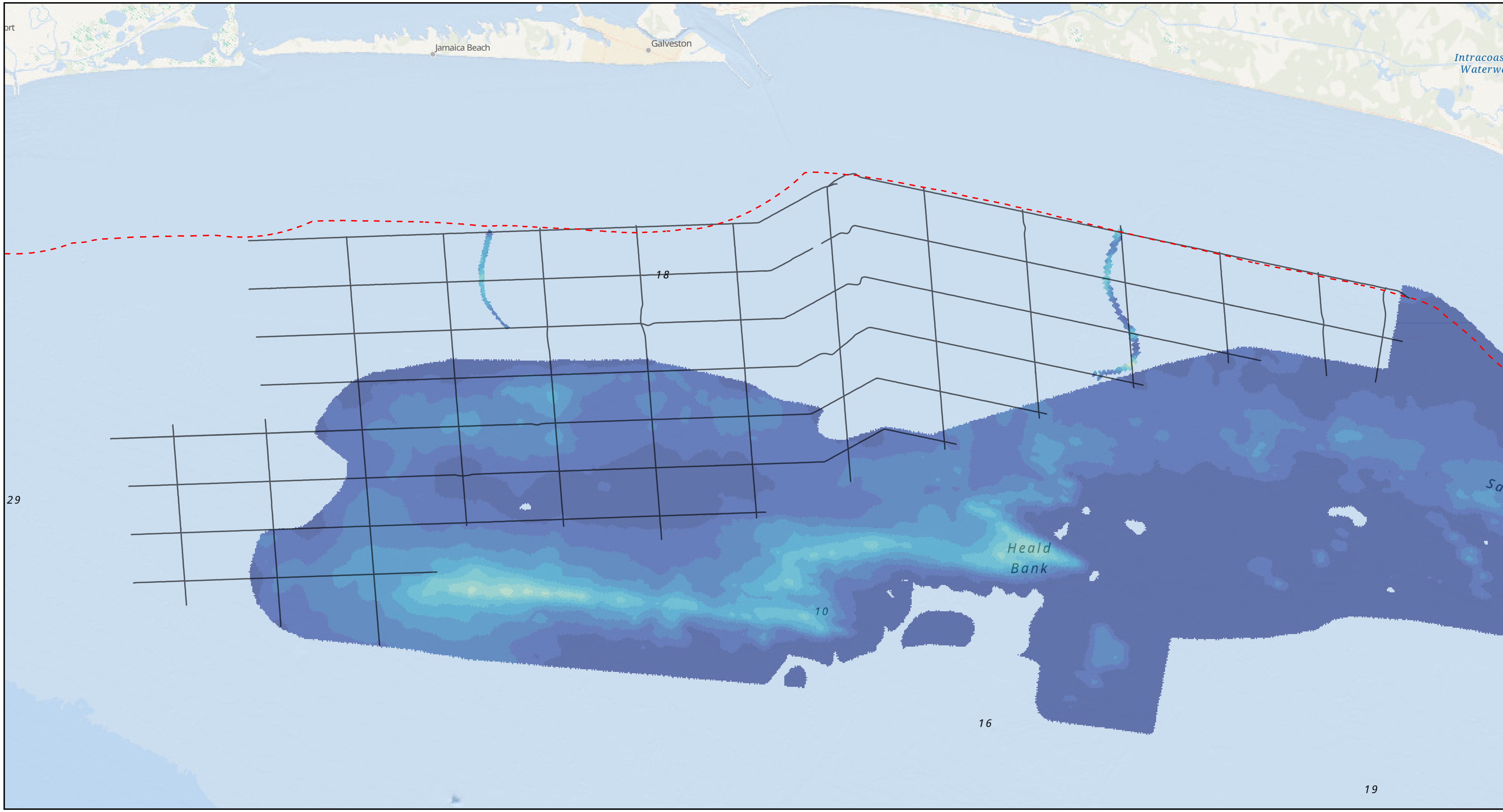
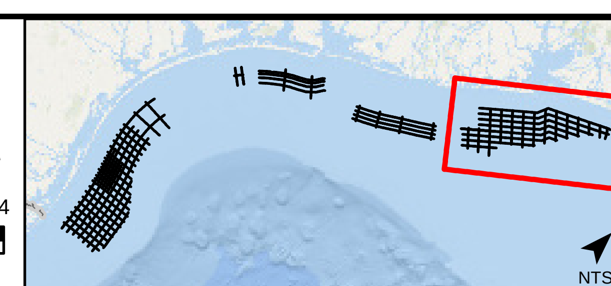
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 9b





Notes:

1. Background is ESRI's World Ocean Basemap.
2. Data collected by APTIM between February 8, 2024 and March 16, 2024.

Legend:

- As-Run Tracklines
- Federal/State Boundary
- U.S Mexico Border

Sand Deposit Thickness (ft)

- 0 - 3
- 3 - 6
- 6 - 9
- 9 - 12
- 12 - 15
- 15 - 18
- 18 - 21
- 21 - 24
- 24 - 27
- 27 - 30
- 30 - 33
- 33 - 36
- 36 - 39

0 1 2 4
Miles

NTS

Title:

Texas General Land Office Lower Coast OCS
Sand Source Survey
Mixed Sediment Thickness

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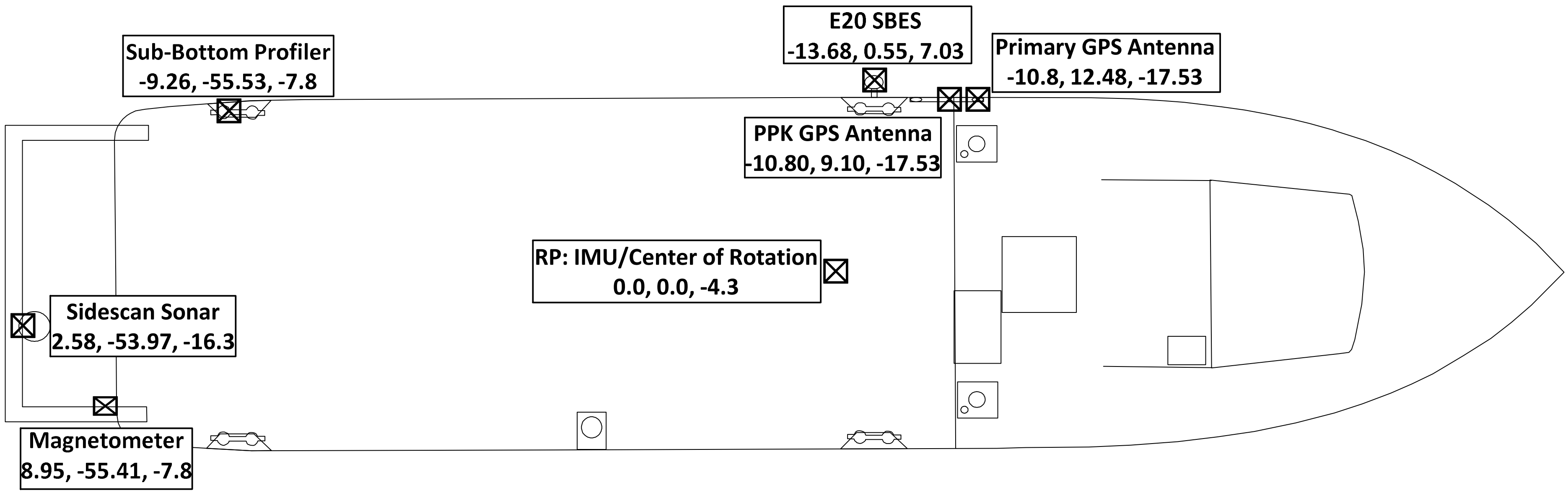
Date: 10/17/2025	Drawn By: CB	Commission No. 631027330	Appendix A Map: 9c

Appendix B: Vessel Diagram

Texas General Land Office
Offshore Sediment Inventory Lower OCS
R/V Rachel K. Goodwin
Vessel Diagram
(not to scale)



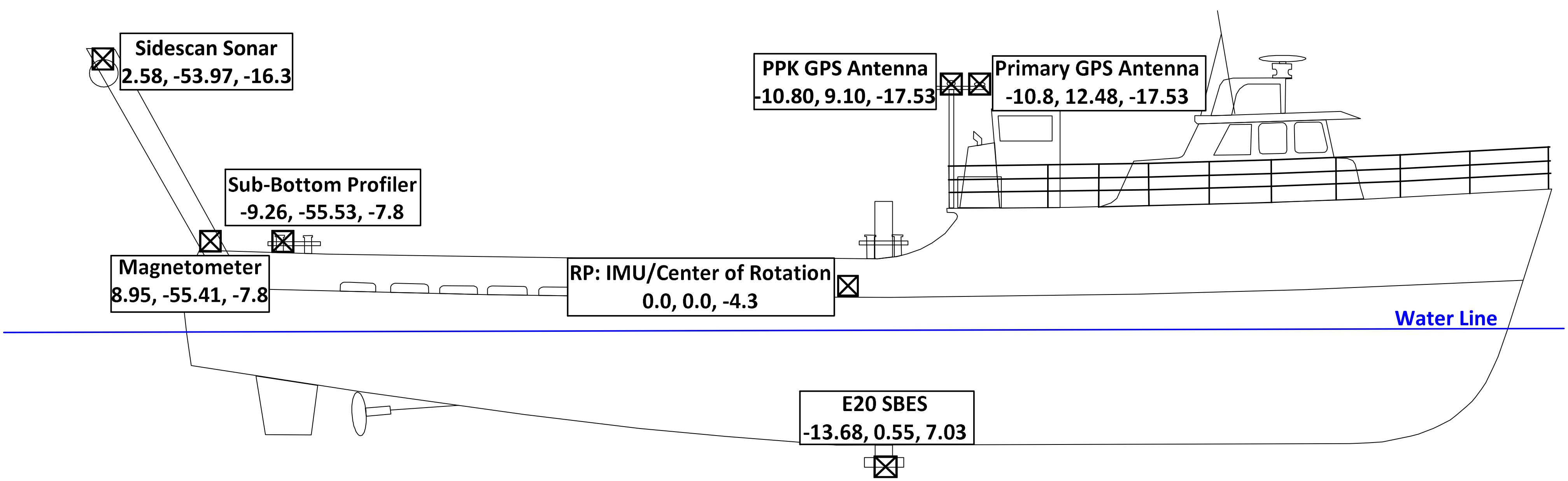


Table 1: Offset applied to systems during geophysical data collection.

R/V Rachel K. Goodwin Offsets via Measured Relative to Permanent Shipboard Benchmarks. Offsets are relative to Reference Point (RP) or Waterline	**Forward Positive (ft)**	**Starboard Positive (ft)**	**Down Positive w.r.t. RP (ft)**	**Down Positive w.r.t. Waterline (ft)**
RP: IMU/Center of Rotation	0.00	0.00	0.00	-4.30
E20 Single-Beam Echosounder	0.55	-13.68	11.60	7.03
Primary GPS Antenna	12.49	-10.80	-13.23	-17.53
Sub-Bottom Profiler Tow Point	-55.53	-9.26	-3.50	-7.8
Sidescan Sonar Tow Point	-53.97	2.58	-12.00	-16.3
Magnetometer Tow Point	-55.41	8.95	-3.5	-7.8

Appendix C: MMIS Database (digital only)