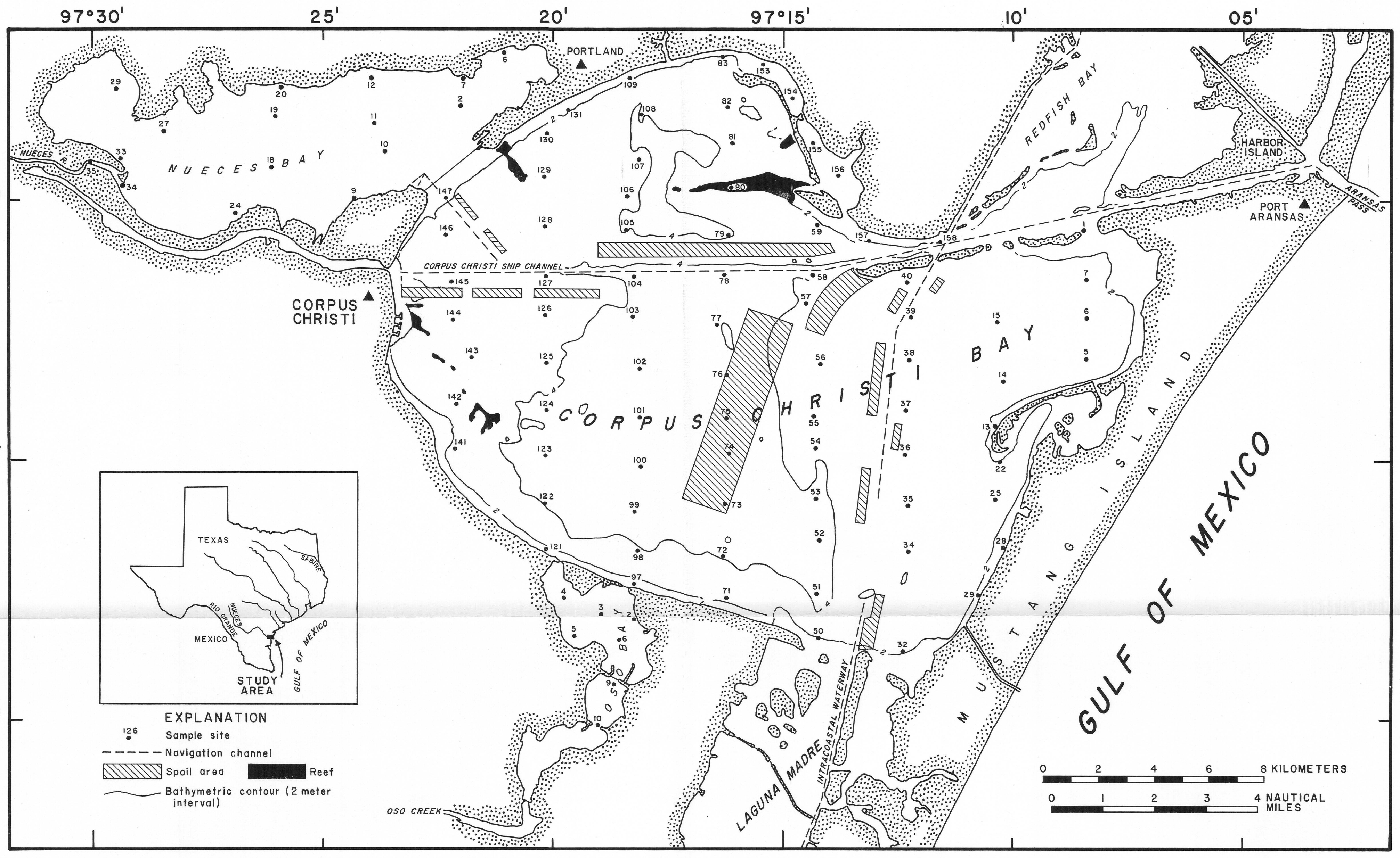

Figure 1.—Index map of study area showing bathymetry, navigation channels, spoil areas, reefs, and sample sites.

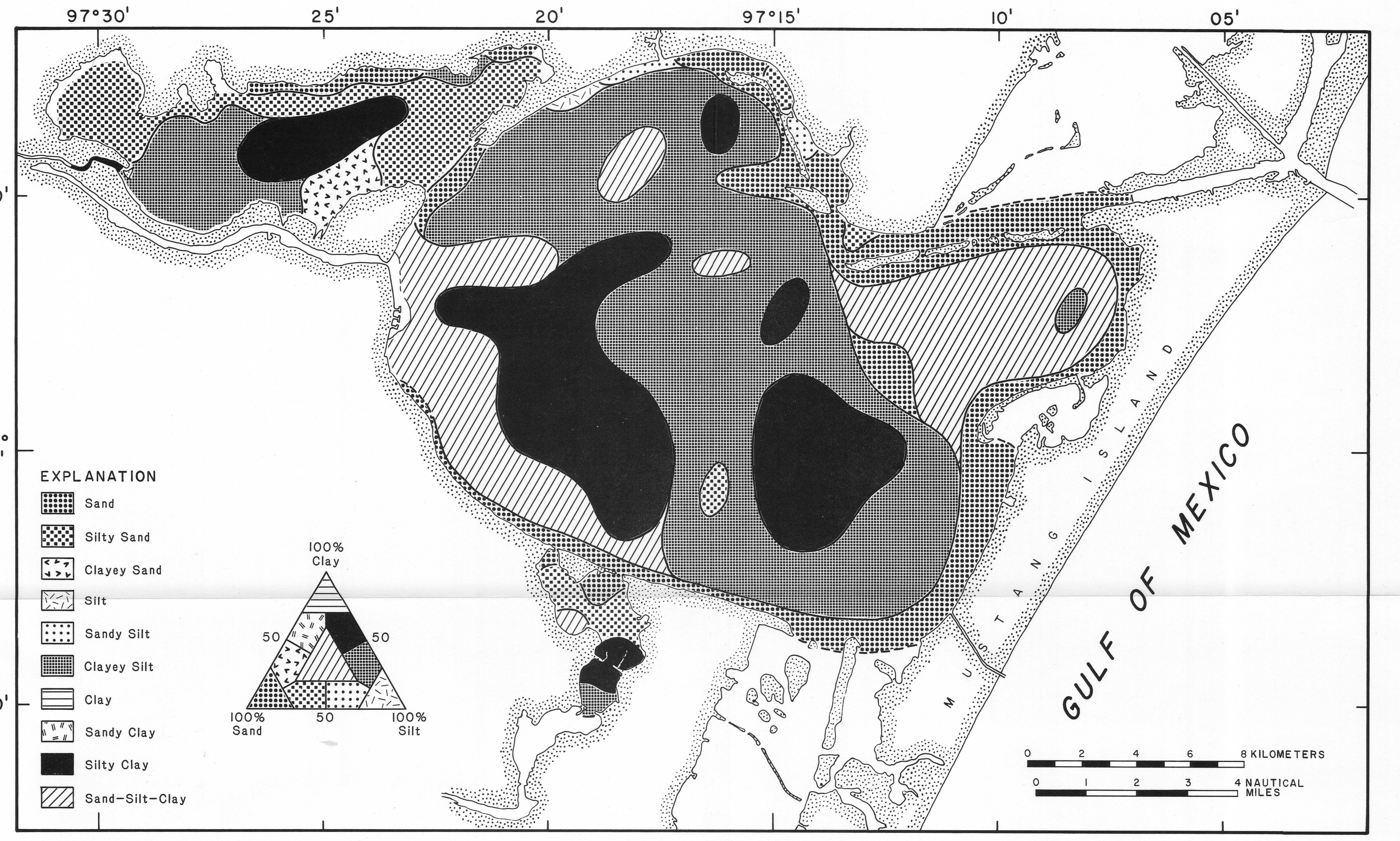

Figure 3.—Distribution of sediment textural classes based on proportions of sand (2 mm-63 μm), silt (63 μm-4 μm), and clay (<4 μm) components.

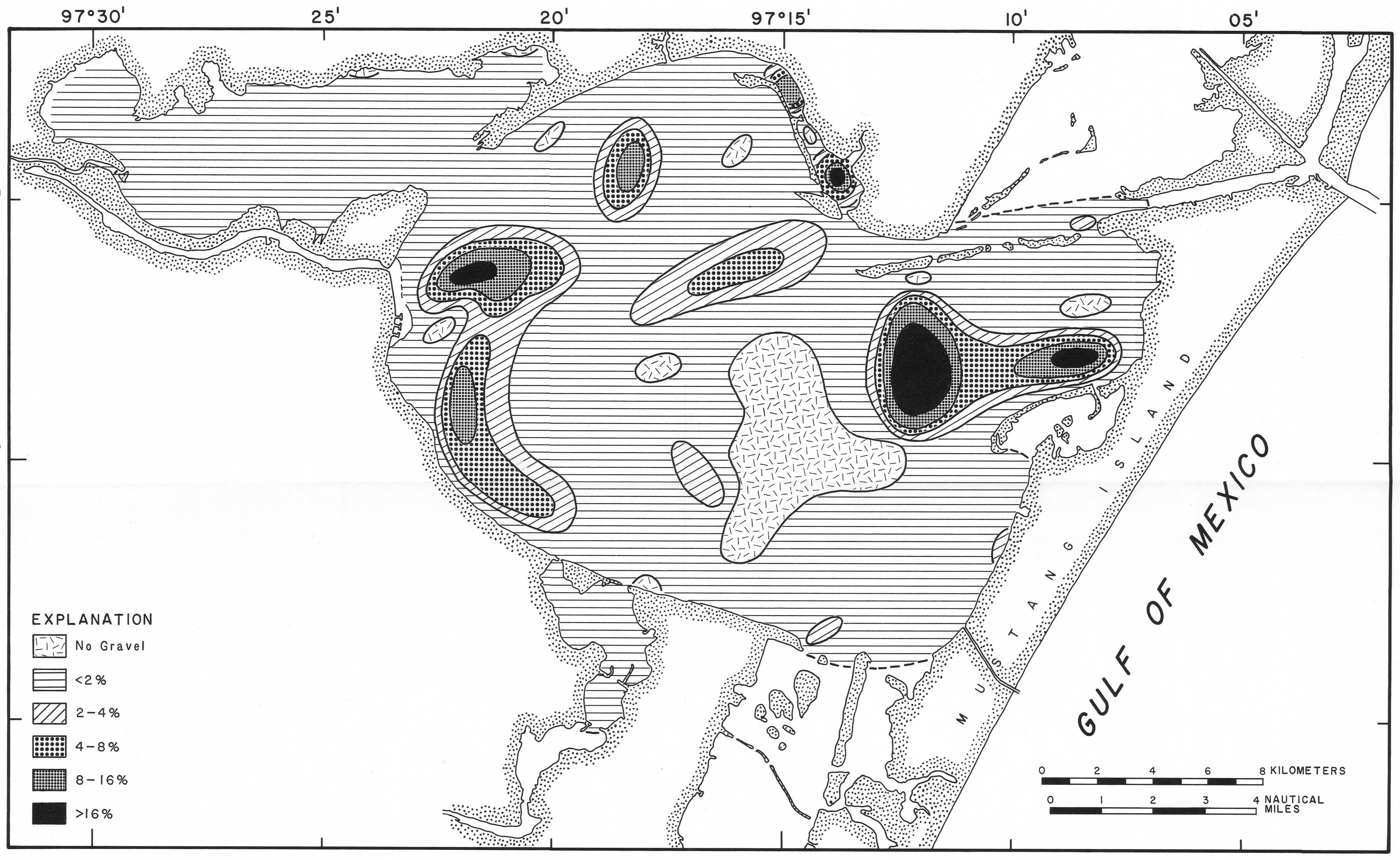

Figure 2.—Weight-percentage distribution of gravel-size (>2 mm) detritus.

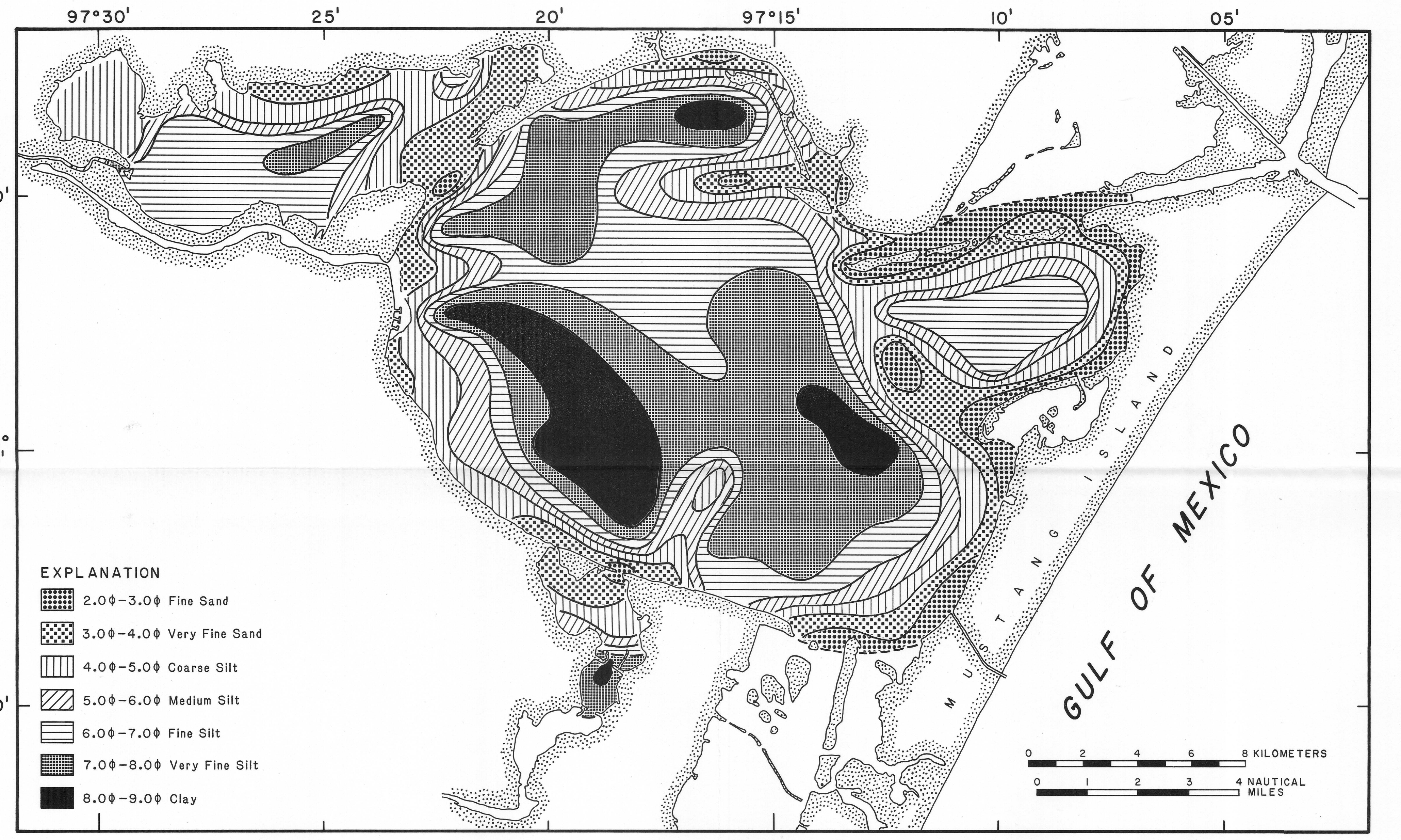

Figure 4.—Distribution of mean particle diameters (ϕ) of the nongravel (<2 mm) fraction.

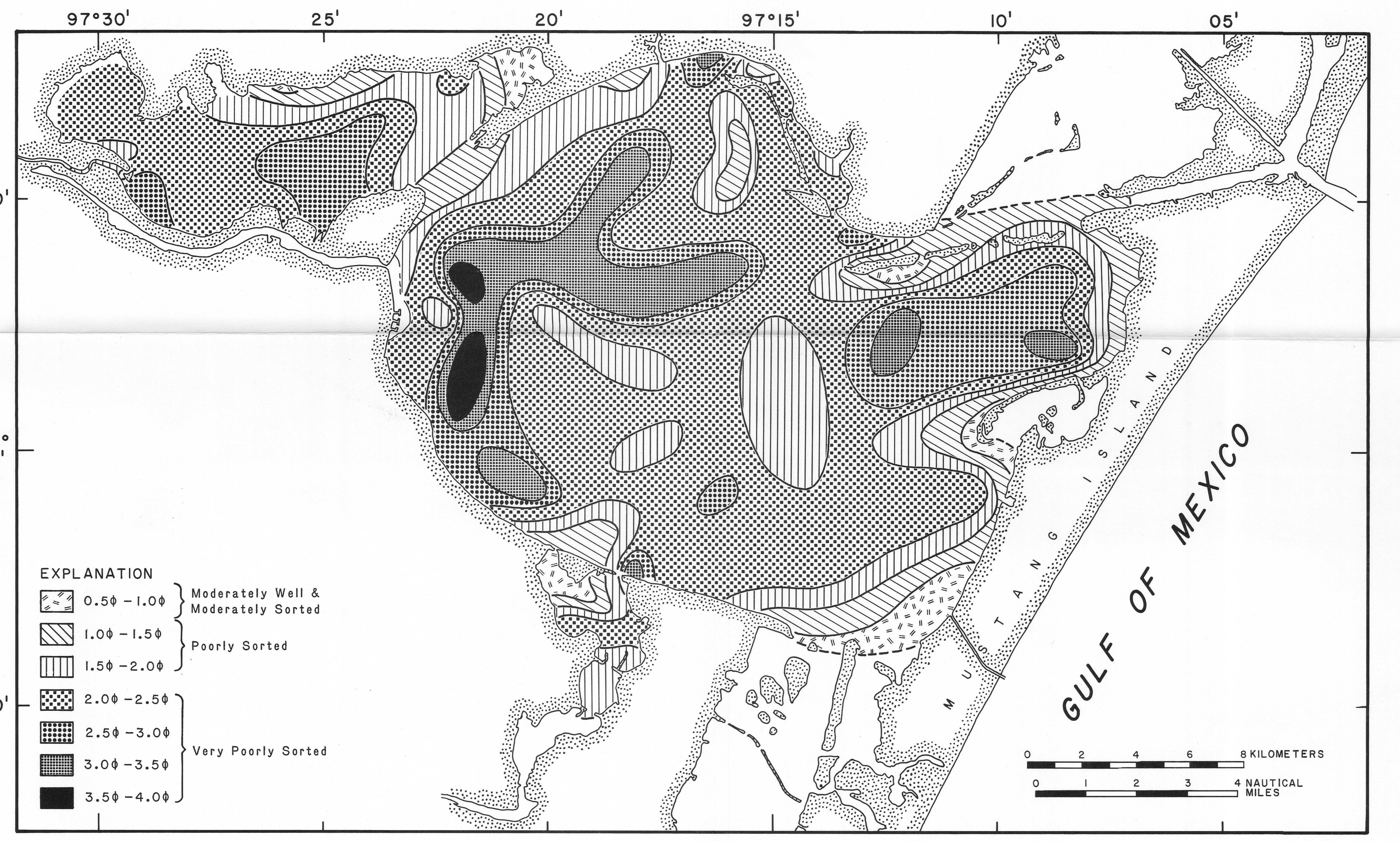

Figure 5.—Distribution of standard deviations of particle diameters (ϕ) of the nongravel (<2 mm) fraction.

INTRODUCTION

Corpus Christi Bay is a heavily used estuary on the south Texas coast in the northwest Gulf of Mexico (fig. 1). The Bay is stressed by diverse activities which could substantially affect its ecosystem. Such activities include shipping, resource production (oil, gas, and construction aggregate), commercial and sport fishing, and recreation. Shipping activities alone have had a substantial impact on the bay. For example, the past maintenance of navigation channels has required extensive dredging and spoil disposal within the estuarine system. Numerous subaqueous spoil disposal sites and subaerial spoil banks are present throughout the bay (fig. 1), and the selection of future spoil disposal sites is becoming a critical local problem. As activities in the bay increase, the need for effective environmental management becomes increasingly important, and effective management necessitates a good understanding of the bay's physical characteristics. The objective of this study is to provide detailed information about the textural composition of bottom sediments within the estuarine system, information which could be used in making environmental-management decisions. Visual descriptions of bottom sediments in Corpus Christi Bay and adjacent areas have been presented by McGowen and Morton (1979). Additionally, a study of the textures of sediments on the Inner Continental Shelf adjacent to the bay has been presented by Shideler and Berryhill (1977).

Corpus Christi Bay is a restricted "bar-built" variety of estuary (Schubel, 1971) that formed during the late stages of the Holocene rise in sea level. The bay is separated from the Gulf of Mexico by the Mustang Island barrier, and its main tidal inlet (Aransas Pass) is located near the city of Port Aransas, Tex. The main fluvial input to the estuarine system is from the Nueces River. The river discharges into shallow (<2 m deep) subsidiary Nueces Bay which, in turn, has water exchange with Corpus Christi Bay through a causeway-connected inlet. Minor stream discharge also enters Corpus Christi Bay along its south shore from Oso Creek via shallow (<1 m deep) Oso Bay. Corpus Christi Bay is generally less than 5 m deep; an exception is the Corpus Christi ship channel which is maintained at a depth of approximately 14 m by means of dredging. A few oyster reefs are located in the marginal areas of the western bayhead sector. Reconnaissance observations of the bay's turbidity and hydrographic patterns suggest that wind is the dominant forcing agent influencing sediment dispersal within the bayhead sector, whereas tides appear to be the dominant forcing agent toward the baymouth sector (Shideler, 1980).

METHODS

Sediment samples were collected from 102 sites throughout Corpus Christi Bay and subsidiary Nueces and Oso Bays (fig. 1). Sites were selected to provide complete and reasonably uniform coverage of the estuarine system. Samples were obtained from the upper 18 cm of bay-floor sediment by means of a clam-shell grab sampler having a 0.004-m^3 capacity. Shipboard navigation was accomplished by means of triangulation and dead reckoning.

Textural analyses were performed in the laboratory on representative splits of the sediment samples. The samples were digested in hydrogen peroxide (30 percent) to oxidize carbonaceous matter; they were then washed to remove soluble salts and were dispersed in a 5-gram/liter sodium hexametaphosphate solution. After dispersion, the samples were separated by means of wet-sieving into gravel (>2 mm), sand (2 mm-63 μm), and mud (<63 μm) fractions, and the weight percentage of each fraction was determined. The gravel fractions were examined microscopically to determine their general composition. Grain-size distributions of the sand fractions were determined using a Rapid Sediment Analyzer settling tube similar to the instrument described by Schlee (1966). Grain-size distributions of the mud fractions were determined by means of a Coulter Counter[1] (Model TA), using techniques described by Shideler (1976). The analyses of the sand and mud fractions were integrated to produce a composite grain-size distribution at a 0.5 ϕ interval over a -1.0 ϕ (2 mm) to 11.0 ϕ (0.49 μm) size range. The mean and standard deviation (first and second moment measures) of particle diameters in the nongravel fraction were derived using a computer program. Maps (figs. 2-5) were prepared to illustrate the areal distribution of the following sediment characteristics: weight percent of gravel-size detritus, non-gravel textural classes, and the mean and standard deviation of particle diameters in the nongravel fraction. All size terminology is in accordance with the Udden-Wentworth grade scale.

DISCUSSION

Gravel Fraction

Sediments of gravel size (>2 mm) within the Corpus Christi Bay estuarine system are mainly biogenic detritus. Visual estimations suggest that, on the average, mollusc shell fragments comprise more than 90 percent of the gravel fraction. More than 85 percent of the mollusc shell fragments are pelecypod shells which include oysters; whereas, gastropod shells are of minor abundance. Trace amounts of barnacles, serpulids, bryozoa, and coral also are present in the gravel fraction. Terrigenous components of gravel are minor (<5%) and consist mainly of quartz pebbles and limestone fragments.

Quantitatively, gravel-size detritus is not a major constituent of the estuarine sediments (fig. 2). Gravel contents among individual sample sites range from a trace to a maximum of 37 percent of the total sediment weight (at sample site 38). Bottom sediments throughout most of the estuarine system contain less than 2 percent gravel, and a few local areas are totally devoid of gravel. Sediments having gravel concentrations greater than 2 percent generally have no apparent systematic distribution, although some high-gravel sediments are closely associated with spoil disposal sites, which may reflect shell concentrations redistributed from dredging operations. Other high gravel concentrations have no apparent relationship to spoil sites, nor, with the single exception of station 142, are they localized near reef structures. The relative effects of natural processes versus man's activities in establishing the present distribution of gravel-size sediment within the estuarine system are uncertain.

Nongravel Textural Classes

The nongravel fraction of the estuarine sediments is characterized in terms of its relative proportions of sand (2 mm-63 μm), silt (63 μm-4 μm) and clay (<4 μm) particles. The estuarine sediments are divided into eight textural classes (fig. 3) using a classification system based on the relative weight percentages of these three end members (Shepard, 1954). The most widespread sediment class is clayey silt. Next in areal distribution are silty clay and a sand-silt-clay mixture which are present in nearly equal proportions. These three textural classes constitute the bottom sediment throughout most of the estuarine system. Sand and silty sand are the dominant sediment types along the periphery of Corpus Christi Bay, along the northern half of Nueces Bay, and in the bay-mouth area of Oso Bay. Other minor sediment types within the estuarine system are silt, sandy silt, and clayey sand. The general distribution pattern of sediment types (fig. 3) indicates that the interiors of Corpus Christi Bay and Nueces and Oso Bays are depocenters for mud (silt and clay) influx from the Nueces River and Oso Creek, and for mud eroded from the bays' shorelines. The peripheral sandy sediments appear to be mainly residual lag deposits from shoreline erosion.

Nongravel Statistical Parameters

The grain-size distributions of the nongravel fractions of the estuarine sediment samples are described in terms of mean particle diameters (first moments) and standard deviations (second moments) of particle diameters in order to more clearly delineate textural gradients. These statistical parameters are expressed as Krumbein's (1934) phi equivalents ($\phi = -\log_2 D$, where D = diameter in mm).

The mean particle diameters of estuarine-sediment samples collected for this study range from 2.3 ϕ to 8.6 ϕ among individual sample sites. In terms of grain-size classification, the sediments range from clay to fine sand. The distribution pattern of mean diameters (fig. 4) illustrates that silt-size (4.0 ϕ-8.0 ϕ) detritus is the most widespread sediment throughout the estuarine system. The distribution pattern also illustrates some prominent textural trends. Corpus Christi Bay sediments show a general reduction in grain size from sandy peripheral areas toward a silty interior; clay deposits are restricted to three isolated localities. This pattern suggests that much of the bay's interior sediment fill consists of wave-sorted mud derived as erosional products from relatively high-energy shoreline areas. Textural gradients in Nueces Bay also illustrate a general reduction in grain size toward the bay's interior; highest gradients occur along the northern and eastern margins. This pattern probably reflects the mixing of muddy effluent from the Nueces River with coarser sediments derived from erosion of the bay's northern and eastern shorelines. In Oso Bay, an upstream reduction in grain size away from the baymouth is probably caused by muddy effluent derived from Oso Creek. The muddy sediments in the interior of both Nueces and Oso Bays are isolated from the muddy sediments in the interior of Corpus Christi Bay by baymouth sand shoals. However, a substantial amount of mud flows in suspension from Nueces and Oso Bays into Corpus Christi Bay, as evidenced by turbid sediment plumes (Shideler, 1980); this indicates that the inlets of both Nueces and Oso Bays are mud-bypass areas characterized by relatively high-energy conditions.

The uniformity or sorting characteristics of the estuarine sediments are indicated by the standard deviations of particle diameters, which range from 0.6 ϕ to 3.7 ϕ among individual sample sites. On the basis of Folk's (1965) sorting classification scale, the estuarine sediments range from moderately well sorted to very poorly sorted. The standard deviation distribution pattern (fig. 5) illustrates that very poorly sorted (>2.0 ϕ) sediment is the most widespread type in the Corpus Christi Bay estuarine system. The pattern also illustrates a general trend of improved sorting from the interior toward the peripheral areas of Corpus Christi Bay and improved sorting toward the northern and eastern margins of Nueces Bay. This sorting trend shows general agreement with the mean diameter trend, whereby the sandy deposits tend to be best sorted. As reported by Moss (1963), earlier workers have established empirical relationships between grain size and sorting; fine sand (2.0 ϕ-3.0 ϕ) tends to be better sorted than either finer or coarser sediments, possibly because of its hydrodynamic properties. This relationship between grain size and sorting appears to be at least partly reflected in the sediments of the estuarine system. Furthermore, some of the most poorly sorted sediments are associated with navigation channels and adjacent spoil disposal sites; this suggests the possible additional influences of man in establishing the present sorting pattern of sediments within the Corpus Christi Bay

ACKNOWLEDGEMENTS

This study was conducted in cooperation with the Bureau of Economic Geology, of the University of Texas at Austin. Appreciation is expressed to the Sediments Laboratory staff of the U.S. Geological Survey's Corpus Christi office for performing the textural analyses.

1 Use of trade names in this publication is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

REFERENCES CITED

Folk, R. L., 1965, Petrology of Sedimentary Rocks: Austin, Texas, Hemphills, 159 p.
Krumbein, W. C., 1934, Size frequency distributions of sediments: Journal of Sedimentary Petrology, v. 4, no. 2, p. 65-77.
McGowen, J. H., and Morton, R. A., 1979, Sediment distribution, bathymetry, faults, and salt diapirs, submerged lands of Texas: Bureau of Economic Geology, University of Texas, Austin, 31 p.
Moss, A. J., 1963, The physical nature of common sandy and pebbly deposits; Part II: American Journal of Science, v. 261, p. 297-343.
Schlee, John, 1966, A modified Woods Hole Rapid Sediment Analyzer: Journal of Sedimentary Petrology, v. 36, no. 2, p. 403-413.
Schubel, J. R., 1971, The classification of estuaries, in Schubel, J. R. (Conv.), The estuarine environment—estuaries and estuarine sedimentation: AGI Short Course Lecture Notes, p. II-1-8.
Shepard, F. P., 1954, Nomenclature based on sand-silt-clay ratios: Journal of Sedimentary Petrology, v. 24, no. 3, p. 151-158.
Shideler, G. L., 1976, A comparison of electronic particle counting and pipette techniques in routine mud analysis: Journal of Sedimentary Petrology, v. 46, no. 4, p. 1017-1025.
______1980, Reconnaissance observations of some factors influencing the turbidity structure of a restricted estuary—Corpus Christi Bay, Texas: Texas Journal of Science, v. 32, no. 1, p. 59-71.
Shideler, G. L., and Berryhill, H. L., Jr., 1977, Maps showing sea-floor sediment texture on the south Texas Inner Continental Shelf, Corpus Christi Bay to Baffin Bay: U.S. Geological Survey Miscellaneous Field Studies Map MF-901.

MAPS SHOWING TEXTURAL CHARACTERISTICS OF BENTHIC SEDIMENTS IN THE CORPUS CHRISTI BAY ESTUARINE SYSTEM, SOUTH TEXAS

By
Gerald L. Shideler, Charles E. Stelting, and Joseph H. McGowen[1]
1981

[1] Bureau of Economic Geology, University of Texas, Austin

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1981
For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225