Physical and Environmental Assessment of Sand Resources—Texas Continental Shelf

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SUMMARY

A recent inventory of nonfuel minerals in the northwestern Gulf of Mexico demonstrated that potentially economic deposits of sand, gravel, and heavy minerals occur on the Texas continental shelf. Particularly promising for leasing and commercialization in the near term are deposits of sand that form shoals on the inner continental shelf. Preliminary analyses indicate that these sand deposits are suitable for beach replenishment because sediment textures of the shoals are generally compatible with those of native beach sand. Offshore sand extraction may become attractive economically if onshore sources of beach-quality sand are volumetrically limited. Offshore mining of sand could also reduce the degradation of wetlands caused by onshore mining activities.

Demand for beach replenishment sand along the northwestern Gulf of Mexico is increasing as the combined effects of rising sea level and land subsidence are manifested as rapid beach erosion. In Texas, Sabine and Heald Banks are two offshore sand deposits that have the greatest economic potential for near-term exploitation because they are (1) suitable for beach replenishment, (2) the largest sand deposits located offshore of some of the most rapidly eroding developed shores, (3) relatively close to potential markets in both southeastern Texas and western Louisiana, and (4) relatively close to major ports that can support offshore mining activities.

The principal efforts of this study were directed toward assessing the quality and volume of Sabine and Heald Bank sediments and evaluating the composition and thickness of overburden materials. To accomplish this, the banks were cored, sediment textures and mineralogy were determined, and volumes of the sand deposits were estimated using bathymetry, seismic profiles, and lithologic information. Geographic locations and attributes of all the pertinent offshore data sources were incorporated into ARC/INFO, a widely used geographic information system (GIS). An additional task evaluated the potential environmental impact of mining the sand deposits by examining the overburden. Another task reviewed the available extraction technologies and determined which are likely to be most appropriate for developing the identified sand resources on

the Texas continental shelf. We also conducted a preliminary investigation of potential obstructions to extraction operations such as production platforms and offshore pipelines.

The preliminary findings of this study indicate that Sabine and Heald Banks may each contain nearly 2 billion m^3 of sand and muddy sand. Most of that material would be suitable for beach replenishment and other applications that can use well-sorted fine sand with some shell and some sediments finer than sand. The sand deposits are located in water depths ranging from 4.5 m to about 17 m with the greatest thickness of sand coinciding with the shallowest water depths. Several petroleum pipelines, production platforms, and a lighthouse are located within the trend of high-quality sand deposits. Although these structures would locally interfere with sand extraction, they would not necessarily preclude the dredging of sand from the banks. Equipment designed for open-water dredging (moderate wave climate) would be required to extract the sand resources. Because of the distances between the sand deposits and their potential market, it is anticipated that dredging and sand transportation would be separate operations. On the basis of current technology, costs, and efficiencies, it appears that a hydraulic sidecast dredge or bucket dredge would be appropriate for sand extraction and a system of tugs and scows would be needed to move the sand between the Banks and beach fill sites.

INTRODUCTION

Statement of the Issue

Potentially economic concentrations of sand, shell, and heavy minerals have been identified in the northwestern Gulf of Mexico during decades of exploration and research on the continental shelf. On the Texas portion of the continental shelf, significant sand accumulations at or near the sea floor occur as shore-aligned sand bodies and a patchy accumulation of transgressive sands that were deposited during the most recent rise in sea level (Paine et al., 1988; Table 1). Fluvial sand and gravel occur within late Wisconsinan stream courses that extend across the continental shelf, but these valley-fill deposits may be covered by tens of meters of overburden.

Potential markets for offshore sand exist along the northwestern Gulf of Mexico. Sand contained in drowned shoreline and nearshore deposits has the greatest near-term economic potential because it can be used for beach-replenishment projects. Beach replenishment can be justified where large recreational, residential, and industrial investments would be damaged or destroyed by continued coastal erosion and storm impacts. Long-term erosion of Texas beaches and heavy beach use near population centers make beach replenishment an attractive alternative to other methods of shoreline stabilization.

Purpose of the Study

One of the primary objectives of this study is to determine the suitability of offshore sand for replenishment of beaches along the southeastern Texas and western Louisiana coasts. To reach this objective, the following physical attributes were determined for each of the priority offshore sites: (1) the three-dimensional geometry of the deposits and their approximate volumes; (2) the mineralogy and textural characteristics of the deposits, including grain size, sorting, and lateral and vertical variation; and (3) the degree to which the mineralogical and textural characteristics of the banks match characteristics of nearby beaches. The detailed sedimentological data provided a basis for calculating sand volume, determining its suitability for beach replenishment, and providing a basis for assessing the economics of extracting sand from these deposits.

Another objective of the study was a preliminary assessment of the potential environmental impact of offshore dredging near Sabine and Heald Banks. Some of the most important environmental issues related to offshore mining involve disposal of the overburden

Table 1. Attributes of prospect types on the Texas continental shelf. BN = beach nourishment; Ind = industrial uses; Con = construction. From Paine et al. (1988).

Prospect Type	Resource	Best Example	Time of Formation	Suitable for BN	Ind	Con	Comments
Shore-parallel sands	sand	Sabine and Heald Banks	post-Wisconsinan	yes	yes	yes	May contain some shell
Stream courses	sand, gravel	Mustang Island Area	late Wisconsinan to early Holocene	no	yes	yes	May be covered by several meters of overburden
Shelf-margin deltas	sand	Rio Grande Delta	Wisconsinan	no	?	?	May contain silt and clay
Transgressive sands	sand, heavy minerals	South Padre Island Area	post-Wisconsinan	yes	yes	yes	May contain shell; Rio Grande area promising

material, concentration and composition of the dredging plume, and potential alterations to the physical processes as a result of the mining activity. To address these issues, preliminary assessments were conducted of the thickness and composition of material other than sand covering the sand deposits.

REGIONAL SAND RESOURCE EVALUATION

Previous Work

Several earlier studies have investigated the distribution of surficial sediments on the Texas continental shelf including the sand shoals of Sabine and Heald Banks. Those studies, which were based mostly on widely spaced bottom samples, provide a regional depiction of surface sediment types, but they are one-dimensional in scope. Consequently, the published transects and sediment maps do not provide information regarding the thickness, geometry, and lateral extent of the lithologic units. Also, most of these studies did not report grain-size analyses so that sediment textures could be compared quantitatively.

Stetson (1953) conducted a regional survey of sediment textures that included the distal part of Heald Bank but not Sabine Bank. The Heald Bank transect, as well as adjacent transects off Galveston and southwestern Louisiana, showed that the shelf surface sediments are patchy, poorly sorted, and composed mostly of silt with some fine sand.

Curray (1960) used sediment textures and composition as well as radiocarbon dates to interpret the geologic history of the northwestern Gulf of Mexico during the Holocene rise in sea level. He reported that Holocene sediments of the shelf were composed of two facies, a basal sheet of transgressive nearshore sands overlain by shelf muds. According to Curray, this idealized facies succession is present over much of the shelf except where sedimentation rates are low and the basal sand facies is exposed at the seafloor. The sand deposits associated with Sabine and Heald Banks were considered to be part of the basal sand sheet.

Frazier (1974) presented a map showing extensive sand deposits blanketing the continental shelf of the southeastern and central Texas coast. Like Curray (1960), Frazier also used sediment textures and radiocarbon dates to interpret the sea-level history. He also concluded that the blanket sands are transgressive shelf and shoreline deposits that accumulated during the Holocene rise in sea level.

Williams et al. (1979) investigated the potential sand resources on the inner continental shelf between High Island and Freeport, Texas. An objective of the study was to locate sand deposits that could be used for beach replenishment projects on or near Galveston Island. Their work did not include Sabine and Heald Banks because they were considered too far offshore for commercial utilization. In their study, high-resolution seismic profiles and vibracores were used to conclude that the best nearshore sand deposits were associated with the ebb tidal deltas at Bolivar Roads and San Luis Pass.

White et al. (1985) collected and analyzed numerous surface sediment samples from the inner continental shelf along the upper Texas coast. Their sample sites came close to but did not include Sabine and Heald Banks. Nevertheless, the results of the study suggest that Sabine and Heald Banks are the only sand deposits in the area that are large enough to support offshore mining.

Nelson and Bray (1970) and Thomas (1990) both used high-resolution seismic profiles, cores, and radiocarbon dates to investigate the incised valley of the Sabine-Neches river system and the relationship of Sabine Bank and Heald Banks to sediments within the valley fill. Both studies concluded that the banks are accumulations of shoreline sands deposited during a stillstand in sea level and that the banks were submerged during a subsequent rapid rise in sea level. Neither of these studies specifically examined the sediment textures of the banks and their potential for beach replenishment.

Paine et al. (1988) conducted a regional synthesis of lithologic data for the continental shelf that included surface sediment samples, shallow cores, and foundation borings. An objective of this study was to identify the locations of non-fuel mineral deposits including beach-quality sand. Results of the study have shown that near-surface sand accumulations are generally thin,

discontinuous, and not nearly as widespread as indicated by Curray (1960) or Frazier (1974). The study also identified Sabine and Heald Banks as favorable sites for beach-quality sand and recommended specific studies related to the volume and quality of sand within the Banks.

Potential Uses of the Sand Resource

In Texas, several beach replenishment projects have been recommended for Galveston Island (U.S. Army Corps of Engineers, 1983) to restore a beach that once existed seaward of the Galveston seawall, to offset high rates of erosion on beaches west of the seawall (Morton, 1974; Paine and Morton, 1989), and to replace contaminated sand removed from beaches after an oil spill (Morton and Paine, 1985). Some Galveston Island property owners have used muddy Pleistocene sediments for beach fill (Morton and Paine, 1985) because sand suitable for beach replenishment is locally unavailable.

Other segments of the southeastern Texas coast are also undergoing widespread and rapid beach erosion, including the eastern part of Bolivar Peninsula, much of the shore from High Island to Sabine Pass, and the western Louisiana coast. An investigation of historical trends of beach erosion in southeastern Texas and western Louisiana and their causes is being conducted as part of a cooperative program between the U.S. Geological Survey (USGS), the Bureau of Economic Geology (BEG), and the Louisiana Geological Survey (LGS).

Locations of the Sand Resource

The largest potential sources of beach-quality sand offshore of the southeastern Texas and western Louisiana coast are Sabine Bank and Heald Bank (Paine et al., 1988). These sand-rich shoals, interpreted as reworked nearshore and shallow marine sediments, are located 40 to 50 km offshore and in water depths of 4.5 to 17 m (Figure 1). Sand deposits associated with the banks cover more than 1,000 km^2 (Table 2) and are as much as 8 m thick. Widely-spaced cores, foundation borings, and seismic records indicate that average thickness of the sand is about 3 m.

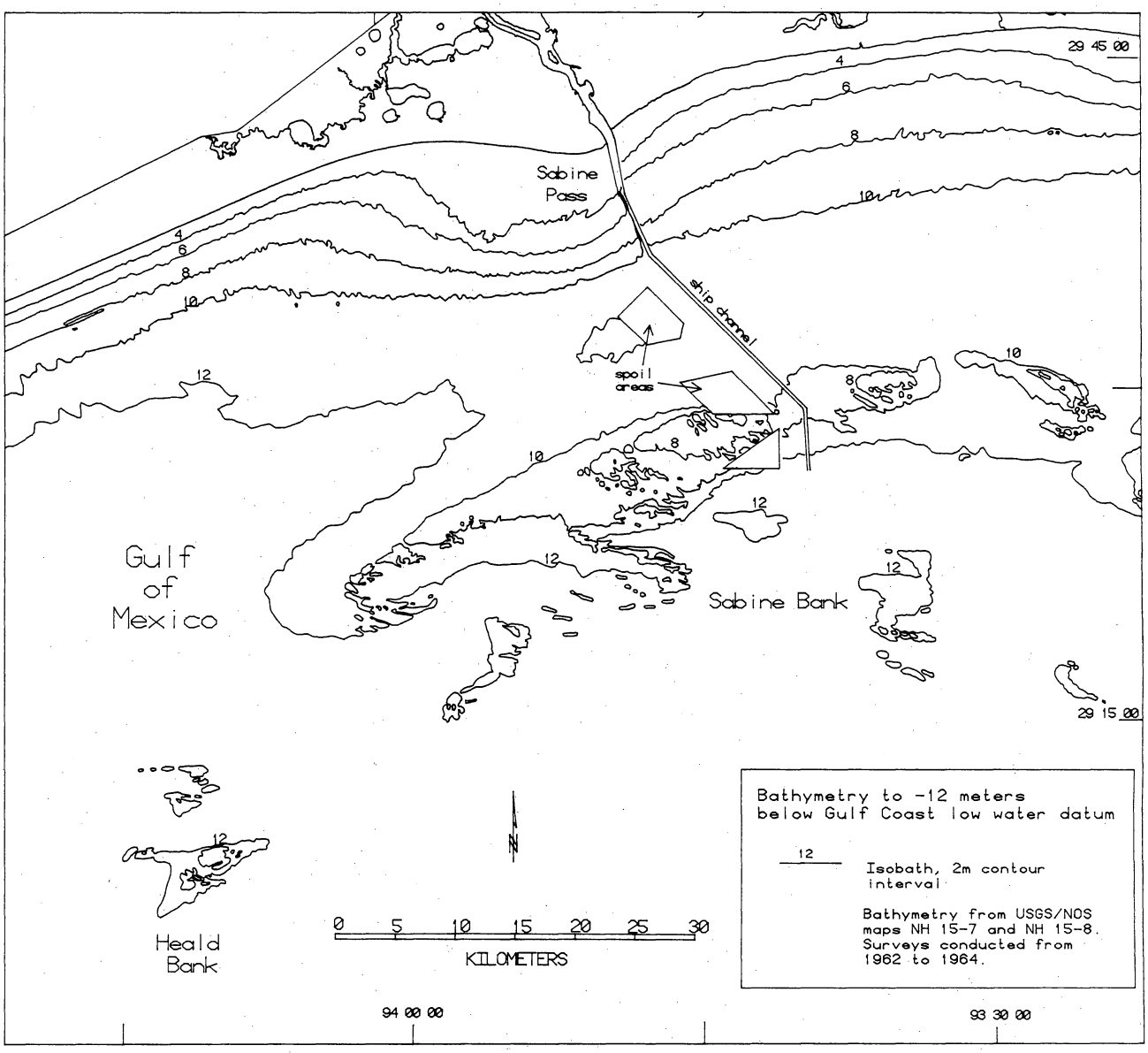

Figure 1. Location of Sabine and Heald Banks and related bathymetry of the continental shelf.