TEXAS SUBMERGED LANDS

Sampling and Preliminary Analysis and
Mapping of Texas Bays and Inner
Continental Shelf

December 1975 through August 1977

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By

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INTRODUCTION

In December 1975, the first cruise of the Texas submerged lands research program began aboard the research vessel Faye, with 14 days of marine seismic profiling on the inner continental shelf off Brownsville and southern Laguna Madre, Texas. Since that first cruise, research scientists of the Bureau of Economic Geology have spent many months mapping the Texas shelf aboard the University of Texas research vessel Longhorn, and aboard smaller boats, airboats, and land vehicles in and around the Texas bays from Louisiana to the Rio Grande (Fig. 1).

Throughout the program, research personnel of the U.S. Geological Survey, Corpus Christi, Texas, cooperated fully, matched certain funds, and supplied critical equipment and personnel. Consequently, the Texas program was integrated fully with U. S. Geological Survey and Bureau of Land Management studies of the Federal O.C.S. of South Texas.

The Texas program was designed to provide the basic scientific data necessary to assess and predict the problems and potential impacts

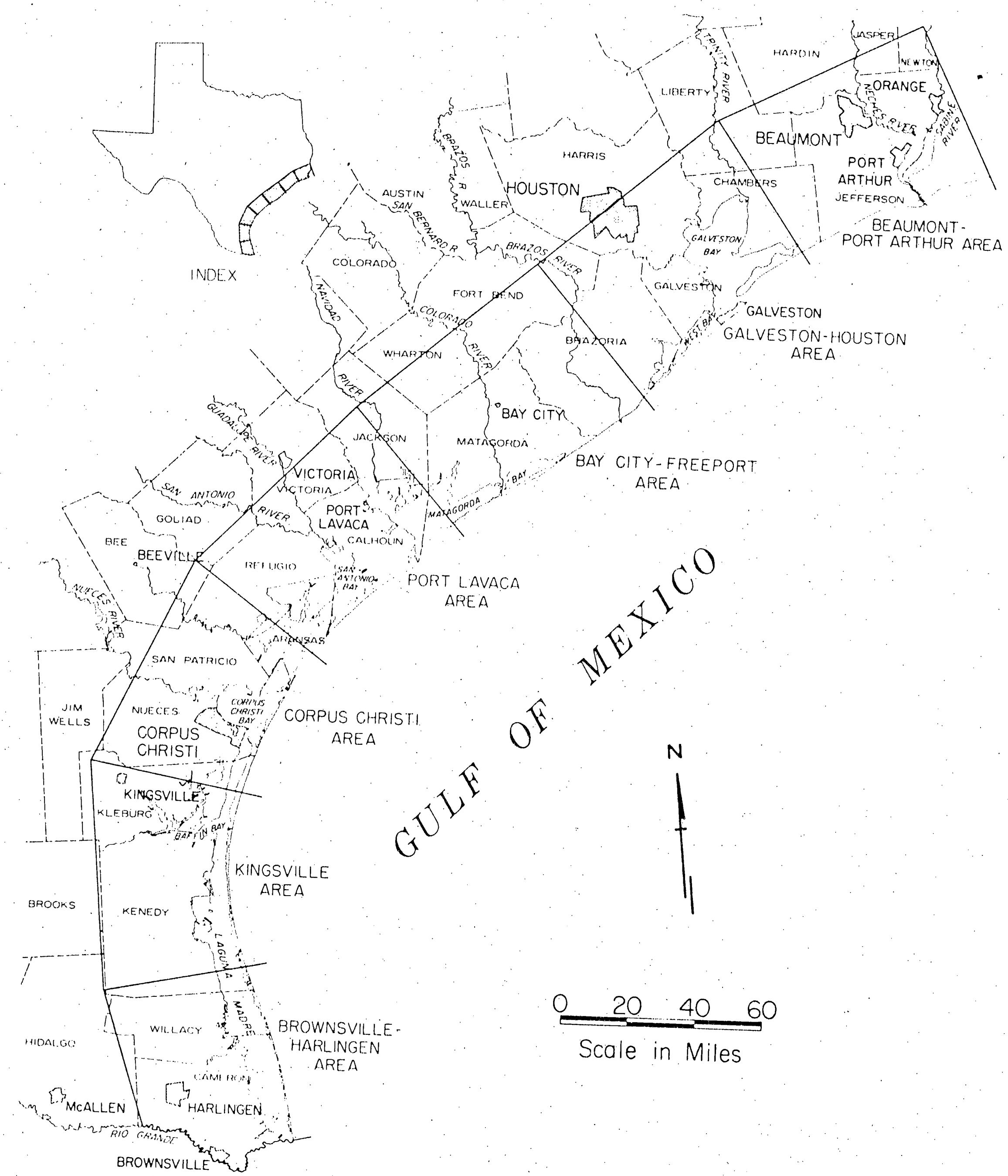
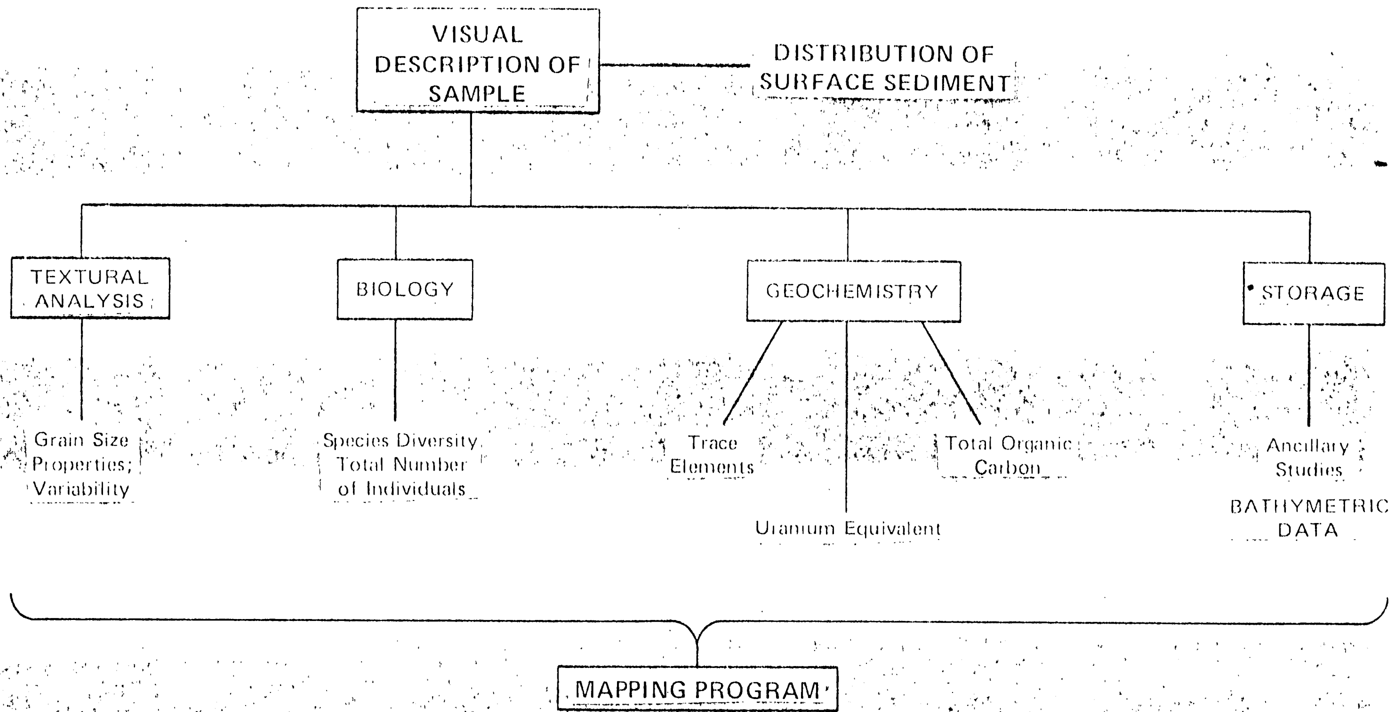


Figure 1. Index map showing seven area maps that cover the submerged coastal lands of Texas.

SAMPLE AND SAMPLE ANALYSIS PROGRAM



GEOPHYSICAL PROGRAM

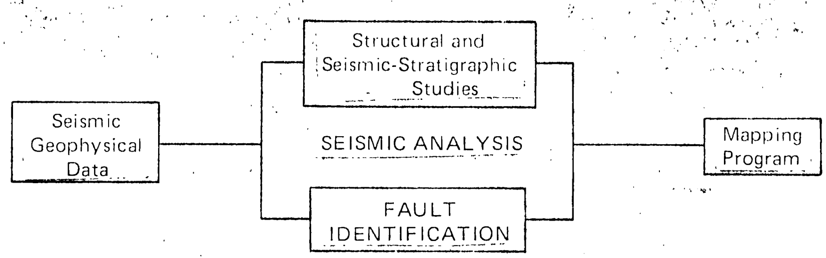


Figure 2. Principal elements and products of submerged coastal land program, Texas bays and inner shelf.

resulting from energy, mineral, transportation, recreation, and industrial development along the Texas coast and beyond, on the Federal outer continental shelf. Results of this project and its on-going analytical/interpretive programs will provide Texas with comprehensive natural resources data with which to assess the various development scenarios that can be anticipated by the Texas Coastal Management Program.

Using precise radionavigation techniques, the entire Texas coastal waters, from rivers to 10.3 miles (3 leagues) offshore, were surveyed onto a grid of 1-mile sample stations. By August 1977, 6,697 samples had been collected (Fig. 2). During the same period, on separate cruises, over 4,100 nautical miles of high resolution seismic surveys were recorded; these surveys covered all of the Texas inner shelf, and most of the bays (Table 1).

By August 1977, 18 percent of the collected samples (3,088) had been geochemically analyzed for 20-30 trace elements. Approximately 50 percent of the samples were analyzed for organic carbon, and preliminary biological analysis of 580 samples was completed by August 1977. Geophysical analysis has permitted delineation of the active and shallow faults beneath the Texas inner shelf. Visual analysis of the 6,697 samples has been completed, in order to prepare preliminary sediment distribution maps. The Bureau's cartographic section also has completed two sets of 1:125,000 base maps (seven sheets per set; Fig. 1). One set contains sample stations for use in the mapping program, and the other set contains all geophysical cruise/profile lines on which geophysical interpretations will be charted.

Table 1. Status of sampling and sample analysis, Texas submerged coastal lands program, August 31, 1977.

Tasks	Bays	Shelf	Total
Total Samples Collected	3197[2]	3500[1]	6697
Geophysics: Nautical miles of high resolution seismic	600[3]	3500	4100
Analyses:			
Sediment textures	Initiated: Complete in FY 78-79		
Geochemistry			
Total Organic Carbon	788[4]	2300[4]	3088[4]
Trace Metals	357	750	1107
Biology	280[5]	300[5]	580
Seismic Interpretation[6]	Initiate in FY 78	Fault Mapping completed; Stratigraphic analysis initiated	

[1] Two remaining strips to be completed in September, 1977

[2] Bays to be completed in FY 1978

[3] Approximately 2 weeks of sampling remaining in northern Laguna Madre

[4] Analysis underway as funding permits

[5] Preliminary analysis with faunal lists. Detailed assemblage studies scheduled for FY 78-79. Total of 3,197 biologic samples from shelf and bays collected in program.

[6] Extensive analysis scheduled for FY 78-79

Table 2. Status of map preparation, Texas submerged coastal lands program, August 31, 1977.

	Beaumont-Port Arthur		Galveston-Houston		Bay City-Freeport		Port Lavaca		Corpus Christi		Kingsville		Brownsville-Harlingen	
	Bays	Shelf	Bays	Shelf	Bays	Shelf	Bays	Shelf	Bays	Shelf	Bays	Shelf	Bays	Shelf
Surface Sediment	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total Organic Carbon			X		X		X*	X	X*	X	X	X	X	X
Biologic Assemblages	X		X				X		X		X		X	
Faults & Diapiric Strs.		X		X		X		X		X		X		X
Barium								X		X		X		X
Chromium								X		X		X		X
Iron								X		X		X		X
Lanthanum								X		X		X		X
Lead								X		X		X		X
Manganese								X		X		X		X
Strontium								X		X		X		X
Vanadium								X		X		X		X
Zirconium								X		X		X		X

*partially completed

Although the Fiscal Year 1976-1977 program was designed principally as a data collection phase of the submerged lands program, considerable interpretation, mapping, and analyses of the vast information system were well underway by the end of Fiscal Year (FY) 1977 (Tables 1, 2). With only a few small sample areas remaining on the inner shelf and in the bays by August 1977, the Texas submerged lands program enters on October 1, 1977 a second phase involving intensive, sophisticated analyses, interpretation, and mapping of data. Possible coring operations will also permit differentiation between the components of the shallow subsurface that lies beneath the bays and inner shelf.

This report is designed to summarize the status of the submerged lands program as of August 31, 1977, at the end of the collection/survey phase, and at the beginning of the analytical, interpretive, and charting phase. In addition to description and initial interpretation of data, there also is included a folio of maps depicting the distribution of data that have been collected and analyzed to date. These maps are, of course, preliminary, and they will be intensively reviewed, supplemented, and completed during FY 1978-1979. Preliminary biologic assemblage lists are included in the Appendix. Large volumes of analytical data are available at the Bureau; these will be processed beginning October 1, 1977.

Figures 3 and 4 illustrate the progress and current status of the submerged lands study.

J. H. McGowen supervised bay studies, and R. A. Morton supervised shelf investigations. T. R. Calnan directed bay biologic analysis.

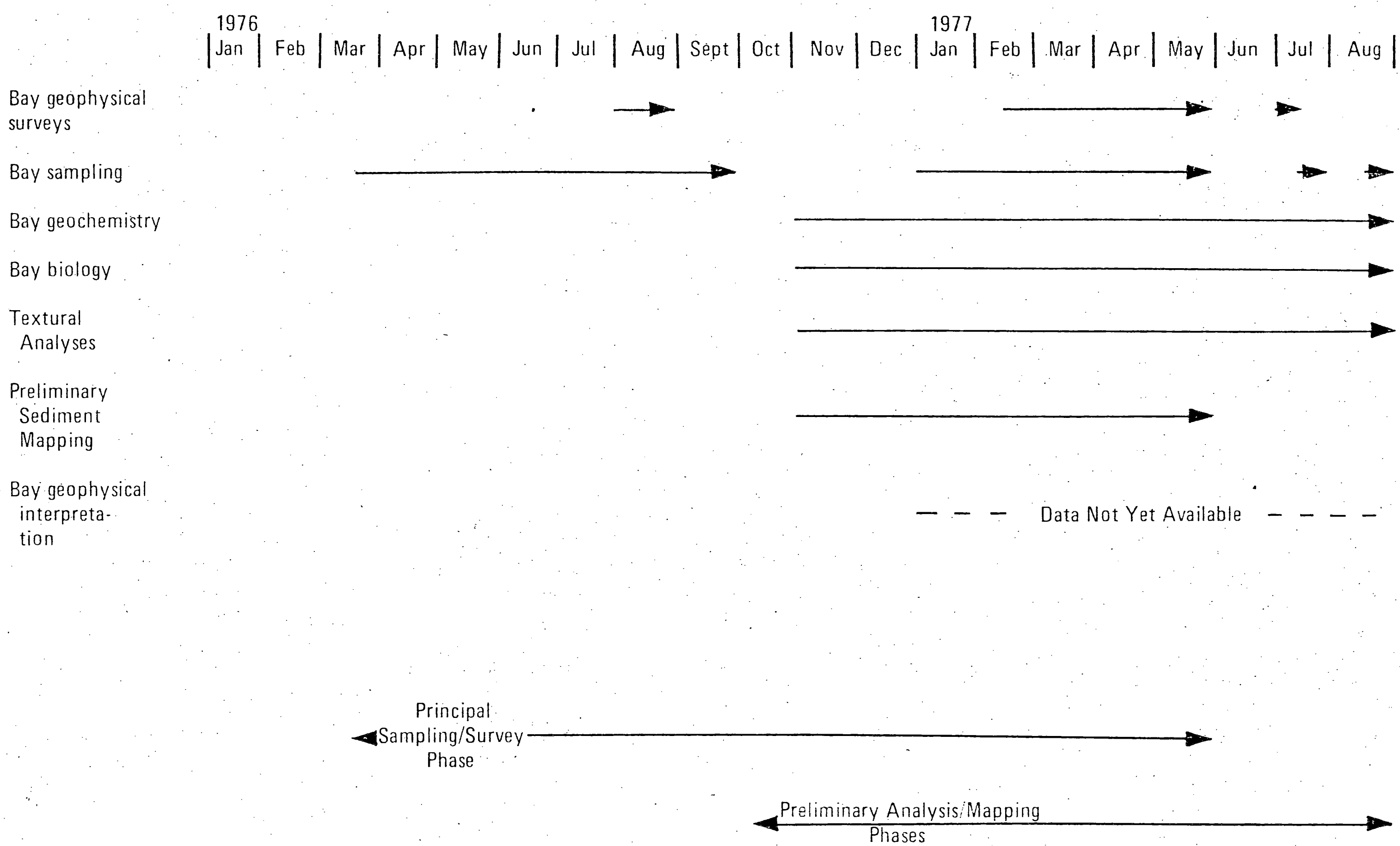


Figure 3. Bay studies, Texas submerged coastal lands program, December, 1975 through August, 1977.

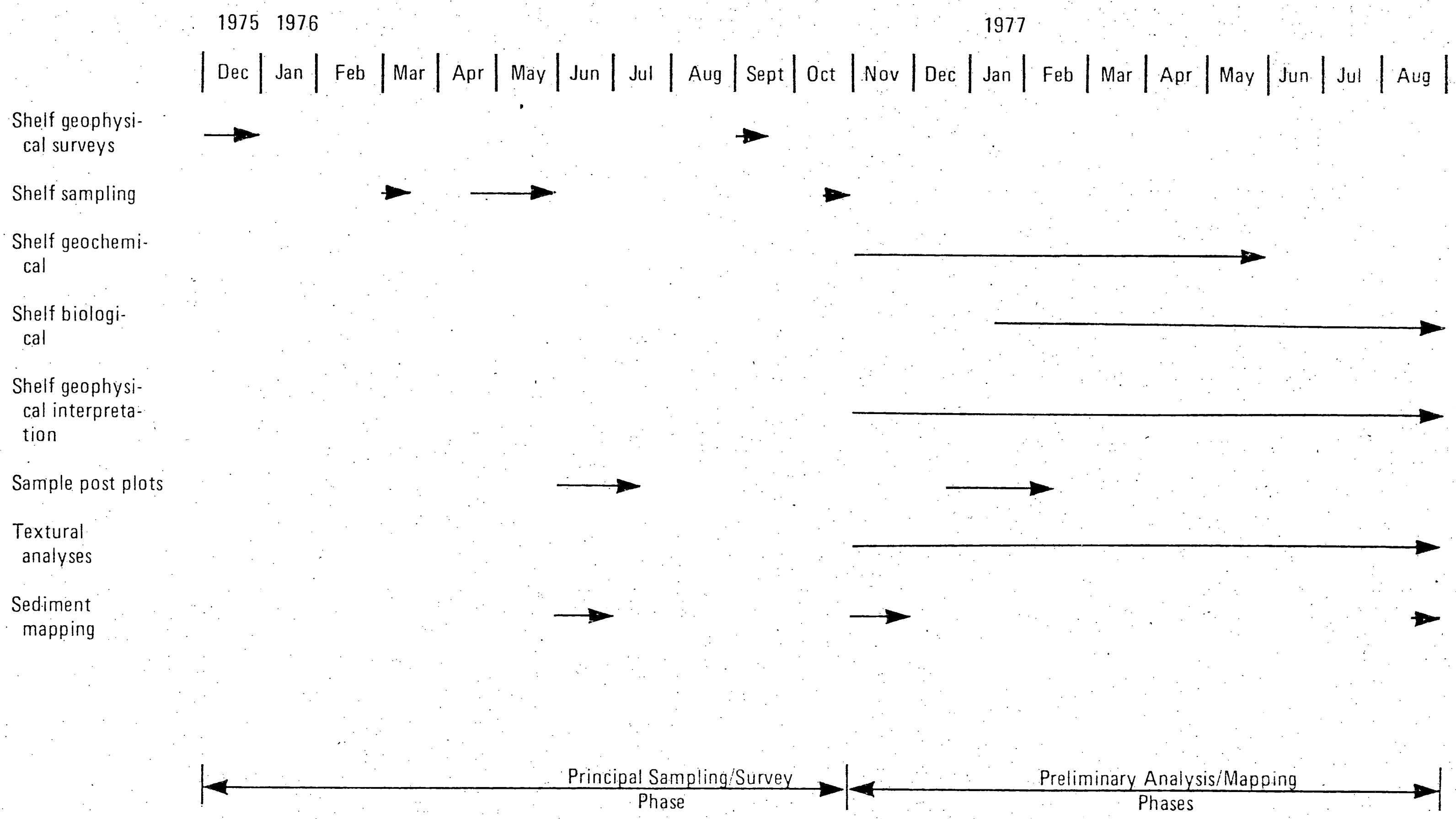


Figure 4. Shelf studies, Texas submerged coastal lands program, January, 1976 through August, 1977.

L. F. Brown, Jr. coordinated the program and provided liaison with the General Land Office. Responsibility for writing this report is as follows: J. H. McGowen, Bay Studies; R. A. Morton, Inner Shelf Studies; T. R. Calnan, Bay Biology and Appendix A; and L. F. Brown, Jr., Introduction, Summary and Conclusions, and coordination of report preparation. Principal support in preparing geologic analyses and maps included M. K. Pieper, J. L. Chin, J. P. Herber, R. L. Andersen, C. R. Lewis, B. Sepassi, and C. Safe.

A field program of the magnitude of the FY 1976-1977 submerged lands studies required the support of many people. Bureau staff members active in the geophysical and sample collection programs included J. H. McGowen (bay investigator), R. A. Morton (shelf investigator), J. L. Chin, T. R. Calnan (biologist), J. P. Herber, C. R. Lewis, L. C. Safe, M. K. Pieper, W. A. White, Dale Solomon, Charles Greene, Carl Christiansen, Dwight Williamson, Mike Stewart, Carl Warning, Greg Miller, Pam Luttrell, Steve Seni, John Kieschnick, Guy Tidmore, George Granata, Dawn McKalips, C. D. Henry, and L. E. Garner.

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Many members of the General Land Office and Coastal Zone Management Program supported the program throughout its entirety, including Bob

Armstrong, Commissioner, General Land Office; Ron Jones, Director, Coastal Management Program; and Bob Waddell, John D. Macklin, Jr., C. M. Woodruff, Jr., William L. Longley, Andrew E. Reed, Stephen Minick, and Christine Gever.

Bureau support staff included chemists of the Mineral Studies Laboratory, D. A. Schofield and Laurence McGonagle, in charge; technicians of the Well Sample and Core Library, Douglas Ratcliff, in charge; Cartographic Staff, James Macon, in charge; Editorial Processing, Margaret Gaines, in charge; Bettye Blitch, purchasing officer; and Eloise Hill, contract and accounting support.

BAY STUDIES

Comparable data were collected from bays, estuaries, and lagoons, and from the inner continental shelf. These data include sediment samples and high-resolution sub-bottom sparker profiles. Sediment from each sample station was sub-sampled for (1) textural analyses, (2) trace metal geochemistry, (3) total organic carbon content, (4) uranium equivalent content, and (5) identification of the benthic fauna. Geophysical lines were run perpendicular and parallel to the long dimension of bays, estuaries, and lagoons; where water depth permitted, geophysical lines were spaced 2 miles apart.

Surface sediment samples were collected with a clam-shell grab sampler, capacity 0.25 cubic foot. Sample stations were pre-plotted on navigation charts; actual plotting of a sample station was made on-site, using the resection method when in sight of land. Where land could not be sighted, sample stations were plotted by steering a given compass course for a specific length of time. Water depth and time of sample collection were recorded at each station. When the sample was brought on board, it was described (color, texture, shell content, and organic content were recorded), and it was split for chemical, biological, and textural analyses. Field descriptions are entirely visual, and the 20 sediment types that have been recognized are based on three sediment end-members (shell, sand, and mud), and mixtures thereof (Fig. 5). Two reef types (oyster and serpulid reefs) have been included with sediment types for convenience of mapping.

Geophysical lines were pre-plotted on navigation charts. However, water depth restrictions required that the position and trend of some

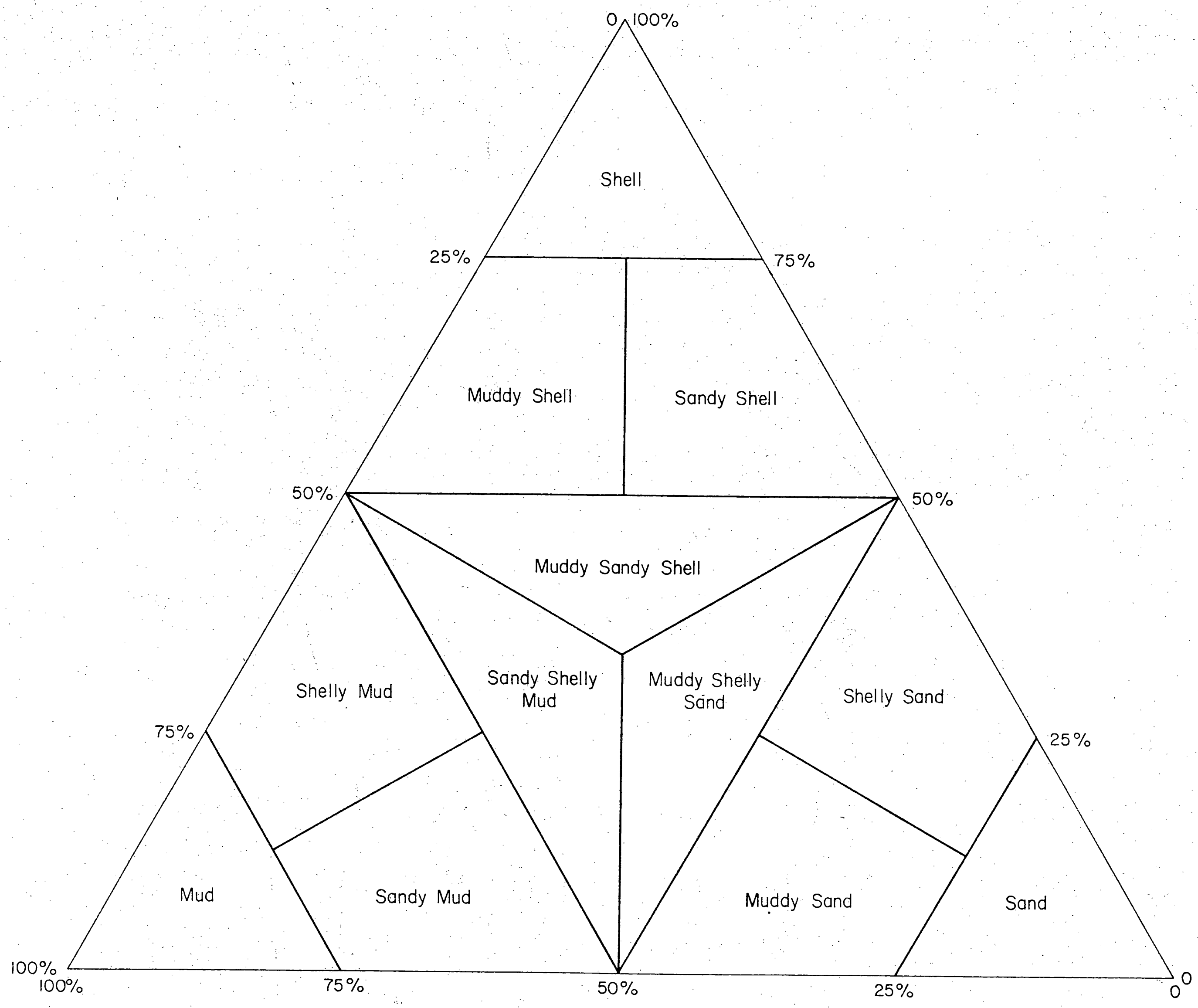

Figure 5. Classification of sediment types based on visual analyses, Texas submerged lands.

lines be altered significantly from the pre-plot position. A shallow-draft, 23-foot Pen-Yan boat was utilized for bay geophysics. Both the boat and the high-resolution sparker equipment were provided by the U.S. Geological Survey at Corpus Christi, Texas. A mini-range-radionavigation system was used to locate precisely the geophysical shot points (shot points were taken at 1,000-foot intervals). Geophysical lines were then post-plotted, using the shot points as co-ordinates.

Surface Sediment Distribution

Spatial relationships of sediment types (determined from field descriptions) are presented on maps at a scale of 1:125,000. Base maps utilized for presentation of sediment data are the same scale as those used in the Bureau of Economic Geology's "Environmental Geologic Atlas of the Texas Coastal Zone." Maps presented in this report represent the same seven areas as the Environmental Geologic Atlas Series (Fig. 1).

Beaumont-Port Arthur Area

Sediment is delivered to Sabine Lake primarily through the Sabine and Neches Rivers. Smaller drainage systems to the west, such as Taylor Bayou, discharge into either the Sabine Neches Canal or the Port Arthur Canal; most of the sediment delivered by these streams bypasses Sabine Lake and is transported to the Gulf of Mexico through Sabine Pass. Some of this sediment may be transported into Sabine Lake during flood tide, and a small amount is derived from the adjacent shoreline, through erosion. *Crassostrea virginica* and *Rangia sp.* also contribute to the bay fill. Man's activities too have affected the normal distribution of sediment; for example, both freshwater and sediment have been diverted through channelization and by spoil disposal.

The sediment distribution map was constructed from field descriptions of 157 surface sediment samples. Ten sediment types were recognized, and their spatial relationships are depicted on the sediment distribution map. Sand and muddy sand are found most often at the head of Sabine Lake, reflecting sediment contribution through the Sabine and Neches Rivers; sand also is found locally in the Sabine River, the Neches River, and some dredge channels. Muddy sand is situated along bay margins as a result both of reworking of Pleistocene materials forming the shoreline, and of reworking of spoil, particularly in the Port Arthur vicinity.

Sandy mud is found at the head of Sabine Lake, adjacent to the shoreline, and offshore from spoil disposal areas. At the head of Sabine Lake muddy sand displays a normal distribution pattern; sediment tends to become finer grained with distance from a river mouth. Small areas of sandy mud are restricted to the lake margin along the Louisiana shoreline, and along the banks of Sabine Pass. The largest area of sandy mud lies along the west shore of the lake, and extends east and northeast into the lake center; this sandy mud was deposited by dredging activity, and by the reworking of dredge material by waves and currents.

Mud composes the largest part of the lake bottom; it occurs in both the shallow and deep parts of the lake, and extends from the head of the lake through Sabine Pass.

The remaining sediment types are mud with shell material (shelly mud, sandy shelly mud), sand with shell material (muddy shelly sand),

and shell (clean, gravel-size shell debris, and shell in a mud matrix). Shelly mud is situated along the southern shore (3' - 6' of water) and in Sabine Pass (15 feet of water), as well as in parts of the Sabine Neches Canal and the Gulf Intracoastal Waterway. Shell within the lake is primarily Crassostrea virginica and Rangia sp. Sandy shelly mud (station 27) is a minor sediment type found along the south lake margin in about 4 feet of water; live Rangia are found in this area. Muddy shelly sand (station 57) is situated in 5 feet of water near the west shore, adjacent to a spoil disposal area; this sediment type is a man-made product. Muddy shell occurs in two small, widely separated areas (see stations 10.5, 12 and 73), one at the south end of the lake (8 feet of water), and the other near the north end (5 feet of water). Live oysters are present at stations 10.5 and 12. Shell gravel (station 11.5) is associated with muddy shell at the south end of the lake. Shell gravel lies in about 11 feet of water, contains live Crassostrea virginica, and probably represents reef flank material.

Relict Pleistocene mud is present in Sabine Pass in 17 to 45 feet of water (station 1 in 17 feet of water, station 4 in 45 feet of water).

Houston-Galveston Area

The Houston-Galveston area is characterized by the largest bay-estuarine system in the entire Texas Coastal Zone. The system comprises Trinity, Galveston, East, West, Chocolate, Christmas, and Bastrop Bays. Maximum depths of Galveston and Trinity Bays are 10 and 9 feet respectively. Bolivar Roads, the tidal inlet for Galveston, Trinity, and East Bays, and part of West Bay, has a maximum depth of 40 feet where maintained by dredging, and a maximum of 23 feet in a natural state. East and West Bays reach maximum depths of 7 and 6 feet respectively. The other bays are approximately 3 to 4 feet deep at their centers.

Sediment is supplied to this bay-estuarine system by rivers, from the Gulf of Mexico through tidal inlets and across barrier islands during storms, through erosion of Pleistocene deposits forming mainland shorelines, and from production of shell material by molluscs. From east to west, the fluvial systems that contribute sediment to the bay-estuarine system include Trinity River, Cedar Bayou, San Jacinto River, Buffalo Bayou, Clear Creek, Dickinson Bayou, Halls Bayou, Chocolate Bayou, and Bastrop Bayou.

Distribution of sediment within the system is related to such factors as (1) site of fluvial discharge, (2) lithology of the Pleistocene forming the mainland shoreline, (3) bathymetry, (4) location of tidal inlets, and (5) proliferation of molluscs such as *Crassostrea virginica*.

Most of the fluvial systems discharging into the bay-estuarine system are characterized by a large suspension load relative to bed-load material. Consequently, the shoreline and bay bottom adjacent to the mouths of most of these streams are typically muddy. The Trinity River is an exception; a relatively large delta has been constructed at the head of Trinity Bay, and delta front sands fringe the subaqueous part of the area.

Much of the mainland shoreline consists of Pleistocene deltaic muds and sands. In some areas the mainland shoreline is composed of Pleistocene strandplain sand. Where the mainland shoreline is represented by Pleistocene deltaic deposits, bay margin deposits are sand, muddy sand, sandy mud, or mud -- depending, for the most part, upon the local occurrence of Pleistocene sand within the shoreline materials. Pleistocene strandplain deposits (predominantly sand) form the mainland shoreline in the vicinity of Smith Point and Dollar Bay; bay margin deposits in these areas are predominantly sand and muddy sand.

Mud is the dominant sediment type within the deeper parts of the bay-estuarine system. Deeper parts of bays are relatively far away from river mouths, tidal inlets, and shallow bay margin areas. Hence, the deeper parts of bays are perhaps the lowest physical energy environment of the bay-estuarine system; the deeper, lower-physical energy part of the system is conducive to accumulation of the finest fraction of the terrigenous clastic sediment delivered to the bay.

Gulf and bay-estuarine water and sediment are mixed or exchanged either through natural or man-made inlets. In the Houston-Galveston area there is one man-made tidal exchange pass (Rollover Pass), one jettied and dredged natural pass (Bolivar Roads), and one semi-pristine natural pass (San Luis Pass). Normally, part of the bay water and its associated suspension sediment load leave the system through inlets; bay water and fine sediment form a sediment plume that overrides the more saline Gulf water as the plume moves seaward. Longshore currents move sand along the beach and shoreface of Bolivar Peninsula, Galveston Island, and Follets Island. If it is not stopped by jetties or groins, part of this sand moves into the bay-estuarine system with currents produced by flood tides. Some of this sand, the bedload, accumulates within the bays as flood tidal deltas at the termini of tidal channels. Another part of the sand returns to the Gulf of Mexico with the ebb tide. Some of this sand accumulates at the seaward terminus of the tidal channel as a poorly-defined ebb delta, and the remainder is picked up by longshore currents and is carried down the coast.

Locally, the bay bottom has been built upward by Crassostrea virginica to within a few feet or inches of the water surface. Oyster reefs and flanking shell-bearing deposits are most numerous in the constricted part of Galveston Bay. Most of the other bays also have oyster reefs; however, they are not as well developed as those in Galveston Bay.

Seven hundred and five sediment samples were collected from the bay-estuarine system in the Houston-Galveston area. From field descriptions of these samples, 15 sediment types (including oyster reefs) were plotted, and their spatial distribution were mapped. There are four terrigenous clastic textural types within this bay-estuarine system — sand, muddy sand, sandy mud, and mud. The other sediment types, except oyster reefs, shell gravel, and rock gragment gravel, are representative of these four basic textural types, with shell mixed in.

Quartz sand occurs, for the most part, in the higher physical energy environments, such as (1) near the mouth of the Trinity River, (2) in shallow bay margins, and (3) in tidal inlets and tidal deltas. There are also local concentrations of sand adjacent to the Intracoastal Waterway. This sand was reworked from spoil placed beside the dredged channel.

Muddy sand generally is found in depositional environments characterized by somewhat less intense physical processes than those which characterize the clean quartz sands. Muddy sand forms bands that approximately parallel the bay shoreline. This type of sand is situated adjacent to, but in deeper water than clean quartz sand. Sometimes it may occupy the same position relative to shoreline and water depth, where physical energy is reduced by marine grasses or by shoreline orientation.

Sandy mud generally lies adjacent to sand or muddy sand in bay margin and tidal delta areas. In some protected areas (for example, Moses Lake, Chocolate Bay, and Bastrop Bay) sandy mud abuts the shoreline. Sandy mud is, in most areas, a transitional facies between muddy sand and mud, and, as such, extends from the more shallow to deeper parts of the system.

Mud, the finest terrigenous clastic fraction, is found in lowest physical energy environments and deeper parts of the system. Many of the small, shallow bodies of water are floored with mud. In the Baytown area, the small bodies of water that parallel the San Jacinto River receive suspension load material mainly from overbanking of the river. Most of the mud contained in the bay-estuarine system was derived from rivers and creeks that discharge into the system. Lesser amounts of mud are derived through shoreline erosion, from the Gulf of Mexico during tidal exchange through tidal inlets, and from the sea during the passage of tropical storms.

The coarsest sediment in the system is gravel-size shell debris and rock fragments. Shell gravel is an integral part of oyster reefs, where it forms reef flank deposits. Shell gravel also serves as a floor for part of Bolivar Roads. It forms (1) beaches on some spoil mounds, (2) shell veneer over bay muds where spoil has been reworked, and (3) small patches where oyster clumps have been reworked. Gravel-size rock fragments, a rare sediment type, results from redistribution of spoil adjacent to the Gulf Intracoastal Waterway.

Shell with sand and mud form three minor facies: sandy shell, muddy sandy shell, and muddy shell. Sandy shell occurs (1) in Bolivar Roads, and is transitional with shell to the north and with sand to the south, (2) next to the Houston Ship Channel in a spoil area, and (3) along the bay margin near Swan Lake, where it is associated with rather large areas of shell deposits. Muddy sandy shell occurs in Trinity Bay (station 296), Galveston Bay (station 248), and in West Bay (stations 29, 42, and 45), where it is associated with oyster reefs and a relatively large area in the vicinity of North Deer Island and South Deer Island. Muddy shell has very limited distribution in Bastrop Bay, where it lies next to dredge channels, and in Christmas Bay (station 131).

Sand with shell has very limited distribution; it is represented by two facies: shelly sand, and shelly muddy sand. Shelly sand occurs in Bolivar Roads (station 29), in Galveston Bay in association with oyster reefs (stations 136 and 139), and in the Swan Lake area (stations 2 and 11).

Mud with a shell admixture forms three subordinate sedimentary facies: shelly mud, sandy shelly mud, and shelly sandy mud. Shelly mud is most commonly associated with oyster reefs (see, for example, Redfish, Hanna, and Carancahua Reefs). Shelly mud also occurs in Bolivar Roads (station 18), in the Swan Lake area (station 1), and locally within West Bay, Bastrop Bay, and Christmas Bay (stations 96, 15, and 132 respectively). Sandy shelly mud occurs in three areas in Galveston Bay (stations 9, 70 and 106), primarily where man has affected the natural environment through dredging activities. Shelly sandy mud was identified at one station (station 141) in Galveston Bay, in an area that also has been affected by dredging.

Large oyster reefs are present in Trinity, Galveston, East, and West Bays. A few small reefs are situated between Christmas and Drum Bays. Reefs generally develop where currents are strong, and in areas where the bay bottom is relatively free of mobile sand or shell debris. Where the width of bays or estuaries narrows, for example, between San Leon and Smith Point, current strength increases; oyster reefs were at one time continuous in this area.

Bay City-Freeport Area

The Bay City-Freeport area includes East Matagorda, Matagorda, Tres Palacios, and Turtle Bays, all of which are components of the Matagorda Bay system. This system is second in size only to the Trinity-Galveston Bay system. Maximum depth of East Matagorda Bay is about 7 feet. Brown Cedar Cut, the only tidal inlet for East Matagorda Bay, has a maximum depth of about 8 feet; it decreases in depth over short distances seaward, and toward the bay. Near the western limit of the map area, Matagorda Bay reaches a maximum depth of 12 feet. Maximum depths of Turtle and Tres Palacios Bays are 5 and 7 feet respectively. Some tidal exchange occurs between the Gulf of Mexico and Matagorda Bay through the lower part of the Colorado River (a man-made channel through Matagorda Peninsula), and through Tiger Island Channel.

Sediment accumulating in the Matagorda Bay system is transported to the area by rivers, from the Gulf of Mexico through tidal inlets and across Matagorda Peninsula during tropical storms, through erosion of Pleistocene and Holocene deposits constituting bay shorelines, and in situ production of molluscan shell material. Streams contributing sediment to the bay system are, from east to west, Boggy Bayou, Live Oak Bayou, Peyton Creek, Big Boggy Creek, Colorado River, Tres Palacios Creek, Turtle Creek, and Reed Creek. Much of the sediment delivered by streams to East Matagorda Bay, however, is intercepted by the Gulf Intracoastal Waterway.

Sediment distribution within the bay system is affected by (1) site of fluvial discharge, (2) height and lithology of Pleistocene and Holocene shoreline features, (3) bathymetry, (4) location of tidal inlets and washover channels, and (5) proliferation of *Crassostrea virginica*.

All the streams discharging into the bay system, except the Colorado River, are small, and originate in the coastal plain. Since their sediment loads are relatively small, they have not filled their estuaries (for example, see heads of Tres Palacios and Turtle Bays). The Colorado River, on the other hand, has filled its estuary, and between 1929 and 1935, after a log jam was removed by the Corps of Engineers, the Colorado constructed a delta across Matagorda Bay (Wadsworth, 1941, 1966). Bottom sediment adjacent to the Colorado delta and the mouths of lesser streams is typically muddy.

Much of both the mainland shoreline and bay shore in the Bay City-Freeport area is eroding (McGowen and Brewton, 1975; McGowen and others, 1976). Mainland shorelines from the vicinity of Lake Austin eastward are composed of Holocene deltaic sands and muds. From Lake Austin westward, they are composed of Pleistocene fluvial-deltaic and marine sands and muds. Most of the bay sediment adjacent to the mainland is mud; sand occurs locally in headland areas. Bay margin deposits associated with Matagorda Peninsula are predominantly sand; this sand, which is transported across the peninsula during storms, is derived chiefly from the Gulf of Mexico.

Mud is the dominant sediment type in the deeper parts of bays and estuaries, which are relatively far from river mouths and other areas of terrigenous clastic sediment input. Deeper parts of bays are typically the lowest physical energy bay segments, and are therefore sumps in which the finest-grained sediment accumulates.

Brown Cedar Cut is the only natural, active tidal inlet in the Bay City-Freeport area. Sand, shell, and rock fragments are transported by currents through this inlet during flood tides and storms. Sediment accumulates as a flood tidal delta within East Matagorda Bay.

Several oyster reefs are located west of the Colorado delta (see Dog Island Reef, Shell Island Reef, Mud Island Reef, and Half Moon Reef). Part of Dog Island Reef was covered by the Colorado delta, and much of the remaining reef was removed by shell dredgers. Reefs are oriented approximately perpendicular to elongation of the bay, and they have grown upward to distances from a few feet to a few inches below the water surface.

Distribution of six sediment types is shown on the Bay City-Freeport map. These sediment types are based on shell/sand/mud ratios from the laboratory study of 322 samples. Four terrigenous clastic types (sand, muddy sand, sandy mud, and mud), one sediment type made of shell material (shell gravel), and one sediment type composed of terrigenous clastics with shell admixture (muddy shelly sand) all characterize the bay and estuary bottoms.

Quartz sand occurs along bay margins, and locally at the head of Tres Palacios Bay. Sand is representative of the highest physical energy environments within the bay. A broad, almost continuous band of sand exists along the bay side of Matagorda Peninsula. This sand was deposited by normal tidal processes and storms at Brown Cedar Cut, and by storm washovers along the remainder of Matagorda Peninsula. A small lobate sand body has accumulated at Tiger Island Cut; this is an active sub-delta the Colorado River is constructing. Similarly, a small sand area has accumulated at the head of Tres Palacios Bay, where Tres Palacios Creek enters the bay. At other points within the bay area, sand occurs both as narrow beaches, and as a veneer over truncated Pleistocene deposits in the shallow bay margin.

Muddy sand occurs along bay margins in juxtaposition with both clean quartz sand and the bay shoreline, and it extends to the southwest from spits and other salient features. Muddy sand accumulates in a less intense physical environment than does quartz sand. There is a band of muddy sand extending across Lake Austin; this band is coincident with Pleistocene sand exposed in the low bluffs forming the lake shoreline.

Sandy mud occurs in all the bays, as well as in Lake Austin. Sandy mud is present at both the north and south ends of the Lake; the north end is influenced by fluvial processes and the south end by tidal processes. Within East Matagorda Bay, sandy mud lies adjacent to the north shore, is found down current from promontories, and occurs as a fringe around part of the Colorado delta. The area of East Matagorda Bay defined by stations 9, 10, 37, 38, and 39 contains representative sediment derived from dredge spoil. Distribution of sandy mud in Matagorda Bay is similar to that in East Matagorda Bay, except for the area partly defined by stations 179, 185, and 190. Here sandy mud extends from Matagorda Peninsula almost across the bay; this pattern is the product of storm processes. The broadest band of sandy mud in the bay system covers much of the bottom of southwestern Tres Palacios Bay; this pattern results from counter-clockwise currents operating in the area.

The dominant sediment type is mud, which is present in all bay segments at all water depths. Mud accumulates at or near mouths of streams, in protected bay-margin areas, and in the deeper parts of bays.

Gravel-sized shell, including disarticulated whole shell as well as shell fragments, is associated primarily with oyster reefs and oyster flats, shallow bay margin areas where oysters occur in scattered clumps. Shell-gravel forms reef flank deposits, it grades away from the reef into bay mud. Individual oyster clumps in the shallow bay margin areas are commonly attached to a firm substrate, usually tough Pleistocene mud. Large waves rip these clumps from the substrate, disarticulate and fragment the shell, and redistribute it as shell pavement and shell beaches.

Muddy shelly sand was identified in only two areas: (1) Lake Austin (station 9), and (2) Tres Palacios Bay (station 9). Water depth in Lake

Austin was about 2.0 feet, and shell was mostly *Rangia sp.* and *Crassostrea virginica*. Water depth in Tres Palacios Bay was about 3.0 feet, and shell was predominantly *Crassostrea virginica*.

Oyster reefs are very small in East Matagorda Bay, although such reefs were at one time well developed in the area (see Dog Island, Shell Island, Mad Island, and Half Moon Reefs). In the early 1950's some of these reefs were dredged (Dog Island Reef, for example), and only isolated patches remain. Sampling in former reef areas failed to produce any shell material.

Port Lavaca Area

The Port Lavaca area is characterized by numerous interconnected bays and estuaries that form a continuous water system bounded on the Gulf side by Matagorda Peninsula, Matagorda Island, and San José Island. For convenience of discussion, these bays and estuaries are divided into three areas. Area one includes Matagorda, Carancahua, Keller, Cox, Lavaca, and Chocolate Bays, and Powderhorn Lake. Area two includes all the water bodies from Pass Cavallo on the northeast, through Mesquite Bay to the southwest. Aransas, St. Charles, and Copano Bays make up the third area.

In the Matagorda Bay system (area 1), maximum water depth of 14 feet is in Matagorda Bay; Matagorda Ship Channel is 36 feet deep, and Pass Cavallo ranges from 9 to 33 feet in depth. Maximum depths of the subsidiary Carancahua, Keller, and Lavaca Bays are 5, 6, and 7 feet, respectively.

The San Antonio Bay system (area 2) is somewhat shallower than the Matagorda Bay system. Maximum water depth of the system is 8 feet in

Espiritu Santo Bay. Maximum depths in the other bays are San Antonio, 6 feet; Ayers, 4 feet; Mesquite, 4 feet; and Carlos, 4 feet. Cedar Bayou, a small, long, narrow tidal pass connecting Mesquite Bay with the Gulf of Mexico, is only 2 to 3 feet deep.

Parts of Aransas and Copano Bays, and all of St. Charles Bay (area 3), constitute the Aransas Bay system. Maximum water depth in Aransas and Copano Bays is 9 feet, and in St. Charles Bay it is 5 feet.

Sediment sources for the bays in the Port Lavaca area are the same as for other areas. These sources include rivers, the Gulf of Mexico, Pleistocene deposits forming uplands adjacent to bays, and shell produced by bay organisms.

Fluvial systems discharge into Carancahua, Keller, Lavaca, Chocolate, San Antonio, St. Charles, and Copano Bays. Streams transporting a sizeable bedload (sand or coarser material), in conjunction with washload (silt and clay), deposit the coarse material almost immediately upon entering the bay. Lavaca River, Garcitas Creek, and Guadalupe River each transports sufficient sand to construct bayhead deltas. The washload from these and other streams travels beyond the river mouths to accumulate in quieter, deeper water.

Sediment from the Gulf of Mexico accumulates as flood tidal deltas at the termini of tidal channels, and as washover aprons along the bay margins of barrier islands. Both bedload and suspension load arrive at the bays through tidal inlets and storm channels. However, only sand and shell derived from the Gulf can be identified visually.

Most of both the clean and the muddy sand forming mainland beaches and bay margin deposits was derived through erosion of Pleistocene fluvial-deltaic and strandplain deposits exposed in bluffs that form the shoreline. Widespread sand distribution in certain bay margin areas indicates that adjacent Pleistocene deposits have a high sand percent.

Oyster reefs have contributed significantly to the fill of some bays. San Antonio, Aransas, and Copano Bays exhibit the greatest development of oyster reefs. Shell dredging has been pursued extensively near the head of Lavaca Bay, within the northwestern part of Matagorda Bay, and throughout San Antonio Bay.

The distribution patterns of eight sediment types, including oyster reefs and flanking shell debris, was determined from field and laboratory descriptions of 786 sediment samples. Bay deposits comprise three dominant sediment groups: (1) terrigenous clastics consisting of sand, muddy sand, sandy mud, and mud; (2) terrigenous clastics with shell consisting of shelly sandy mud and shelly mud; and (3) biogenic sediment represented by muddy shell and oyster reefs.

Matagorda Bay system. Six sediment types (sand, muddy sand, sandy mud, mud, shell, and oyster reefs) are present in the Matagorda Bay system. Sand has wide distribution and occurs in the shallow bay margin adjacent to almost all shoreline segments. It is present in the Lavaca River and occupies a narrow zone west of the Lavaca delta. Sand in Garcitas Cove was derived from Garcitas Creek. The Gulf of Mexico is the primary source for bay margin sand along Matagorda Peninsula and in the Pass Cavallo area. In other areas bay margin sand was eroded from

Pleistocene deposits exposed in the bluffs forming most of the mainland shoreline.

Muddy sand is confined primarily to the shallow bay margin areas, but locally it extends into deeper water. Muddy sand deposits exist as a low sill lying between Lavaca and Matagorda Bays.

Sandy mud lies along bay margins locally, paralleling trends of sand and muddy sand. It occupies a significant area at the head of Lavaca Bay, and serves as a floor for most of Carancahua Bay. A large sandy mud area extends from the Half Moon Reef area (see also Bay City-Freeport map) into the deeper waters of Matagorda Bay. Sandy mud accumulates in quieter water than does either sand or muddy sand, and sandy mud is supplied to the bay system from rivers, shoreline erosion, and the Gulf of Mexico.

Mud, the finest sediment fraction in the bay system, has the greatest areal extent of all sediment types. Mud occurs in all water depths and in all bays; it accumulates in the area of lowest physical energy.

Biogenic sediment constitutes a very small total area of the bay. Gravel-sized shell occurs in inlets between Carancahua and Matagorda Bays, and between Huisache Cove and Cox Bay. Shell of Crassostrea virginica, derived locally from oyster clumps, is plentiful. Reefs are rare in the Matagorda Bay system. Before dredging, reefs were widely distributed in Lavaca Bay; now there are only small, scattered reefs at the head of the Bay.

San Antonio Bay system. Bays comprising this system form an inverted "T," with San Antonio and Hynes Bays as the stem. Nine sediment types are represented in the San Antonio Bay system. These are sand, muddy sand, sandy mud, mud, shelly mud, shelly sandy mud, muddy shell, shell, and oyster reefs.

Clean quartz sand is distributed over a relatively small area of the bay margin. At the east end of Espiritu Santo Bay, sand, derived principally from the Gulf of Mexico, forms part of a large asymmetrical flood tidal delta. Bay margin sand, also derived from the Gulf of Mexico, occupies a narrow band adjacent to the bay shore of Matagorda and San José Islands. At other locations within the system, bay margin sand was derived from the erosion and redistribution of Pleistocene strandplain and fluvial-deltaic sand (McGowen and others, 1976).

Muddy sand occupies the same general areas as does the clean quartz sand, but the muddy sand extends beyond the areas of sand distribution to form a complete band around the bay system, except at the head of Hynes Bay and in Mission Lake. Muddy sand is supplied to the system through Lavaca River, Gulf of Mexico, and shoreline erosion. It normally accumulates in more protected areas or in deeper water than does clean sand.

A much larger area of bay bottom is covered by sandy mud rather than by sand or muddy sand. Like muddy sand, sandy mud forms an almost continuous band around the bay system; it also is locally absent, however, at the head of Hynes Bay and in most of Mission Lake. Panther Reef appears to have served as a barrier to sediment dispersal; a large sandy mud area lies "upcurrent" (northeast) of the reef. Sandy mud forms the floor of most of Ayers and Carlos Bays.

Mud is primarily confined to the deeper parts of bays. However, it does extend to the bay shore in such protected areas as Hynes Bay and Mission Lake.

Shelly sandy mud has very limited distribution, and, indeed, it was identified at only one locality (station 31). It occupies the same position along the bay margin as does clean sand. Shelly mud is coincident with oyster reef distribution. Shell is derived from the reef, and is mixed with terrigenous mud to form a transitional deposit from reef to muddy bay bottom.

Muddy shell is present in Espiritu Santo Bay (between the Ferry Channel and flood tidal delta), and in Ayers, Mesquite, and Carlos Bays, where it forms reef flank deposits. Muddy shell in Espiritu Santo Bay is not related to oyster reef; its occurrence may be related to storm activity.

Gravel-sized shell debris was identified at one locality (station 105) adjacent to Panther Reef. Shell, derived from the reef, accumulates as a reef-flank deposit.

Oyster reefs are perhaps better developed in the San Antonio Bay system than in any other bay area of the Texas Gulf Coast. However, their areal distribution is steadily decreasing because of dredging activities.

Aransas Bay system. Only a small part of the Aransas Bay system is present on the Port Lavaca map area. Fine-grained terrigenous clastics are the dominant sediment type.

Clean quartz sand has very limited distribution along bay margins. Within Copano Bay, bay margin sand is derived from erosion of shoreline materials. At stations 10 and 22 (north shore of the bay), sand is eroded from Pleistocene deltaic deposits, and at station 16 (just west of the causeway), sand is being eroded from Pleistocene strandplain deposits.

Sand also occurs adjacent to the bay shore of San José Island.

Muddy sand forms a band adjacent to and parallel with the shoreline of Copano Bay. Within Aransas Bay, muddy sand lies more than a mile offshore from the mouth of St. Charles Bay, in water 6 to 8 feet deep. This appears to be an anomalous occurrence, perhaps related to dredging activities.

Sandy mud occupies a relatively large part of the bay bottom in the northern part of the system. Bottom sediment in St. Charles Bay is almost entirely sandy mud. The possible source of this sediment type is the Blackjack-Lamar Peninsula area, which is underlain by Pleistocene strandplain sand.

Mud is found in the deeper bay segments and in protected areas, such as parts of bays enclosed by oyster reefs.

Terrigenous clastic sediment with biogenic components is represented by shelly mud, which forms reef flank deposits, and by shelly sand. Two areas in Aransas Bay are characterized by a limited extent of shelly sand -- the area adjacent to Long Reef (station 70), and the area near the west shore of the bay (station 76). These are high physical energy areas in 2 to 3 feet of water.

Gravel-sized shell debris (stations 71, 77, 78, and 91 in Aransas Bay, and station 4 in St. Charles Bay) either is associated with oyster reefs, or was derived from redistribution of individual oyster clumps. Muddy shell forms reef flank deposits, in association with the oyster reefs separating Carlos from Aransas Bay.

Oyster reefs form long, relatively continuous, rigid structures in Aransas and Copano Bays. The larger reefs are barely awash, and at times their upper surfaces are exposed.

Corpus Christi Area

Bays and estuaries of the Corpus Christi map area are interconnected, and they form a continuous, although variable, water body. San José, Mustang, and Padre Islands separate bays and estuaries from the Gulf of Mexico. These water bodies are divided into three so-called bay systems to facilitate the following discussion. Aransas Bay system includes all water bodies north of Aransas Channel (part of Redfish Bay, Aransas Bay, Copano Bay, and Mission Bay). The Corpus Christi Bay system is composed of Redfish Bay south of Aransas Channel, Corpus Christi Bay, and Nueces Bay. Packery Channel and the John F. Kennedy Causeway form the boundary between the Laguna Madre and the Corpus Christi Bay systems.

In the Aransas Bay system maximum water depths of component bays are (1) Mission Bay, 2 feet; (2) Copano Bay, 8 feet, (3) Aransas Bay, 12 feet; and (4) the northern part of Redfish Bay, 5 feet, with tidal channels attaining depths to 9 feet. Lydia Ann Channel has a maximum depth of 23 feet near its confluence with Aransas Pass.

The Corpus Christi Bay system is made up, for the most part, of Corpus Christi Bay, with a maximum depth of 13 feet. Water with a depth of 12-13 feet makes up a large part of the bay, and a situation reflected in the large area underlain by fine-grained sediment. Maximum depth of Redfish Bay south of Aransas Channel is about 2 feet. Nueces Bay is shallow (depths of 2 to 3 feet are common), with maximum depth being about 4 feet.

The northern part of Laguna Madre has been altered considerably through dredging operations and spoil disposal. Here depth is commonly less than 1 foot. South of the dredged area, however, maximum depth is about 4 feet.

Sediment sources for the bays in the Corpus Christi system are the same as for the bays and estuaries to the northeast -- rivers, Gulf of Mexico, Pleistocene deposits forming the mainland shoreline, and biogenic products. Rivers in this map area play a less important role in bay sedimentation than in some other systems because a climatic gradient causes a decrease in rainfall from east to south across the state (Carr, 1967).

Fluvial systems issue into Mission, Copano, Corpus Christi, and Oso Bays. All streams, except the Nueces River, are small and originate within the coastal plain. Because of their small size, these streams normally contribute relatively little sediment to the bay-estuary system; their discharges, however, are excessively high during the passage of tropical storms. Nueces River is building a delta into the bay; a large part of the suspension load material moving beyond the river mouth is trapped in Nueces Bay (Compare maximum depth of 4 feet in Nueces Bay with maximum depth of 13 feet in Corpus Christi Bay.).

Sediment from the Gulf of Mexico is transported into the bays through tidal inlets and storm channels, and across low-lying barrier segments, such as North Pass near the southern tip of San José Island (see Price, 1956; Nordquist, 1972). In the recent past, sediment moved through Aransas Pass and Corpus Christi Pass (shown as Packery Channel on recent charts and on this map) to form extensive flood-tidal deltas. Aransas Pass has been jettied since the late 1800's. This reduces the volume of sand moving, via the tidal inlet, along the shore and then into the bay. Corpus Christi Pass became inactive in the early 1900's because of a change in bay circulation caused by channel dredging in Corpus Christi Bay (Price, 1952). Storm surge floods overwash both the southern parts of San José (North Pass area) and of Mustang Island. Large volumes of sand have been contributed to bay margins by hurricane washovers.

Sand accumulated in bay margin areas adjacent to the mainland shoreline has its source in Pleistocene fluvial-deltaic and strandplain deposits (Brown and others, 1976). Widespread distribution of sand in some bay margin areas reflects the local occurrence of Pleistocene deposits with high sand content; such shoreline segments face either the prevailing south or north winds.

With the exception of Copano Bay, the bays within the Corpus Christi map area have not been prolific producers of biogenic materials, specifically oyster reefs.

Sediment distribution patterns were determined from field descriptions of 485 grab samples. Bay deposits are composed of three dominant sediment groups: (1) terrigenous clastics consisting of sand, muddy sand, sandy mud, and mud; (2) terrigenous clastics with an admixture of shell (shelly sand, shelly muddy sand, muddy shelly sand, shelly mud, shelly sandy mud, sandy shelly mud); and (3) biogenic sediment represented by shell gravel, sandy shell, muddy sand shell, muddy shell, and oyster reefs.

Aransas Bay system. Twelve sediment types have been mapped in the Aransas Bay system. Sediment exhibits a normal pattern of distribution for most of the area (sand at the margin to mud in bay centers). The exception is Redfish Bay, which displays a patch-work distribution pattern resulting from dredging and spoil disposal.

Clean quartz sand occupying bay margins in Copano and Aransas Bays in the Rockport-Fulton area was derived from erosion of Pleistocene deltaic and strandplain deposits (Brown and others, 1976). Reworked spoil is indicated as the source of sand adjacent to dredge channels in southwestern Aransas Bay (stations 14, 15, and 27). Bay margin sand adjacent to San José Island (Allyns Bight area) was reworked from the island by saves and currents, and sand in the North Pass area was deposited by storm surge flooding (Nordquist, 1972).

Sandy mud is largely confined to Mission and Copano Bays. Here, the sand is derived principally from erosion of Pleistocene deposits forming the shoreline. Very limited distribution of this type can be seen in Aransas Bay, next to San José Island (stations 21 and 48). Muddy sand at station 21 represents an area of spoil disposal. One area of muddy sand was mapped in Redfish Bay (station 19); this is related to the large flood-tidal delta, "Harbor Island" (see Hoover, 1968; Manson, 1975).

The area in which sandy mud is found is much smaller in the Aransas Bay system than in the map areas to the northeast. Sandy mud does not form a continuous band along the bay margin, but it does occur in discrete patches of various sizes. The floor of Mission Bay consists primarily of sandy mud transported to the area by Mission River. Most of the other areas of sandy mud probably represent the mixing of sand, derived from the Pleistocene exposed along the shoreline, with mud transported to the bays through fluvial systems. Sandy mud also records mixing of sediment types through dredging activities (Aransas Bay, stations 9, 25, 28, and 29).

Mud covers large, continuous parts of bay centers, and also accumulates in small, shallow, protected areas. Small areas of mud deposition include Mission Lake, at the mouth of Aransas River, and at the northern part of Redfish Bay.

Most of the sediment typified by mixing shell with terrigenous clastics occurs in the Redfish Bay area where dredging has been conducted. Three such sediment types are shelly sand (adjacent to the dredged part of Lydia Ann Channel, and at stations 26 and 39 in Aransas Bay), muddy shelly sand (confined to Redfish Bay--stations 25 and 28), and shelly mud (relatively wide, although patchy distribution). Shelly mud is found in Copano Bay (stations 3, 13, 16, 24, 38, 41, 42, and 50); most of these areas are representative of the natural association of terrigenous clastic sediment with shell-producing organisms.

Shell material occurs in deposits of gravel-sized shell fragments that are virtually free of terrigenous clastics, and as shell debris mixed with sand and mud. Gravel-sized shell occurs both in Copano Bay (stations 29 and 30), and in Aransas Bay (station 52) adjacent to Frandalig Island, where there has been considerable dredging. Sandy shell is found near Hog Island (station 24), in about 4 feet of water adjacent to a tidal channel in Redfish Bay. Muddy sandy shell forms a band that lies to the west of Taylor and Talley Islands (stations 29 and 30), and adjacent to a spoil disposal area (station 21) associated with the Gulf Intracoastal Waterway. Muddy shell is found in Copano Bay, where it primarily forms reef flank deposits; in Aransas Bay (station 20), in association with dredge spoil; and in Redfish Bay (stations 20, 21, 22, and 23), in association with marine grasses.

Oyster reefs are restricted to Copano Bay, where they are oriented perpendicular to its long dimension.

Corpus Christi Bay system. The distribution of 14 sediment types was mapped from field descriptions of sediment grab samples. Most of Corpus Christi Bay exhibits a normal sediment dispersal trend. Redfish and Nueces Bays have been affected by channelization and extensive shell dredging; distribution of bottom sediment in these bays reflects man's activities.

Bay margin sand adjacent to the mainland shoreline was reworked from Pleistocene deltaic and strandplain deposits. Some spoil islands are flanked by sand reworked from dredge spoil (stations 40 and 44). Longshore currents and waves have reworked some of the sands associated with Mustang Island (stations 4, 22, and 24). The relatively broad sand area defined by the Gulf Intracoastal Waterway, Fish Pass, and Packery Channel was transported from the Gulf of Mexico (1) through Packery Channel (formerly Corpus Christi Pass), when it was an active tidal inlet; and (2) across the southern part of Mustang Island through washover channels (for example, Newport and Corpus Christi Passes) during tropical storms.

Muddy sand is present at the head of Nueces Bay and along its north and east shores; muddy sand at the bay head was transported there through the Nueces River. Muddy sand, eroded from the Pleistocene, also occupies the bay margin along the west and north mainland shores of Corpus Christi Bay. Muddy sand along the margin of Mustang Island and within tidal inlet-tidal delta areas is related, in part, both to the daily tidal regime and to seasonal storm processes.

Sandy mud covers a large part of the Nueces Bay bottom. In other areas sandy mud is found in rather small isolated patches (Oso Bay, station 5; Corpus Christi Bay, stations 6, 7, 9, 25, 59, and 155). In general, sandy mud accumulates in deeper or quieter water than does sand and muddy sand; this does not apply to Nueces Bay, however, which has been dredged extensively for oyster shell.

The centers of Nueces and Corpus Christi Bays are characterized by mud. Small areas of mud accumulation are found in northeastern Nueces Bay (station 5), southwestern Corpus Christi Bay, eastern Oso Bay, and eastern Redfish Bay (station 18). Mud accumulates in the deeper-water areas, and in the areas of lowest physical energy.

The Corpus Christi Bay system contains six sediment types resulting from the mixing of shell with terrigenous clastic deposits. These types are shelly sand, shelly muddy sand, muddy shelly sand, shelly mud, shelly sandy mud, and sandy shelly mud. Most of these sediment types result from the mechanical mixing of shell and terrigenous clastics, a process caused directly or indirectly by man's activities. Shelly sand occurs only in Redfish Bay; it covers most of Redfish Cove and parallels the Intracoastal Waterway. Muddy shelly sand is situated adjacent to dredge channels at the head of Nueces Bay (station 31), and along La Quinta Channel in Corpus Christi Bay (stations 154 and 156). One can demonstrate that shelly mud is associated with dredging in at least three areas (Redfish Bay, stations 4 and 12; Corpus Christi Bay, station 65); in other areas, however, this sediment type apparently is associated with high biologic activity. Sandy shelly mud occurs in the east-central part of Nueces Bay (probably a product of shell dredging), in Corpus Christi Bay next to Shamrock Island, and in several areas of Redfish Bay. In Corpus Christi and Redfish Bays this sediment type probably is related to high shell productivity combined with relatively strong tidal currents.

Sediment composed predominantly of shell fragments (sandy shell, muddy sandy shell, and muddy shell) has rather limited distribution. Sandy shell is present in the shallow waters of Redfish Bay (stations 13 and 14), and in Nueces Bay (stations 1 and 17). Muddy sandy shell is found only in Redfish Bay (station 11), inside the area of numerous spoil islands. Muddy shell, in most instances, appears to be a product of natural physical and biological processes. Muddy shell usually is associated with oyster reefs (Nueces Bay, station 22; Corpus Christi Bay, stations 142 and 151); these are reef flank deposits. In the vicinity of Ransom Island (Redfish Bay, station 10), muddy shell is juxtaposed to shell islands.

Oyster reefs cover a small part of the bay bottom in the Corpus Christi system. During the sampling of Nueces only one reef was encountered (see station 22); most of the reefs in this bay have been removed by shell dredging operations. Known reefs in Corpus Christi Bay are situated in the western part of the bay (Alta Vista Reef), in the northwestern part of the bay at Indian Point (Indian Reef), and near the north shore (Donnel and Long Reefs).

Laguna Madre system. Laguna Madre differs from the bays and estuaries to its north and east by having very limited water exchange with the Gulf of Mexico, by having no perennial streams discharging into it, by being extremely shallow, and by lying in an arid climatic belt. All these factors acting in concert have produced a long, north-south trending water body higher than normal salinity; the system is relatively unaffected by daily fluctuations of astronomical tide. The water level in Laguna Madre fluctuates with wind direction, intensity, and duration. Because of its hydrologic regime and the rate and kind of sediment delivered to Laguna Madre, it contains considerably less mud than bays and estuaries to the north and east.

Ten sediment types have been recognized in the northern part of Laguna Madre. These are sand, muddy sand, sandy mud, mud, shelly sand, shelly muddy sand, shelly sandy mud, sandy shelly mud, shell gravel, and sandy shell.

Sand forms a narrow band next to mainland and barrier island shorelines; near the southern map limit sand is displaced toward the center of the lagoon. Muddy sand generally occurs next to sand and approximately parallels the lagoon shorelines. In some spoil areas muddy sand, reworked from that spoil, is the dominant sediment type. Sandy mud, in the absence of reworked spoil, covers most of the central lagoon. Mud is a rare sediment type in Laguna Madre; it accumulates in protected areas formed by dredge channels and spoil mounds (stations 7, 11, 26, and 33). It appears that most of the other sediment types are associated with man's activities within the lagoon. Exceptions are shelly sand (stations 51 and 52), and sandy shell (station 59). Shell gravel (station 14), shelly mud (stations 41, 46, and 56), sandy shelly mud (stations 45 and 57), shelly sand (station 49), and shelly sandy mud (station 50) all appear to be associated with dredging or drilling activities.

Kingsville Area

Bays and lagoons in the Kingsville map area lie in an arid to semi-arid climatic zone, and they receive a limited amount of freshwater from streams draining the adjacent uplands. During hurricanes large volumes of freshwater are contributed to the system; during this time freshwater virtually replaces saline water in the bays and lagoons (Behrens, 1969). Because there is more evaporation than precipitation, the salinity of water bodies is generally greater than that of seawater (Brown and others, in press). Under normal sea conditions there is no direct communication between bays and lagoons in the map area, and the Gulf of Mexico.

To the north of the area water flows into Laguna Madre from Corpus Christi Bay, which is connected to the Gulf of Mexico both through Aransas Pass and through a man-made water-exchange pass (Watson and Behrens, 1976). There is water exchange between Laguna Madre and the Gulf of Mexico to the south (see Brownsville map area). Laguna Madre, south of Baffin Bay, has been compartmentalized into two large salient features known as

Middle Ground (see Zupan, 1970; Brown and others, in press), and Land-Cut Area (see Fisk, 1959; Brown and others, in press). This division was caused by large washover and heavy wind deposits.

These factors -- low rainfall, excessive evaporation, limited water exchange with the Gulf of Mexico, and compartmentalization of bays and lagoons -- have exerted a tremendous influence both upon the types of sediment delivered to and produced within these water bodies, and upon the distribution of these sediments.

Bays and lagoons of the Kingsville map area have been arbitrarily divided into two systems: (1) the Baffin Bay system, which is stretched out approximately perpendicular to the Gulf shoreline; and (2) the Laguna Madre system, a long, shallow water body bounded on the east by Padre Island. The Baffin Bay system consists of four bay segments: (1) Baffin Bay, maximum depth of 9 feet; (2) Alazan Bay, maximum depth of 6 feet; (3) Cayo del Grullo, maximum depth of 7 feet; and (4) Laguna Salada, maximum depth of 7 feet. In the map area, Laguna Madre falls into three natural divisions: (1) north of Middle Ground, where depths reach 8 feet; (2) The Hole, which is perhaps 2 feet deep; and (3) south of the Land-Cut Area, where depth is up to 4 feet. Since sampling has not been completed in Laguna Madre, the discussion below is limited to sediment distribution in the Baffin Bay system.

Sediment is delivered to the Baffin Bay system by Tunas, San Fernando, and Olmos Creeks, all of which are small, ephemeral streams (Brown and others, in press). Sediment also is contributed to the system through erosion of Pleistocene strandplain, deltaic-marine material, and loess deposits that form the shoreline. Wind is also a factor in bay sedimentation; sand and silt are delivered to the bay from the southeast under prevailing wind conditions, and from the north during northers. Considerable carbonate sediment, ranging from serpulid reefs (Andrews, 1964; Dalrymple, 1964) through oolites (Dalrymple, 1964; Behrens, 1964; Frishman, 1969), also is generated within the bay system. Baffin Bay is unique among the Texas bays in that it is the only bay in which carbonates form a significant volume of sediment.

Baffin Bay system. Distribution of 15 sediment types was mapped from field descriptions of 159 samples. Baffin Bay, in addition to three sediment end members common to other bays (terrigenous clastics, terrigenous clastics with shell admixture, and biogenic sediment), also has carbonate deposits (for example, coated grains and oolites).

Terrigenous clastics are sand, muddy sand, sandy mud, and mud. Sand is distributed in a very narrow band next to the shoreline. It is derived primarily from erosion of shoreline materials; some is transported to the bay margin by wind. Muddy sand also occurs along the bay margin. It forms discontinuous bands broader than clean quartz sand; some muddy sand occurs at the heads of bays (for example, Laguna de los Olmos). Sandy mud is patchily distributed (mouth of Baffin Bay, southeast shore of Alazan Bay, and Cayo del Grullo). It occurs in somewhat deeper water, and in areas less affected by waves and currents, than does either sand or muddy sand. Mud occupies the central, deeper parts of all bays, and it would form a continuous blanket throughout the system if sediment sills were not present at the mouths of Alazan Bay and Cayo del Grullo.

Shell-bearing terrigenous clastics are confined primarily to bay margin areas. These clastics consist of shelly sand, shelly muddy sand, muddy shelly sand, sandy shelly mud, and shelly mud. Shelly sand occupies the same position relative to shoreline as clean quartz sand, and in some areas grades laterally (along shore) into clean quartz sand. Along the north shore of Baffin Bay shelly sand grades westward into oolites, and eastward into coated grains. Shelly muddy sand occurs in four areas of the Baffin Bay system: (1) near Point of Rocks; (2) between serpulid reefs in Penascal Rincon area; (3) at the head of Alazan Bay; and (4) at the head of Cayo del Grullo. Muddy shelly sand occurs in Cayo del Grullo (station 70), and in Alazan Bay (stations 8 and 9); these two areas are in the wind shadow of prevailing southeast winds. Sandy shelly mud occupies low physical energy areas comparable to that occupied by muddy shelly sand. Sandy shelly mud occurs in Cayo del Grullo (stations 68 and 72), and in Alazan Bay (station 6). Shelly mud is confined to the western part of the system in the following areas: (1) along the axis of Cayo del Grullo (stations 71 and 75); (2) at the mouth of Cayo del Grullo (station 58.5); (3) in Laguna Salada (station 61); and (4) near Kleberg Point (station 51). These sites are representative of deeper, quieter water-bay segments, or else they lie in shallow water near shore, in a wind-shadow area.

Biogenic sediment, either pure or with varying amounts of terrigenous materials intermixed, is represented by gravel-sized shell, sandy shell, sandy muddy shell, and serpulid reefs. Only two areas of clean gravel-sized shell debris were identified in the Baffin Bay system -- at Riviera

Beach (station 82), and opposite Kleberg Point at station 54. Sand and shell ridges are prominent shoreline features in the vicinity of station 54, suggesting either tropical storms or northers as the agents of shell gravel deposition. Sandy shell has very limited distribution, and was identified in only one area (station 5 near Point of Rocks). Here, sandy shell is associated with five sediment facies (mud, sandy mud, shelly sand, serpulid reefs, and sandy muddy shell). Sandy muddy shell occurs in at least three areas: (1) near the mouth of Baffin Bay, in a broad, grass-flat area generally less than 3 feet deep; (2) near the southeast shore of Alazan Bay, in association with marine grasses in 1 to 2 feet of water (station 20); and (3) near the head of Cayo del Grullo in association with Halodule wrightii in about 1.5 feet of water (station 74). Serpulid reefs are abundantly distributed in Baffin Bay, but they are rare in the other bays. These reefs occur primarily in bay margin areas, and they reach from about 2 to 8 feet above the bay bottom. Reefs are rock-like structures formed by calcareous tubes of serpulid worms. These reefs, which are no longer active, probably thrived when the salinity of Baffin Bay was considerably less than it is at present (Dalrymple, 1964; Andrews, 1964).

Coated grains and oolites comprise the two carbonate sediment facies. These facies have developed in bay margin areas along the north shore of Baffin Bay (station 19, 20, and 26), across the mouth of Alazan Bay (stations 21, 25, and 42), and in the Kleberg Point area (Frishman, 1969). Coated grains occur in shallow water, having accumulated in alternating bars and troughs aligned parallel to the shoreline. These coated grains are associated with sparse to dense growth of marine grasses and green algae. Oolites form a bar across the mouth of Alazan Bay. Oolites have been reported in the Kleberg Point area by Dalrymple (1964), Behrens (1964), and Frishman (1969); Bureau samples from that area did not contain oolites. Oolites form beaches in the Starvation Point and Kleberg Point areas. Oolites at the mouth of Alazan Bay, and elsewhere, are in a high physical energy environment where grains are in more or less constant motion; marine grasses and green algae are rare in these areas.

Brownsville-Harlingen Area

Laguna Madre, in the Brownsville-Harlingen area, is characterized by broad wind-tidal flats stretching from the north map boundary southward to the vicinity of La Punta Larga. These flats are alternately either part of the bay bottom or emergent, depending upon wind direction, velocity, and duration. In general, water depths of Laguna Madre are shallowest where wind-tidal flats are broadest. North of the Port Mansfield Ship Channel, the part of Laguna Madre adjacent to the Gulf Intracoastal Waterway is about 3 feet deep; elsewhere water depth is less than 1 foot. Water depth increases to the south, and in the vicinity of Port Isabel maximum depth is about 5 feet; average depth is 3 feet. South Bay, which lies to the west of Brazos Island and is connected to Laguna Madre, is 1 to 2 feet deep.

The Brownsville-Harlingen area also is characterized by an arid climate, where evaporation exceeds precipitation (Carr, 1967; Brown and others, in press). Prevailing winds are from the southeast, and they transport sand from the beach and dune areas of south Padre Island to the northwest. There it either accumulates on the wind-tidal flat, or moves into Laguna Madre. In recent years the fluvial systems in the Brownsville-Harlingen area have been altered through construction of dams, irrigation canals, and channel diversion. There are two fluvial systems in the Brownsville-Harlingen area: (1) Arroyo Colorado, which now discharges into Laguna Madre near Horse Island; and (2) Rio Grande, which discharges into the Gulf of Mexico. At present neither stream, under normal rainfall conditions, contributes much sediment to Laguna Madre. Water and sediment, however, both are contributed to Laguna Madre from the Gulf of Mexico during tropical storms. Heavy rainfall accompanying some hurricanes floods much of the adjacent mainland; runoff from the mainland transports sediment to Laguna Madre.

The distribution of 12 sediment types was mapped in the area, utilizing field descriptions of 583 grab samples. These 12 sediment types are composed of three groups: (1) terrigenous sediment consisting of sand, muddy sand, sandy mud, and mud; (2) terrigenous sediment with a mixture of shell; and (3) shell (biogenic sediment) with varying amounts of terrigenous clastics. Laguna Madre contains neither serpulid nor oyster reefs.

The sediment map of the Brownsville-Harlingen area differs somewhat from maps of other bay areas. Within the central area of the lagoon, the sampling system was changed from 1-mile centers to 1/2-mile centers. The result of this change is a patch-work distribution pattern.

Sampling has not yet been completed in the Brownsville-Harlingen area; areas still to be sampled are south of the Port Mansfield Ship

Channel, and north of the Channel in the shallow water adjacent to the wind-tidal flats.

Terrigenous clastics are the dominant sediment types, and they are distributed throughout the system. Clean quartz sand is present in part of the Port Mansfield Ship Channel, in the Brazos Santiago Pass, in some spoil disposal areas, along parts of the mainland shoreline, and along the bay margin of Padre Island, particularly in wind-tidal flat areas. Sand along the margin of South Padre Island was deposited primarily by washovers during the passage of tropical storms, and by prevailing southeast winds carrying the sand northwest across the island. Muddy sand occurs adjacent to spoil mounds, sporadically in the shallow bay margin area next to the mainland shoreline, lagoonward of the broad sand belt adjacent to the wind-tidal flat, and in a narrow band at the edge of the wind-tidal flat. Sandy mud is confined to Laguna Madre south of the Port Mansfield Ship Channel, where it is found in all water depths. Mud covers the least area of any of the terrigenous clastic sediment types. It occurs, for the most part, in the shallow protected areas adjacent to the mainland shoreline, in the vicinity of spoil mounds, and to the lee of natural features, such as Green Island. The floor of South Bay is primarily mud.

Terrigenous clastics with shell admixture have an apparent random distribution within Laguna Madre. Some of these sediment types are clearly related to dredging activities. Others probably record storm events. Shelly sand occurs adjacent to ship channels (stations 203 and 351), close to clean bay margin sand (stations 224, 230, 306, 314, 315, and 330), and toward the lagoon center (stations 192 and 198). Shelly muddy sand is found adjacent to the Gulf Intracoastal Waterway (stations 309 and 317), a spoil area north of Port Isabel (station 387), and lagoonward of sand and muddy sand derived from the Gulf of Mexico (stations 46, 117, 194, 258, 266, 274, 276, 286, and 292). Muddy shelly sand covers most of the deeper part of Laguna Madre north of the Port Mansfield Ship Channel. North of the Ship Channel muddy shelly sand occurs adjacent to muddy sand, and in areas that have been dredged (stations 260 and 377A). Shelly sandy mud is found in small isolated patches toward the lagoon center (stations 17, 29, 31, 55, 70, 89, 103, 148, 229, 267, and 304); it also is found in dredged areas (station 308), in shallow bay margin areas (stations 10 and 38), and in the deeper part of the lagoon near Bayside (stations 360, 361, 379, and 375). Sandy shelly mud occurs at all water depths, along bay margins as well as in bay centers, and in association with spoil areas; it appears to result both from natural processes and from man's activities. Shelly mud was reported in only one area (station 127), and is close to muddy shell, sandy shelly mud, and sandy mud.

Pure shell deposits were not encountered during the collection of sediment samples. Muddy sandy shell and muddy shell are the biogenic sediment types identified for Laguna Madre. Muddy sandy shell was reported for a single area (station 176), where it is associated with a salient feature more shallow than the adjacent lagoon bottom. Muddy shell is also a rare sediment type in Laguna Madre. This sediment type is restricted to the shallow lagoon area south of the Cameron-Willacy county line, and west of La Punta Larga (stations 28, 115, and 118).

Total Organic Carbon

Total organic carbon percentage has been determined for about 1,480 bay sediment samples. Organic carbon content was determined at the Bureau's Mineral Studies Laboratory. The percent of organic carbon for each whole sediment sample was determined by the wet combustion method (Gross, 1971). At this time, however, analyses have not been completed for all bays, although some data are available for all areas except Beaumont-Port Arthur. Data are presented in map form at a scale of 1:125,000.

As a general rule, there is a close association between high total organic values, sediment texture, and water depth. Highest carbon percentages normally occur in muds accumulated in the deeper or quieter parts of bays.

Organic carbon has an affinity for some heavy metals. These metals either may be adsorbed to carbonaceous materials, or they may combine to form organo-metallic complexes. Although at this time we do not have data on distribution of heavy metals in bay surface sediment samples, it is reasonable to expect high concentrations of some metals in sediment characterized by high organic carbon percentages.

Houston-Galveston Area

Organic carbon percentages in bay sediment of the Houston-Galveston area range from less than 0.4 to greater than 2.4 percent. This distribution pattern is such that low values are confined, for the most part, to the shallow-water bay margins, and they correspond closely to sediment with a high terrigenous sand content. Successively high percentages of organic carbon have a concentric arrangement, with highest values occupying the smallest areas. Highest values occur in muds. Values in excess of 4.0 percent occur off the Trinity delta (station 432), where the organic carbon probably was derived from the Trinity River, and in low physical energy environments, such as Galveston Channel, Offats Bayou, and Clear Lake.

Bay City-Freeport Area

Most of the organic carbon values for bay sediment in the Bay City-Freeport area range from less than 0.4 to less than 1.2 percent. Values greater than 2.4 percent are rare, occurring only in Coney Creek, an abandoned course of the Colorado River. The highest organic carbon percentage, less than 2.0 percent, occurs in Matagorda Bay (station 26) in the vicinity of Shell Island Reef; sediment here is mud. Distribution of organic carbon follows, in general, sediment textural trends.

Port Lavaca Area

All sediment samples from the bays of the Port Lavaca area have not yet been analyzed for total organic carbon. Data have been generated for Lavaca, Keller, Carancahua, and Matagorda Bays, for Powderhorn Lake and the extreme northeastern part of Espiritu Santo Bay in the eastern part of the map area, and for Copano Bay in the western part of the area. These latter two areas correspond with the Matagorda and Aransas Bay systems discussed in the above section on sediment distribution.

Matagorda Bay system. Organic carbon percentages in sediment of the Matagorda Bay system range from less than 0.4 to less than 1.6 percent. Low values of less than 0.4 percent occur in sand or sand-bearing sediment in most of the bay margin areas. A large area of low organic carbon content exists in the sands on the bay side of Matagorda Peninsula, and in the tidal inlet-tidal delta associated with Pass Cavallo. The distribution pattern is one of low organic carbon percentage along bay margins, with percentage increasing toward the deeper bay centers, and in fine-grained sediment.

Aransas Bay system. Sediment samples from Copano Bay have been analyzed for total organic carbon; samples from other bays within this system have not been processed. Total organic carbon percentages for Copano Bay range from less than 0.4 to less than 2.0 percent. Distribution of organic carbon follows the expected pattern; low percentages are associated with sand-bearing deposits, and high percentages occur in the deeper, quieter water where mud has accumulated.

Corpus Christi Area

The Corpus Christi area includes Aransas Bay, Corpus Christi Bay, and the Laguna Madre systems; definition of these areas is presented above in the discussion of surface sediment distribution. Analyses of sediment samples for organic carbon is incomplete for these three bay systems. In the Aransas Bay system, only the samples from Copano Bay have been analyzed. Analyses have been completed for samples from Corpus Christi Bay, but other parts of the system (Nueces and Redfish Bays) are incomplete. Organic carbon content has been determined for Laguna Madre sediment samples collected in the area from Pita Island northward.

Aransas Bay system. Organic carbon percentages range from less than 0.4 to less than 2.4 percent for the sediment in Copano Bay. Distribution of organic carbon exhibits the normal pattern of low values near-shore in the more sandy sediment, and high values off-shore in deeper water in association with fine-grained deposits. The trend of the less than 1.6 percent pattern suggests that the Mission River is the source for a large part of the organic material. The highest value, of less than 2.4 percent (station 43), is from a mud sample.

Corpus Christi Bay system. Corpus Christi Bay displays a concentric distribution of organic carbon values. This distribution pattern is typical of most of the bays mentioned above; the low values are associated with bay margin sand or with sand-bearing sediment, whereas the highest values (less than 2.0 to less than 2.4 percent) are found in muds accumulated in deeper parts of the bay. The highest total organic carbon values do not occur in the center of the bay, but rather are displaced toward the south shoreline. The south shoreline is somewhat in the lee of the prevailing southeast winds.

Laguna Madre system. Total organic carbon values in the northern part of Laguna Madre are higher than in the other bays of the Corpus Christi map area. Carbon values range from less than 0.8 to less than 2.4 percent. The normal distribution pattern of low values along bay margins and high values toward bay centers does not apply to Laguna Madre. Lowest values occur primarily along the Gulf Intracoastal Waterway and in washover areas. In general, organic carbon percentages increase from east to west along the lagoon. Since the dominant sediment types in this part of Laguna Madre are sandy mud and muddy sand, the normal association of high total organic carbon percentages with mud (the finest-grained terrigenous clastic sediment type) does not hold true in north Laguna Madre. The reasons for this high organic content in the north Laguna Madre sediment are that this is an area of high production of marine grasses, and that the prevailing southeast winds generating currents within the lagoon that transport much of the dead grass, deposit it downcurrent in the more protected areas.

Kingsville Area

Data on total organic carbon percentages have been generated only for the Baffin Bay suite of sediment samples. Analysis of the Alazan Bay samples is in progress. Total organic carbon content for Baffin Bay ranges from less than 0.4 to more than 2.4 percent. There is a good correlation among sediment distribution, water depth, and percentage of total organic carbon. Carbon values are lowest in the coarsest sediment (shell gravel, clean quartz sand, muddy sand, coated grains, and oolites), and in the more shallow water areas; and they are highest in the deeper water, where dark gray to black mud has accumulated.

Brownsville-Harlingen Area

All of the sediment samples from south Laguna Madre have not been tested for total organic carbon content. However, most of the samples south of the Port Mansfield Ship Channel have been analyzed; in this area values of organic carbon range from less than 0.4 to greater than 2.4

percent. Distribution of total organic carbon in south Laguna Madre does not appear to follow the expected normal trend. There is a general, but unsystematic, increase in carbon percentages from the vicinity of the Cameron-Willacy County line southward to the Port Isabel area. Carbon percentage is generally low where sand and sand-bearing sediment are dominant, although there are exceptions to this pattern. Station 308, for example, is a clean quartz sand in an area of sparse marine grass. There are a series of isolated highs beginning at station 184, near the juncture of the Gulf Intracoastal Waterway and the Arroyo Colorado Cutoff, and extending southeastward across the lagoon, where the highest carbon percentage is found at stations 21 and 22. Sediment types in these areas are both sand and mud, and both types are associated primarily with a moderate to dense cover of marine grasses. In the southern part of the area the highest carbon values occur adjacent to the mainland and barrier shorelines. South Bay, characterized by a mud bottom with abundant oyster clumps, has an organic carbon content ranging from less than 0.8 to less than 1.6 percent; values increase toward the bay center.

Biology

Introduction

A total of 3,197 benthic biological samples were collected from bays, estuaries, and lagoons on the Texas coast. Surface sediment samples were taken at 1-mile intervals with a clam-shell grab sampler with a capacity of 0.25 cubic foot. In the bays and estuaries, biologic samples were collected on a 1-mile grid. On the inner shelf, biologic samples varied according to complexity of faunas, generally on a 2- to 4-mile grid. Samples in Laguna Madre commonly were collected with a post-hole digger. Sediments were washed through a 1 mm screen, narcotized in a solution of magnesium sulfate, and stored in a neutral solution of 10 percent formlin. Rose bengal was placed in the formlin to help distinguish live from dead specimens. Laboratory processing included further washing of the sample and then storing it in 70 percent ethanol.

Molluscs in 274 selected samples were identified to species level, when possible. Live and dead whole shells were counted. Fragments were counted only if identifiable characters and at least 50 percent of the shell were preserved. Live and paired dead pelecypod valves were counted as 1; unpaired valves were counted as 1/2. Lists giving the abundance of each species within a bay or bay system are found in Appendix A.

Distribution of eight molluscan assemblages were mapped from the samples examined. Base maps on a scale of 1:125,000 were used. A modified version of Parker's assemblage classification (1960) was prepared for this preliminary report. Field data on bathymetry, gross sediment, and grass distribution aided in the preliminary mapping of the assemblages. All assemblage boundaries are tentative and may be changed after analyzing additional samples. Also, with the inclusion of other benthic invertebrates such as polychaetes and crustaceans, more accurate maps and descriptions of the biological environment can be made.

Beaumont-Port Arthur Area

Twenty-one biological samples were examined from Sabine Lake, Sabine Pass, and the Neches-Sabine River system. Two molluscan assemblages were recognized, and their distribution was mapped. Tables of species abundance for each assemblage were also prepared (Appendix A-1).

The predominant assemblage was river influenced. Three molluscan species, Rangia cuneata, Mytilopsis leucophaeta and Littoridina sphinctostoma make up almost 90 percent of the assemblage. Rangia cuneata, a characteristic river-influenced species, was found alive in 8 of the 21 stations examined. It ranged throughout almost the entire system, from station 19 in the southern part of the lake to station 39 in the Sabine River. Mytilopsis and Littoridina commonly were associated with Rangia in Sabine Lake. Altogether, a total of 14 river-influenced species were identified.

Two samples from Sabine Pass were examined. Typical inlet species such as Petricola pholadiformis, Parvilucina multilineata, Anadara transversa, Pandora trilineata, Anachas obesa, Epitonium rupicola, and Teinostoma biscaynense were identified, although not in any great abundance.

Houston-Galveston Area

Distribution patterns of six biological assemblages were determined from 32 samples from the Galveston-Trinity Bay system. Dashed lines on the assemblage map indicate tentative boundaries. With further analysis, more definite boundaries can be drawn. Tables giving the abundance of each species within an assemblage were also prepared (Appendix A-2 through A-5).

A river-influenced assemblage was found in East Bay, in Trinity Bay, and at the head of Galveston Bay. Mulinia lateralis and Macoma mitchelli made up 66 percent of the total molluscan fauna in this assemblage. Both whole shells and fragments were rare. Fragments present were worn and unidentifiable.

No live molluscs were present in bay-center Galveston Bay, but 19 molluscan species were identified. However, over 80 percent of the total fauna was composed of one species, Mulinia lateralis.

Thirty-eight molluscan species were identified in the two samples taken from Bolivar Roads. The inlet had both the highest diversity and the greatest numbers of species within the Galveston-Trinity Bay system (excluding West Bay). The molluscan species in Bolivar Roads were capable of ranging either from the nearshore gulf into the inlet, or from the bays into the pass. Many were probably restricted to the inlet environment.

Only one oyster reef sample was examined from the Galveston Bay system. Crassostrea, Brachidontes, Crepidula, Ischadium, and Odostomia impressa were dominant species. This assemblage, with some variation, was typical for most oyster-reef samples examined from the Texas bays.

Of the assemblages in the Galveston-Trinity Bay system (West Bay not included), the bay-margin was the least diverse. However, the number of live molluscs, especially Mulinia and Macoma, was relatively high.

West Bay differs considerably from Galveston, Trinity, and East Bay both in species diversity and in numbers of live molluscs. The bay-margin and bay-center assemblages in West Bay were more diverse than their counterparts in the Trinity, Galveston, and East Bay systems. In contrast to the Galveston-Trinity Bay system, West Bay provided a suitable habitat for live molluscs as indicated by the large number of live Mulinia, Ensis, and *Lyonsia*.

Species identified in San Luis Pass samples were similar to those found in other inlet samples. One inlet sample examined from Christmas Bay had 38 species, including a large number of live bivalves. Forty-eight of the 55 live bivalves were of three species, *Mysella planulata*, *Aligena texasiana*, and *Periploma* cf. *fragile*.

Port Lavaca Area

Samples examined from the Port Lavaca area include those taken from the following bays: Espiritu Santo, San Antonio, Hynes, Ayers, Carlos, Guadalupe, and St. Charles; and from Mission Lake. Copano and Aransas Bays are discussed under the Corpus Christi area section. The distribution of six assemblages was mapped, and their abundance is given in table form (Appendix A-6 through A-13).

Two samples taken from bay-center Espiritu Santo Bay contained a total of 63 species. This diversity in numbers of species has so far not been encountered in any other bay-center assemblage. Sample 3 in Espiritu Santo Bay had 58 species; however, only a small number of these were alive. In contrast, bay-center San Antonio Bay had only one-third the number of species as Espiritu Santo, but over three times the number of live molluscs. *Mulinia lateralis* was the most common live mollusc in the San Antonio bay-center assemblage.

The bay-margin assemblage in Espiritu Santo Bay was characterized by a large number of dead gastropods. Over 70 percent of these were from sample 31, taken on the back side of Matagorda Island.

Three samples from three very different bay-margin habitats in San Antonio Bay were examined. This bay-margin assemblage had brackish-water species, as well as species characteristic of hypersaline waters. Sample 19, taken near Seadrift, had 66 live *Littoridina sphinctostoma*, indicating a low salinity environment. Live *Tellina tampaensis*, *Anomalocardia auberiana*, and other species characteristic of high salinity waters occurred in sample 124, collected off Matagorda Island.

Guadalupe and Hynes Bays, as well as Mission Lake, had river-influenced assemblages. Hynes Bay had more live molluscs, 556 in two samples, than did any bay examined so far. A large population of *Mulinia* and *Littoridina* were living in Hynes Bay.

Four samples were examined from Ayres, Mesquite, and Carlos Bays. Ayres and Carlos Bays were called small enclosed bays primarily because of their size and restricted circulation, rather than because of their molluscan assemblages. The larger Mesquite Bay had a bay-margin and bay-center assemblage. No live molluscs, and relatively few whole shells, were found in the four samples from the three bays.

St. Charles Bay also has been called a small enclosed bay, but its molluscan assemblage composition included a mixture of species from other assemblages. Most of the species in an enclosed bay system are tolerant of environmental changes, and these species occur over a greater range of salinity, temperature, and sediment type than do those of other assemblages (Parker, 1960).

Corpus Christi Area

Aransas Bay system. Aransas, Copano, Port, and Mission Bays are included in the Aransas Bay system. The distribution of seven assemblages from this system was mapped; tables show the abundance of each species within an assemblage (Appendix A-14 through A-18). Copano Bay was the only bay in which all biological samples were examined, and the molluscan species were identified and counted. However, only 18 samples, representing all five Copano assemblages, were selected for inclusion in this preliminary report.

The predominant species in the Copano Bay assemblages were those associated with oyster reefs, brackish water, and highly variable salinites. *Macoma mitchelli*, *Mulinia lateralis*, *Ischadium recurvum*, *Odostomia impressa*, and *Odostomia laevigata* were the most abundant live molluscs in Copano Bay. Although few whole *Crassostrea* shells were taken using the Bureau sampling technique, *Crassostrea* fragments ranged from common to abundant at many stations. The bay-margin fauna had the most diverse numbers of species, while the oyster reef assemblage had the greatest number of live molluscs.

Four samples were examined from Mission Bay and four from Aransas River, including the area where the river discharges into Copano Bay. *Littoridina*, *Macoma*, and *Rangia*, typical brackish-water molluscs, were identified in these river-influenced areas.

Both a grassflat assemblage and small enclosed bay assemblages were mapped for Port Bay. *Macoma mitchelli*, although not typically a grassflat species, was found in abundance. The species composition of the enclosed bay assemblage was similar to that of other enclosed bays discussed above.

Ten samples showing the distribution of four assemblages were mapped for Aransas Bay. No oyster reef samples were examined. The bay-margin assemblage was almost as diverse as that of Espiritu Santo Bay. Although few live molluscs were found, 54 species were identified. Almost 40 percent of the species were Nuculana acuta, Acteocina canaliculata, and Caecum pulchellum. Few whole shells or live molluscs were collected in the inlet and bay-center assemblages of Aransas Bay. Ninety percent of the grassflat molluscs in Aransas Bay were dead shells of Diastoma and Cerithium sp. No live specimens of the two species were found.

Corpus Christi Bay system. The Corpus Christi Bay system includes Redfish, Corpus Christi, Nueces, and Oso Bays. The distribution of six assemblages was mapped; tables give the abundance of each species within an assemblage (Appendix A-19 through A-22).

Redfish Bay is split in half by the Aransas Ship Channel. A grassflat and bay-margin assemblage lies north of the Channel; to the south the assemblages are grassflat, bay-margin, and inlet. A total of 10 samples were examined from the two areas.

Bay-margin Redfish Bay had the greatest number of species of any bay-margin assemblage examined. Eighty-two species were identified from five bay-margin samples. Over 45 percent of the total shells counted were of two species, Cerithium sp. and Diastoma varium. There were approximately five times as many gastropods as pelecypods, and only 103 live molluscs in a total shell count of over 8,500. The grassflats had fewer species, but over 11,500 shells were counted, of which almost 98 percent were gastropods. Only 108 live molluscs were found. A typical inlet assemblage was taken from two samples in the Corpus Christi Ship Channel.

Inlet, bay-margin, and bay-center assemblages were mapped from nine samples taken from Corpus Christi Bay. Over 45 percent of all the molluscs in the three assemblages were *Mulinia lateralis*, and 75 percent of the live molluscs were *Mulinia*. Most of the live species in the assemblages represented less than 1 percent of the total fauna. Species composition in the three assemblages delineates a transitional area between the dry subhumid and the semiarid climatic zones, since species common to both zones are found in the assemblages.

Mulinia lateralis was the most abundant mollusc in each of the three Nueces Bay and Oso Bay assemblages. Four samples were examined from each bay; only one live mollusc was found in Nueces Bay, and only two in Oso Bay.

Laguna Madre system. Laguna Madre extends from Corpus Christi Bay south to Port Isabel. Northern Laguna Madre from Corpus Christi Bay to the land cut just south of the Baffin Bay entrance will be discussed in this section. The southern section will be included in the Brownsville-Harlingen area.

The entire Laguna Madre system lies within the semiarid climatic zone where there are no permanent rivers flowing into the bay, and where rainfall is frequently less than 15-20 inches a year (Parker, 1960). Hypersaline conditions, coupled with high summer water temperatures and periodic freezes, make conditions adverse for most marine life. However, these factors are stable compared with those in many central Texas bays.

Although bay-margin, bay-center, and grassflat assemblages were mapped for the northern Laguna Madre, the boundaries and the assemblage designations may change with further study. These assemblages eventually may be combined into one assemblage, since they closely resemble each other both in species composition and number (Appendix A-23).

Seventeen samples were examined in the northern Laguna Madre. _Anomalocardia auberiana_ and _Diastoma varium_ were extremely abundant as dead shell in all Laguna Madre assemblages. _Anomalocardia_ was rarely found alive. Abundant live _Diastoma_ only occur in the grassflat assemblage. _Laevicardium mortoni_, _Amydalum papyria_, _Argopectin amplicostatus_, _Caecum pulchellum_, _Polymesoda maritima_, _Tellina texana_, _Tellina tampaensis_, and _Sayella livida_ were found in the three northern Laguna Madre assemblages. The abundance and distribution of these eight species varied between the northern and southern Laguna Madre, but they occurred in most of the assemblages throughout the system.

Kingsville Area

Baffin Bay system. Baffin and Alazan Bays are included in the Baffin Bay system. Distribution of four assemblages in Baffin Bay and of two in Alazan Bay were mapped; tables give the abundance of each species (Appendix A-25). Eighteen samples were examined in Baffin and Alazan Bays.

Anomalocardia auberiana and _Mulinia lateralis_ were the most abundant molluscs in the Baffin Bay system. _Mulina_ and _Anomalocardia_ made up more than 70 percent of the total fauna. Pelecypods were dominant in all assemblages. No gastropod species ever accounted for more than 10 percent of the total fauna in any assemblage. However, approximately 20 percent of the gastropods were alive, while only about 4 percent of the pelecypods were living.

A serpulid reef assemblage was found only in Baffin Bay. Two serpulid reef samples were examined. The fauna assemblage was much the same as in other Baffin assemblages, except for the large number of live Brachidontes exustus.

Brownsville-Harlingen Area

The Brownsville-Harlingen area includes lower Laguna Madre from the land cut south to Port Isabel. From approximately 8 miles north to 8 miles south of the Arroyo Colorado cutoff, samples were taken at half-mile intervals. Twenty-three samples were examined from this area, designated the wind tidal flat study area. Altogether, 42 samples representing five assemblages were examined in lower Laguna Madre (Appendix A-26 and A-27).

Pelecypods were the dominant group in all but the river-influenced and grassflat assemblages. Anomalocardia auberiana was the most common pelecypod species, and Diastoma varium the most abundant gastropod. From the 23 samples taken in the wind tidal flat area, over 36,000 Anomalocardia were counted, although only eight of these were alive.

The grassflat and bay-center assemblages had the highest number of live molluscs. Tellina tampaensis, Caecum pulchellum, Diastoma varium, Ensis minor, and Crepidula fornicata were the most abundant species living in the grassflats. The bay-center assemblage contained the greatest number of species as well as the greatest number of live molluscs. The only characteristic brackish-water species identified in the Arroyo Colorado was *Littoridina sphinctostoma*. Typical inlet species, such as *Parvilucina multilineata*, *Petricola pholadiformis*, and *Anachas obesa*, were found in the Port Mansfield Channel.

Status of Bay Studies, Fiscal Year 1976-1977

Field Work

A total of 3,197 surface sediment samples were collected in the Texas bays for textural analyses, heavy metal determination, percent total organic carbon, and biological studies. Sampling has been completed except for the following areas: (1) part of Laguna Madre south of the Land-Cut Area and near the mouth of Baffin Bay; (2) bay margin area of St. Charles Bay; (3) Green Lake; (4) 60 biological samples in Matagorda Bay system; (5) Cow Trap-Cedar Lakes; and (6) small lakes west of Sabine Lake.

Geophysical work, a total of 600 nautical miles of high-resolution shallow sparker profiles, has been completed for southern Laguna Madre, Corpus Christi Bay, Aransas Bay, Copano Bay, St. Charles Bay, Mesquite Bay, San Antonio Bay, Espiritu Santo Bay, Lavaca Bay, Keller Bay, Carancahua Bay, Tres Palacios Bay, and Matagorda Bay. Two seismic lines have been run at the western end of East Bay. Areas that remain to be profiled are Baffin Bay, northern Laguna Madre, East Matagorda Bay, West Bay, Galveston Bay, Trinity Bay, East Bay, and Sabine Lake.

Laboratory Work

Each surface sediment sample will undergo (1) textural analyses; (2) semi-quantitative alternating-current emission spectrographic analyses for 30 elements; (3) total organic carbon percentage analysis by wet combustion method; (4) determination of uranium equivalent content; and (5) a study of the macro-benthic fauna.

Textural analyses of bay sediment samples has not begun. To date, a total of 788 bay sediment samples have been analyzed for percent total organic carbon. Three hundred and fifty-seven bay sediment samples have been submitted to the U.S. Geological Survey for determination of heavy metal content; data from these samples have not been received at this time. Samples will be analyzed by the Bureau of Economic Geology's Mineral Studies Laboratory for uranium equivalent; no data have been received yet for any of the bay sediment samples. Biological studies are underway, and to date about 280 samples from all bays have been studied. This preliminary biological investigation was concerned only with identification of molluscs.

Geophysical records for the bays were not received by the Bureau of Economic Geology in time for analysis and interpretation to be included in this report.

Continuation of Field Work, Fiscal Year 1978

Approximately 30 days of field time will be required to complete the bay sampling program. This will be conducted by a crew of two people. Much of the remaining bay area to be sampled is in extremely shallow water, which necessitates using an airboat.

Geophysical work has been a cooperative effort between the U. S. Geological Survey and the Bureau of Economic Geology. This phase of bay field work, which depends upon the availability of U.S. Geological Survey personnel and equipment, cannot be resumed until the winter of 1977-78.

Since winter storms generating heavy seas are frequent in the Texas Coastal Zone, geophysical work may not be resumed until spring, 1978. Given optimum weather conditions, however, seismic profiling could be completed in two weeks.

Proposed Bay Work, Fiscal Year 1978

In 1978, principal objectives will be to: (1) determine textural parameters of sediment samples; (2) continue the identification of molluscan species, and initiate the identification of soft-bodied organisms in the biological samples; (3) continue the analyses of whole sediment samples for uranium equivalent, heavy metal content, and total organic carbon percentage; and (4) analyze geophysical data from the bay areas.

Processing of sediment, geochemical, biological, and geophysical data will begin in the south (the Brownsville-Harlingen area) and proceed systematically up the coast. The reason for this procedure is that much of this work is being conducted in cooperation with the U.S. Geological Survey. The U.S.G.S. has generated and analyzed a great amount of data from the South Texas Outer Continental Shelf (O.C.S.). A logical step is to tie data generated from Texas submerged lands in South Texas to the Federal O.C.S. data; this will permit a good understanding of the geology, biology, and chemistry of the bays and the continental shelf of South Texas.

During 1978, a sufficient number of samples from each area will be analyzed to permit detailed mapping of: (1) sediment textural parameters; (2) total organic carbon distribution; (3) heavy metals and uranium equivalent distribution; and (4) molluscan and soft-bodied animal assemblages.

All geophysical records will be analyzed in order to map thickness of Holocene bayfill.

The following products are expected from data generated and analyzed during 1978: (1) maps displaying sediment textural parameters; (2) maps of total organic carbon, heavy metal, and uranium equivalent distribution; (3) biological assemblage maps; (4) isopachs of Holocene bay sediment; (5) maps of the configuration of the Pleistocene erosional surface on which Holocene bay sediment was deposited; and (6) seismic cross-sections and maps depicting the three-dimensional distribution of Holocene bay facies.

Time and funds permitting, continuous cores will be taken in selected areas for the purpose of: (1) verifying seismic reflectors; (2) determining facies characteristics; (3) obtaining in situ plant or shell material for radiometric age determination of sedimentary sequences; and (4) determining vertical distribution of heavy metals.

Proposed Bay Work, Fiscal Year 1979

A logical follow-up to the sedimentary, biological, geochemical, and geophysical work conducted in the 1976-1978 fiscal years would be to conduct an extensive coring program within the bays, and along the barrier islands, peninsulas, and deltaic headlands. Cores from the bayfill would provide the data necessary to verify seismic reflectors, thereby enabling investigators to determine the depositional facies of the bayfill with a great deal of certainty. Radiometric dates determined from cores would provide information on: (1) sedimentation rates; (2) chronology of depositional events within a particular bay; and a means of comparing events among the various bays; (3) relative rates of sea level change during the Holocene; and (4) rate of change in the coastal climatic regime.

Cores taken along the Texas Gulf shoreline would provide the only means of correlating the inner continental shelf and bay data. Of particular importance is the necessity of tracing the Pleistocene valley, in which most of the Holocene bayfill has accumulated, beneath barrier islands and peninsulas onto the continental shelf. Core or washdown data would also enable investigators to determine the thickness and geometry of barrier island and peninsula sands, and the nature of the surface upon which these sediments were deposited. This type of information is vital to man's use of barrier islands and peninsulas. Thickness and geometry of the sand body, and the type of sediment underlying these sand bodies, are important to pipeline or channel dredging, foundation stability, and shoreline erosion.

In summary, cores would provide the data necessary for verifying seismic reflectors (a specific interval on the seismic record could indicate a certain sediment type with specific physical properties); for interpreting depositional facies; and for determining rates of sedimentation and sea level rise, climatic changes through time, and Holocene geologic history of barrier islands, peninsulas and bays. All of these factors are important to coastal zone management.

INNER SHELF STUDIES

Surface Sediments

Introduction

Surface sediment samples were collected on the Texas inner shelf with a Smith-McIntyre grab sampler, at sites determined by a grid, with samples spaced 1 mile apart. Penetration depths, which ranged from 4 to 18 cm, and sediment volume depended largely on sediment type. Clean, firm sands in shallow water and stiff, compacted muds hindered penetration, and as a result the sampler would not fill completely. Saturated muds and mixtures of sand and mud, however, allowed full penetration and complete filling of the sampler.

Precision navigation was accomplished primarily with a Motorola Mini-Ranger system, but shipboard radar and LORAN C also were used.

Shipboard descriptions were based on visual observations of sediment type, sediment colors, shell content, degree of bioturbation, abundance of worms, and preservation of individual sediment layers in a vertical sequence. Because of the quantity and diversity of data, the resulting classification is rather complex, but it does provide the most useful method of handling information on sedimentary processes. Similar sediment types from the full range present on the inner shelf were grouped to facilitate mapping.

Texture and Composition

Most of the sediment has a grain size less than 0.5 mm. Sands are fine to very fine, but silts and clays (mud) predominate. Sediments coarser than 0.5 mm are generally whole shells and shell gragments; however, caliche nodules and rock fragments are also present. The carbonate content of shelf sediment depends mainly upon its shell content, which in rare instances ranges up to 100 percent. Other minor carbonate constituents include calcareous nodules.

The composition of sediment load transported by the major rivers emptying into the Gulf of Mexico determines the composition of terrigenous clastic sediments on the inner continental shelf. This relationship has been demonstrated by Bullard (1942), Goldstein (1942), and Van Andel and Poole (1960), among others. The light minerals are quartz with some feldspar; minor amounts of flauconite and pyrite also occur in the sediment. The durable heavy minerals are characteristic of the sediment source, and particular suites of heavy minerals are diagnostic of the Rio Grande, Brazos, Colorado and other Texas rivers. A complete discussion of shelf sediment composition was presented by Curray (1960).

Clay minerals of the northwest Gulf of Mexico are characterized by montmorillonite, illite, and kaolinite, in decreasing order of abundance. Grim and Johns (1955) reported measurable quantities of chlorite, which they attributed to rapid diagenetic processes in the marine environment. Subsequent work by Morton (1966, 1972) and others, however, has shown conclusively that chlorite is neither being transported by Texas rivers, nor being formed diagenetically or authigenetically in Texas bays or along the inner continental shelf. Chlorite from sediment sources including the Mississippi River drainage basin has been reported, however, for the Northeastern Gulf of Mexico.

Surface Sediment Types

Samples of approximately the upper 6 inches of shelf sediment were described at the time of collection, using a three-component classification of sand, mud, and shell (Fig. 5). Visual estimates of the three components were used to describe the sediment type, and sediment color was determined by comparison with a standard color chart. Pertinent information on other characteristics such as worm tube abundance, indications of bioturbation, presence of organic (plant) material, and anomalous features such as bay molluscs, caliche nodules, and rock fragments were also noted.

The vertical sequence of sediment types collected in each sample was recorded to provide the most complete information possible. Consequently, the descriptions of surface sediments are complex, reflecting the variability of modern and relict sediment types, and of related physical and biological processes.

Because of the complex distribution of surface sediments, similar sediment types (dominantly sand, abundant shell, relict sediment) were grouped in order to show the trends of lithofacies and the occurrence of relict sediments.

Dominantly sand. Dominantly sand samples, and dominantly mud or shell samples, include the following sediment types and vertical sequences: sand, muddy sand, sand over muddy sand, muddy sand over sand, shelly sand, and muddy shelly sand. Other samples, with a greater estimated volume of sand than mud, were also included. These samples were generally identified either by description (thin veneer of mud over sand), or by actual thicknesses of individual sediment layers.

Abundant shell. Sample descriptions using shell as a modifier are the most common sediment types in the abundant shell category. These samples include the following types: shell gravel, sandy shell, muddy shell, shelly sandy mud, sandy shelly mud, muddy shelly sand, and shelly muddy sand. These samples were generally described as having abundant shell. In order to be consistent, therefore, all sample description sheets were checked, and those few samples not in one of the above sediment types, but described as having abundant shell, were included. This also provided the best objective means of dealing with multiple sediment types in a vertical sequence.

The surface distribution of abundant shell reflects modern and relict physical and biological processes; this classification, however, does not discriminate between all modern and relict sediments. The identification of brackish-water species will provide a basis for establishing the distribution of relict shelly sediments.

Relict sediment. By definition, relict sediments are not in equilibrium with extant physical processes, but are sediments deposited under different preexisting conditions (Emery, 1968). During the sampling phase, it was apparent that some samples were clearly modern, while others were clearly relict. The reworking and mixing of relict and modern sediments, however, creates a transitional group of sediments that cannot be distinguished from some relict sediments. For example, the erosion of relict shelly mud and its incorporation with modern shelf sandy mud would yield a sandy shelly mud that could be transported by modern processes. In the strictest sense this mixture would be modern because it is in equilibrium with modern shelf processes, but it would be difficult to distinguish such a mixture from a relict sandy shelly mud.

The term relict sediment describes only those samples containing material that was considered "in place" and not reworked. Consequently, the relict sediments are generally firm oxidized muds and sandy muds with root casts. Exceptions are clean, well-sorted, gravel-sized deposits comprised of shell, caliche nodules, and rock fragments. These clean gravels are interpreted as relict beach deposits because of their similarity to modern beaches east of High Island, at Sargent Beach, and west of the Colorado River on Matagorda Peninsula.

Perhaps the most important consideration for mapping relict sediments is their close association with stiff muds, which have engineering properties differing greatly from modern muds. In general, the occurrences of these stiff relict muds can be predicted. This predictive capability should be useful in evaluating inner shelf activities affected by engineering properties.

Distribution of Sediment Types

Dominantly sand. The offshore extent of dominantly sand sediments varies greatly along the Texas coast. Except for a thin band of beach and upper shoreface sand, the upper coast from Sabine Pass to Bolivar Roads is essentially void of sand; shelf mud is the most extensive sediment type. One small area of muddy shelly sand (probably relict) is located at the outer limit of the inner shelf near Sea Rim State Park.

Sand sediments are patchy from Bolivar Road to approximately 8 miles west of the Colorado River. Greatest concentrations are along Galveston

Island and Follets Island, from the Brazos River to Cedar Lakes, and for 11 miles east of the Colorado River on Matagorda Peninsula. Along this regional segment of the coast, dominantly sand sediments extend less than 2 miles offshore. Extensive mud deposits are located in the vicinity of Freeport Harbor, off the mouth of the Brazos River, along Sargent Beach, and in the vicinity of the Colorado River. In the same region, an arcuate trend of sand associated with relict sediment extends from Matagorda Peninsula to 11 miles off Freeport. Sand is relatively continuous along the remainder of the Texas Coast. It extends progressively farther offshore from Matagorda Ship Channel to the area of maximum extent at the Willacy-Cameron County line on South Padre Island; the offshore extent decreases markedly, however, toward the mouth of the Rio Grande. About 5 miles north of Mansfield Channel, a sheet of sandy sediments extends 8 to 9 miles offshore. South of Mansfield Channel sandy sediments extend as far as 11 miles offshore, but in this area such sediments are generally discontinuous.

Offshore changes in sediment type are least complicated from Malaquite Beach to just south of 27°N latitude, where shelf sediments grade from sand to muddy sand and from sandy mud to mud in bands subparallel to the shoreline. This area also has the most extensive blanket of mud without substantial quantities of sand or shell. Perhaps this fact can be attributed to the lack of discharges from fluvial systems and tidal inlets. It also suggests either that seaward transport of sandy by storms is minimal at present in this area, or that mud deposition is substantially greater. When viewed separately, the continuous band of sand adjacent to the shoreline exhibits seaward projections oriented northward from the Rio Grande to Cedar Bayou on Matagorda Island. In contrast, offshore protrusions of dominantly sand sediments show a bimodal distribution, suggesting important differences in the direction of net sediment transport between the wind-driven longshore currents adjacent to the shoreline, and the currents operating farther seaward on the inner shelf.

Abundant shell. Sediments containing abundant whole shells and shell fragments are patchy over most of the inner shelf. Typically, shelf samples from the Colorado River to Yarbrough Pass lack abundant shell material. The greatest concentration of abundant shell occurs from south-central Padre Island to South Padre Island, an area extending roughly 20 miles on either side of Mansfield Channel. In this area abundant shell is continuous, but it generally is restricted to the outer 6 miles except at the northern limits, where the trend comes to within 3 miles of the shoreline. North of the Colorado River, abundant shell is closely related to relict sediments.

Although a few samples from inlet areas have abundant shell, most samples adjacent to inlets and river mouths contain only minor amounts of shell material. Furthermore, there is little correlation between the shelf areas of abundant shell, and shell beaches such as those on Sargent Beach, Matagorda Peninsula east of Greens Bayou, and Big Shell and Little Shell beaches on central Padre Island.

Relict sediment. There is good correlation between the occurrence of offshore relict sediment and the onshore distribution of fluvial-deltaic depocenters. From Rollover Pass to Sabine Pass the relict sediments represent exposures of the Pleistocene Beaumont Formation. In the vicinity of the Holocene Brazos-Colorado delta, the relict sediments follow the same arcuate trend as the dominantly sand and abundant shell samples. Similarly, relict sediments associated with the Holocene Rio Grande delta were encountered south of Mansfield Channel. In the interdeltaic areas, relict sediments are rare and limited to a few samples, except for two small areas of relatively continuous relict sediment off Galveston Island. This distribution pattern suggests that modern sediments probably reach maximum thickness between, Pass Cavallo and Mansfield Channel.

Sediment Color

The upper 2 cm of most samples exhibited an oxidized layer of yellowish brown (10YR4/2) water-saturated mud. A similar thin surface layer was described by Nelson and Bray (1970). The underlying muds and dominantly muddy sediments are olive gray (5Y4/1), dark greenish gray (5GY4/1, 5G4/1), and greenish black (5GY2/1). The relict muds, however, displayed a variety of colors due to alteration of their original colors by burrowing organisms, iron fixation by plant roots, and oxidation during subaerial exposure. Widely varying tones of gray (5Y5/2, 5B5/1, 5G6/1, 5G8/1) and brown (5Y5/6, 5YR6/4, 5YR4/4, 10YR4/2, 10YR5/4) are common colors for relict muds, but grayish red (10R4/2), blue green (5BG5/2), and olive (10Y6/2) also occur. The clean sands are also yellowish brown (10YR4/2), but increased amounts of mud, organic material, or heavy minerals in conjunction with reducing conditions cause the sand to be dark gray (N3, N4) or greenish black (5GY2/1, 5G2/1).

Relationship of Sediment Types to Physiography and Bathymetry

Fathometer profiles recorded simultaneously with sampling, as well as published navigation charts, indicate that much of the inner shelf is a smooth, low-sloping surface with increased gradient across the upper shoreface. The shelf widens considerably from south to north, and the shoreface gradient is more distinct along the central and south Texas coast.

Topographic features control sediment type in several areas. A linear ridge off the western half of Galveston Island in about 45 feet of water is the site of high concentrations of coarser sediment, including sand and shell. Similar but less extensive ridges in the vicinity of Freeport Bank (Curray, 1960) are also the sites of coarser-grained sediments. Perhaps the most distinct control of sediment type by a topographically high area occurs off South Padre Island (Fig. 6), where clean, well-sorted sand outlines a narrow ridge in 60 feet of water trending oblique to the shoreline. Muddy sands are prominent gulfward of the ridge, while sandy mud with shell is most abundant on the lee or landward side.

Where the distribution of sediment type is not affected by relict sediments or bottom topography, there is a general relationship between grain size and water depth. This is best illustrated between Aransas Pass and 27°N latitude. In this zone of net sediment transport, increases in water depth are generally accompanied by decreases in grain size.

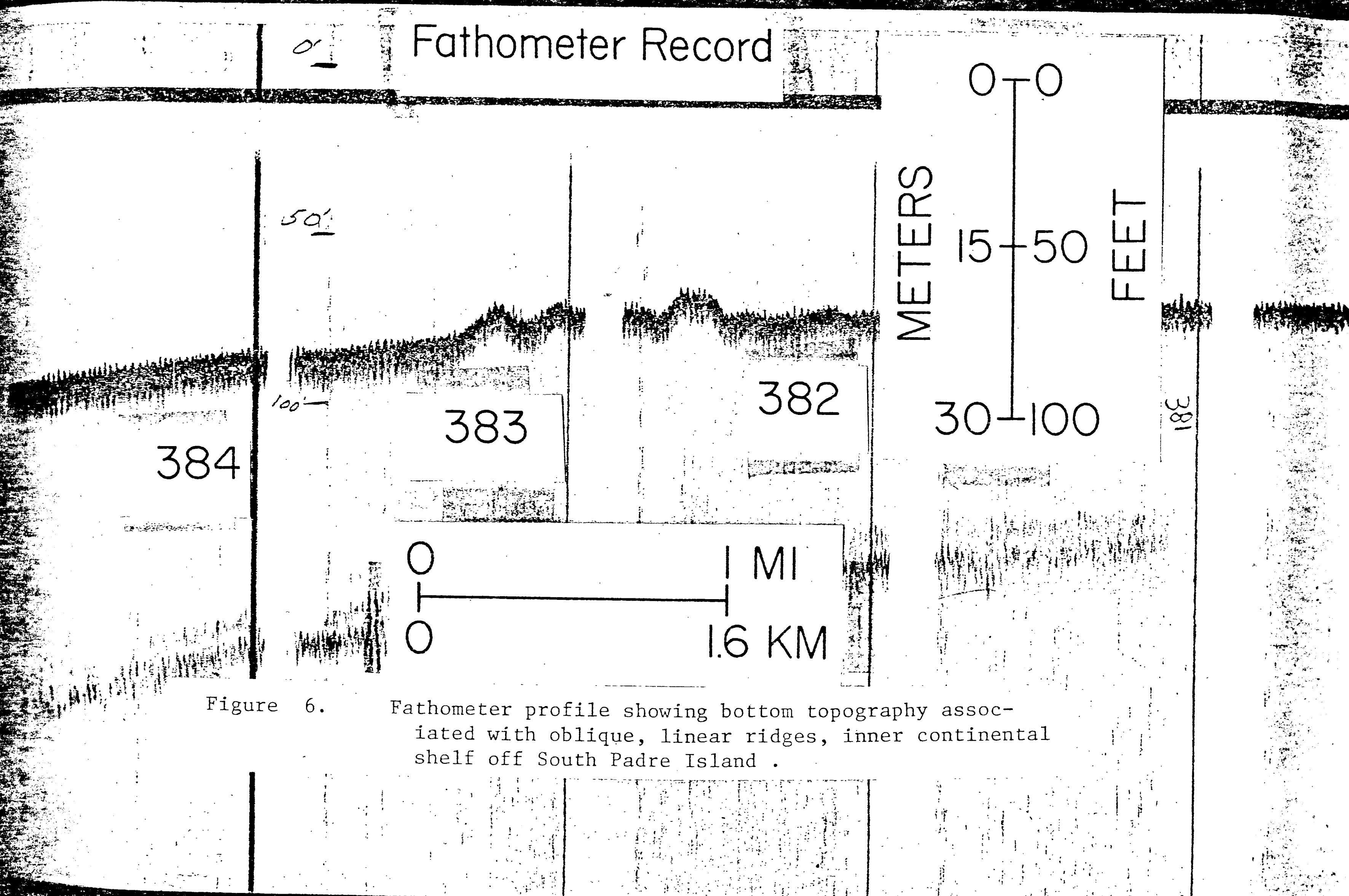

Figure 6. Fathometer profile showing bottom topography associated with oblique, linear ridges, inner continental shelf off South Padre Island .

Comparison with Previous Studies

Although other studies have been conducted of the surface sediment distribution on the inner continental shelf, none of these previous studies exhibit systematic and close spacing of samples on the state submerged lands portion of the shelf. For example, reconaissance sampling reported by Stetson (1953) included very few samples on the inner shelf because of the number of traverses along the Texas Coast (seven), the spacing of samples along each traverse (2 miles), and the starting point for each traverse (in most instances, between 7 and 14 miles offshore).

A similar study was conducted in the 1950's (see Curray, 1960), but again few samples were taken on the state lands portion of the shelf. Less than 100 samples were collected from the inner shelf, and more than half of these samples were obtained offshore Matagorda and San Jose Islands. Despite the limited number of samples, several important trends were delineated. These included: (1) the general gradation from sand to mud along the central and south-central portion of the coast; (2) the increased shell content and the predominance of sand between the Rio Grande and Mansfield Channel; and (3) the dominance of mud along the upper coast.

Other studies of shelf sediment have greater sample density but are limited to particular areas such as Sabine-High Island (Nelson and Bray, 1970), and Galveston Island (Bernard, LeBlanc, and Major, 1962). In general, the present data show close agreement with the general trends established by the previous work.

Geochemistry

The preliminary interpretations of geochemical analyses (Grime and Marranzino, 1968) are limited to broadly generalized descriptions of trends and concentrations. More detailed descriptions of trace element concentrations, and perhaps better explanations of their occurrences, will follow examination of the entire suite of trace elements, their interdependence, and their relationship with different sediment types. Such an examination was not possible because of time constraints on the preliminary work.

Analyses for total organic carbon and trace elements were conducted for the Port Lavaca, Corpus Christi, Kingsville, and Brownsville-Harlingen areas. Values for total organic carbon were contoured, but values for trace element content were simply identified by range within the overall sample distribution. The trace element values will be contoured and analyzed quantitatively in the future.

Total Organic Carbon

In general, the percent of total organic carbon increases from the shoreline seaward. This trend also correlates closely with the sand-mud trends. The sandier sediments tend to have lower concentrations of total organic carbon, whereas the muds exhibit higher concentrations.

Anomalously high nearshore concentrations are located near the mouth of the Rio Grande River, at Aransas Pass, and at Pass Cavallo. These areas are probable sources for some of the organic carbon introduced into the shelf environment in association with suspended sediments.

Barium

Barium does not exhibit systematic lateral variations. The frequency distribution ranges up to 5000 ppm, but most of the samples are between 300 and 500 ppm. Highest concentrations are located offshore Mansfield Channel and near the Brazos-Santiago Pass. Barium concentrations below the median range are scattered throughout the four areas. The most obvious relationship, as might be expected, is higher than normal concentrations of barium in close proximity to areas of hydrocarbon exploration and development. This is attributed to drilling muds containing substantial amounts of barite. Equally high concentrations of barium are found, however, where drilling apparently has not occurred. This suggests sources of barium other than drilling mud.

Chromium

High concentrations of chromium are also scattered throughout the four data areas, but there appears to be a general decrease in chromium content from the Port Lavaca area to about 27°N latitude. South of that area, slightly higher ranges occur from the Willacy-Cameron County lines to the Rio Grande River. Samples with highest concentrations occur in clusters, substantiating the validity of the data.

Iron

The frequency distribution of iron is weighted heavily toward the 0.5-1.5 ppm range, but the peakedness of the distribution does not mask the apparent trends. Concentrations of iron generally increase from the shoreline seaward and generally decrease from north to south. For example, the Port Lavaca area contains numerous samples ranging from 1 to 5 ppm, but the Brownsville-Harlingen area has considerably fewer samples in that range.

Lanthanum

Concentrations of lanthanum range up to 150 ppm. The frequency distribution is heavily weighted in the mid-ranges (50-100 ppm), and general trends indicate decreases in concentrations from north to south. Highest and lowest concentrations, however, are scattered, and in some instances they are juxtaposed. Areas near tidal inlets and channels (Matagorda Ship Channel, Pass Cavallo, Cedar Bayou, Aransas Pass, Mansfield Channel, Brazos-Santiago Pass) and near the Rio Grande River generally have lower concentrations than other areas.

Lead

Lead concentrations range up to 150 ppm, but the median ranges are between 15 and 30 ppm. In general, lead content increases from the shoreline seaward. Highest concentrations of lead ar north from Pass Cavallo, and offshore Aransas Pass to about 10 miles north of Mansfield Channel (Kingsville area). Lowest concentrations occur near the shoreline of the Port Lavaca, Corpus Christi, and Kingsville areas.

Manganese

Some manganese concentrations are greater than 5,000 ppm, but such high values are rare. Most of the samples contain between 300 and 700 ppm. The highest and lowest concentrations, which represent a small proportion of the total number of samples, are scattered. There are no clear trends in these variations.

Strontium

The frequency distribution of strontium is strongly skewed toward values less than 100 ppm, although values range up to 500 ppm. There is a definite increase in strontium from the Port Lavaca to the Brownsville-Harlingen area. This trend also generally coincides with the increase in shell material between the two areas. Apparently the concentration of strontium is not related to type of clastic sediment.

Zirconium

Zirconium concentrations can be greater than 1,000 ppm, and the frequency distribution is strongly skewed toward the higher values. The spatial distribution of zirconium is closely related to the spatial distribution of sand. This is not surprising, considering that zircon is a common heavy mineral in the sand-sized sediment.

Vanadium

Vanadium, which ranges up to 150 ppm, is distributed in a relatively uniform way in the ranges greater than 30 ppm. The spatial distribution of vanadium is similar to that of lead; it generally increases in an offshore direction, and highest concentrations occur north of Mansfield Channel.

Shallow Subsurface Structure

Introduction

The shallow subsurface geological structure of the Texas inner shelf was interpreted from approximately 3,000 nautical miles of continuously recorded high resolution seismic reflection surveys. These surveys were conducted with an 800-joules Del Norte Minisparker system. The geophysical data were recorded at 0.5 second and 1.0 second sweep rates after passing through separate analog signal processors. Penetration was generally less than 0.5 sec two-way travel time, with most time records exhibiting penetration of 0.3 to 0.4 sec. These times represent subsurface depths of between 1,650 and 2,200 feet. The geological formations at these depths are Late Pleistocene in age; younger, Holocene sediments occur at depths generally less than 100 feet.

Tectonic Elements

Regional tectonic features along the Texas Coastal Plain include the Rio Grande and East Texas Embayments, which are separated by the San Marcos Arch (Murray, 1961). Within this broad structural framework are smaller sags and structural highs. The Rio Grande Embayment and San Marcos Arch apparently exerted the greatest control on Late Quaternary sedimentation, as inciated by thickening of sediments offshore and along depositional strike toward the Rio Grande River. By contrast, sediment thickening is not noticeable along the central and upper Texas coast. The San Marcos Arch also marks the limits of salt domes and diapiric structures, which prevail over much of the northwestern Gulf of Mexico (Garrison and Berryhill, 1970).

Faults

Shallow subsurface faults, both active and inactive, were interpreted from geophysical records based on bedding offsets and discontinuities in the records. Active or potentially active faults were defined by their presence near the sea floor. Faults were mapped as potentially active if they exhibited even minor offset within 100 feet of the sea floor. This arbitrary upper limit was necessary because fault displacement rapidly decreases upward in the sediment column, and because displacements less than about 10 feet are below the resolution of the records. Thus, it is possible that active faults with displacements of a few feet intersect the sea floor, but could not be detected with available data. On the other hand, while these faults are not necessarily active, they are potentially active because of their close proximity to the sediment-water interface.

The faults are normal, en echelon growth faults subparallel to the coast. Most faults are down-to-the-basin, but up-to-the-basin faults are also common. These faults belong to the Willamar system (Murray, 1961), a relatively young fault system extending onshore in the vicinity of the Rio Grande River. Many of the faults are nearly vertical, and apparent dips are generally greater than 70°.

Fault density, continuity, orientation, and displacement are diverse along the coast. For example, faulting is concentrated: (1) off South Padre Island between the Rio Grande River and the Mansfield Channel; (2) off Mustang and North Padre Islands between Malaquite Beach and Port Aransas; (3) between the Colorado River and Bolivar Peninsula; and (4) near Sabine Pass. Because of this diversity, faulting will be discussed by geographic area.

Rio Grande delta. Shallow subsurface faulting along the southern part of the coast (Fig. 7) is closely related to the geographic limits of the

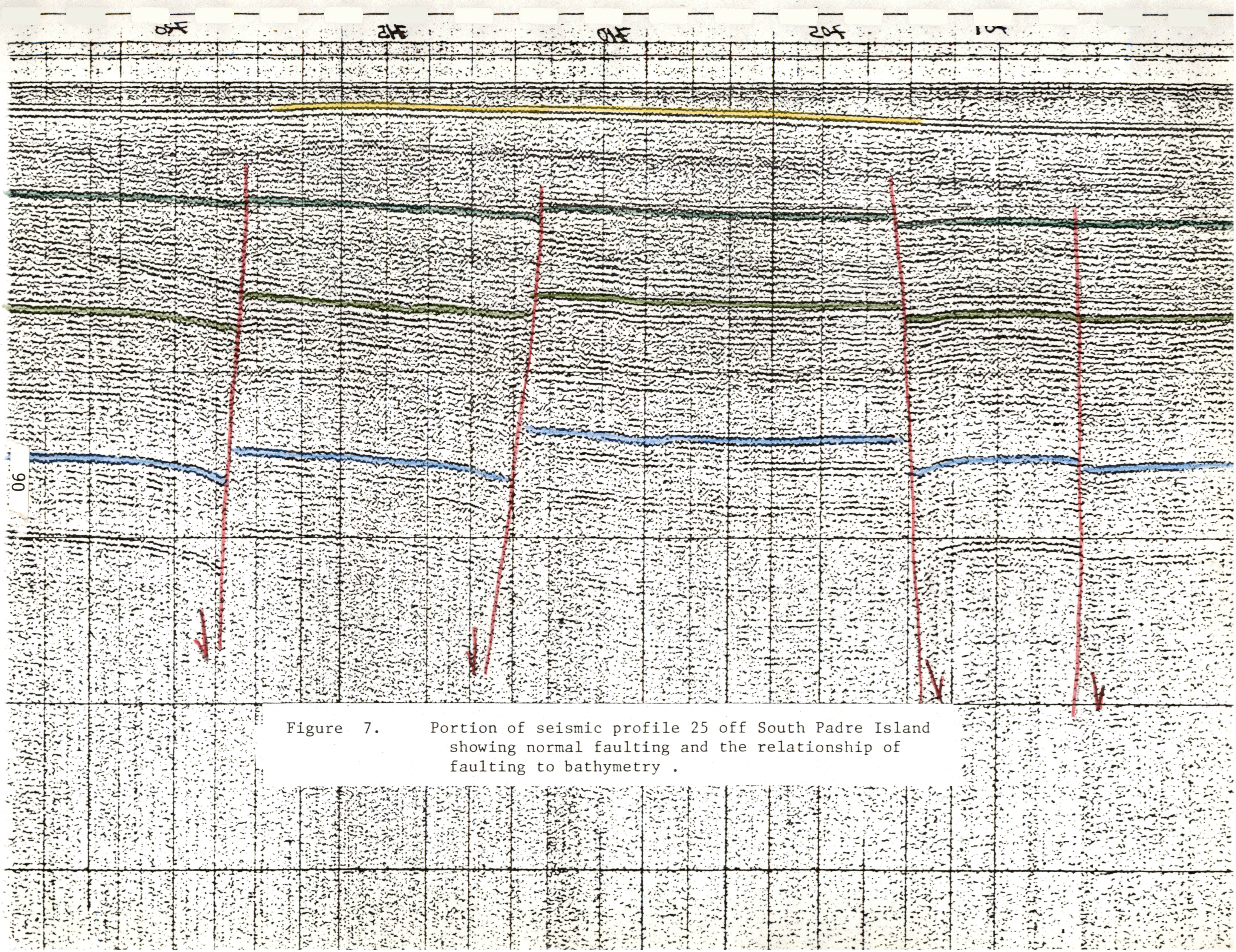

Figure 7. Portion of seismic profile 25 off South Padre Island showing normal faulting and the relationship of faulting to bathymetry .

Holocene Rio Grande delta. Faults in this area are extensive, some being laterally continuous for up to 17 miles. Displacements range from 10 to 200 feet, but most displacements are between 30 and 50 feet. The coincidence of potentially active faults with bottom topography suggests that the oblique linear ridges off Padre Island are fault-related (Figs. 6 and 7). Perhaps these ridges resulted from sediment preferentially cemented along the fault plane by subsurface fluids. Differential erosion of the sediment, controlled by the degree of cementation, caused the more resistant sediments to stand in topographic relief above the sea floor. Similar ridges of cemented sediment on the inner shelf that apparently are not fault-related were studied by Thayer and others (1974).

Central coast. Faults offshore Mustang and North Padre Islands are oblique to the shoreline, and the most extensive faults are arcuate in plan view and generally down-to-the-basin. The most extensive faults in this area are 7 to 10 miles long, but less extensive faults are also common. Displacements range from 10 to 100 feet, and larger displacements are associated with more extensive faults.

Brazos-Colorado delta. Faults between the Colorado River and Galveston Island are related to ancestral and Holocene deltas formed by the combined Brazos and Colorado Rivers. The majority of faults are roughly parallel to the shoreline, although some are nearly perpendicular. Faults range up to 10 miles in length, but most are between 2 and 5 miles long. Displacements are commonly between 20 and 30 feet.

Apparently the bathymetric high charted offshore from the western end of Galveston Island, which controls nearby surface sediment types, is fault-related. In fact, comparing the position of potentially active faults with the surface sediment distribution suggests that subtle sea-floor irregularities, and larger-scale sea floor relief caused by active faults, are both responsible for some of the variability in sediment types.

Upper coast. Faulting east of Galveston Island is sparse, and it is concentrated in two areas, near the southern end of Bolivar Peninsula and west of Sabine Pass. Faults are similar in both areas. The most extensive faults are 5 miles long, but most are 2 to 3 miles long. The faults, which are generally parallel to the coast, have displacements up to 50 feet, but displacements of 20 to 30 feet are most usual.

Origin of Faulting

Over the past few decades, several theories explaining the origin of regional Gulf Coast faulting have been advanced. Most of the theories centered around the sedimentation style within the basin, and the fact that thick clastic wedges of fluvial-deltaic and shallow marine sediment are developed with basin subsidence, and the fact that the clastic wedges overlie a mobile salt bed. The earlier theories were based on gravity sliding, recognizing that many of the faults merge with bedding planes at depth. Gravity sliding clearly is responsible for some of the faulting, for example at the shelf break, but other mechanisms may also be important. Although basement involvement has been documented in some instances (Shelton, 1968), most of the theories do not require basement tectonics, and the faulting generally is restricted to the sediment column. In fact, some faults are known to die out at depth.

More specific mechanisms for the origin of faulting that have been proposed include differential sediment compaction (Carver, 1968), salt tectonics (Quarles, 1953), and deformation related to the geopressured shale section common throughout the northern Gulf of Mexico (Bruce, 1973). sll of these theories have merit, and it is doubtful that a single mechanism is responsible for all faulting. It appears rather that these mechanisms are interdependent and cannot be completely isolated.

Diapiric Structures

Piercement structures (Braunstein and O'Brien, 1938) on the inner shelf that penetrate the sediment column near the sea-floor (Fig. 8) are restricted to an area between Sabine Pass and San Luis Pass. Deep-seated massifs are also marked by structural highs with roughly circular closure, but mapping was limited to those structures whose mobile sediment core appeared on the geophysical records. The three structures that exhibited these characteristics are probably salt spines, but they also could be caused by shale diapirs. Diameters of the three diapirs are generally 2 miles or less. Depth to the mobile sediment ranges from less than 200 feet, to greater than 2,000 feet.

Sea-floor expression of diapiric structures is imperceptible on fathometer records; however, surface sediment maps show subtle changes in sediment type near these structures, which suggests some change in sea-floor slope. Changes in bathymetry related to faults are certainly more evident than changes related to diapiric structures.

Status of Inner Shelf Program

Substantial progress was made for all major tasks proposed for the first 2 years; studies in the field of shelf biology have not yet been completed.

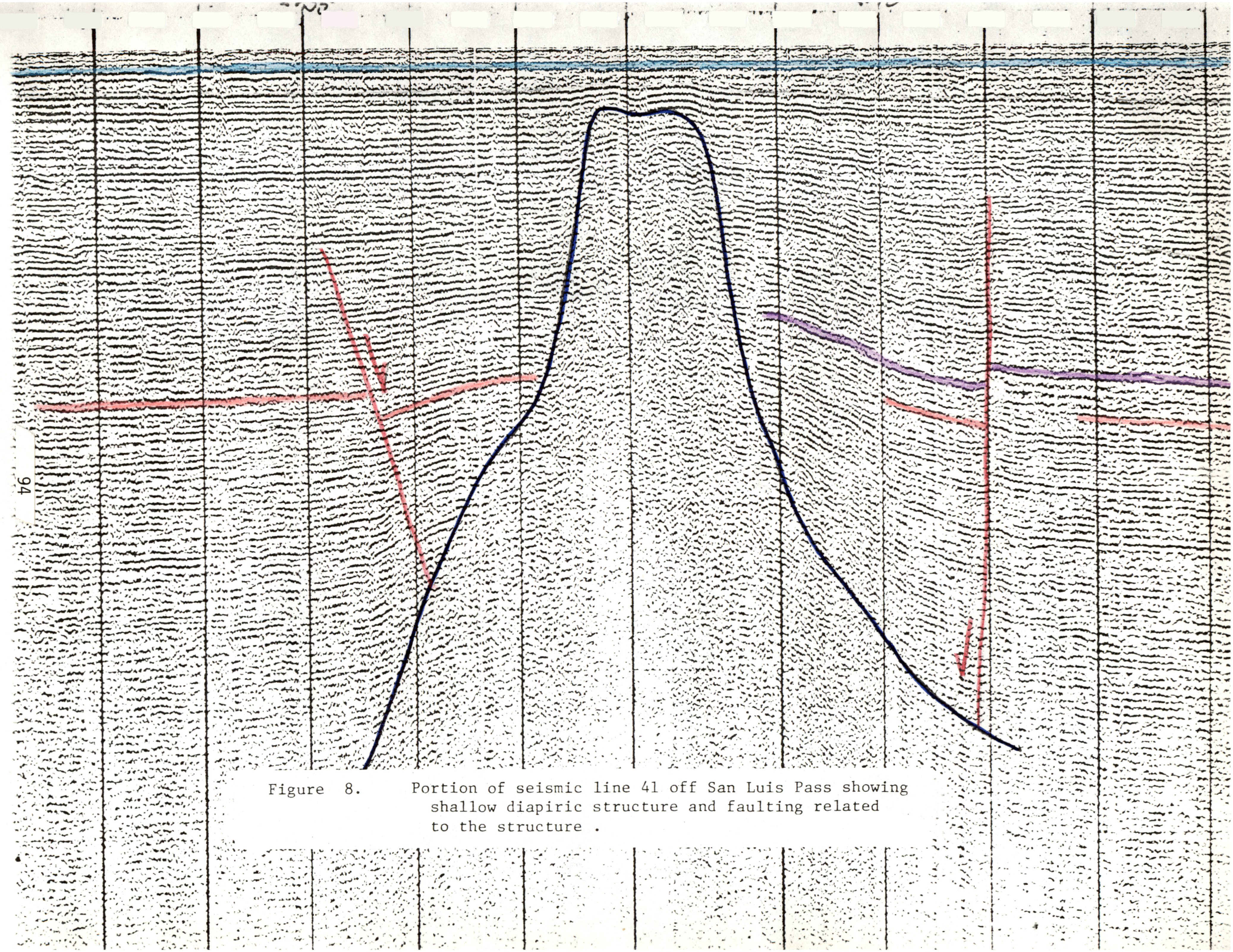

Figure 8. Portion of seismic line 41 off San Luis Pass showing shallow diapiric structure and faulting related to the structure .

Sediment sampling was completed except for two areas between Galveston and Sabine Pass; inclement weather and navigation interference prevented acquisition of these samples. To date 3,500 samples from the Texas shelf have been collected, and it is anticipated that the remainder of the sampling will be completed by October, 1977 (Table 1).

Geographical surveys of the inner shelf are complete, and preliminary maps of faults and shallow diapiric structures, interpreted from those surveys, accompany this report (Table 2). Despite the presently available good geophysical control, including over 3,000 nautical miles of profiles, additional offshore data for the upper coast would be valuable for establishing the regional structural and stratigraphic framework.

Sediments sub-sampled for semi-quantitative geochemical determinations have been submitted for analyses to the U. S. Geological Survey. Chemical analyses have been completed for 570 samples, showing the regional distribution of trace elements between the Rio Grande River and the Matagorda Ship Channel (see accompanying maps). Analyses of the 180 samples selected for the same regional distribution on the upper coast should be available in the near future. Total organic carbon analyses have been completed for essentially all shelf samples between the Rio Grande River and the Matagorda Ship Channel. The remaining samples are awaiting preparation and analysis. Textural analyses of the coarse fraction ($<$ 0.625 mm) are in progress on the same samples under analysis for trace element content.

As mentioned above, the biological studies on the inner shelf have been limited, primarily because the number of samples, the large amount of shell material in some samples, and the diversity of the fauna all necessitate more time than was expected for processing. This effort was being conducted by the U. S. Geological Survey because of their ability and previous experience;

however, unanticipated changes in personnel, coupled with a lack of manpower at the U. S. G. S., have caused additional delays. Biological studies by the Bureau of Economic Geology will be expanded in the future to include the shelf samples.

Future Studies, Fiscal Year 1978-1979

Because of the lack of significant results for shelf benthos, major emphasis will be placed on establishing the regional distribution of biologically productive areas. Ancillary studies will include (1) species diversity; (2) counts of live and dead fauna; and (3) identification of allocthanous and autochthonous assemblages.

Analyses of sediment textures and trace element concentrations will also continue, as will geophysical interpretations. The seismic interpretations will be hampered, however, unless relatively deep core data are available to characterize the subsurface lithologies and depositional environments. Perhaps one method of acquiring such information would be to use available soils boring records obtained for structural design purposes at sites of offshore platforms and navigation projects.

The production of detailed structure and isopach maps, seismic-stratigraphic interpretations, and the Late Quaternary geologic history all will depend largely on the acquisition of core data. Shallow box cores, piston cores, or vibracores would also be valuable, but for different purposes than the deep cores. The shallow cores would provide additional sedimentological data on the relative importance of physical and biological processes in sediment transport and deposition.

SUMMARY AND CONCLUSIONS

1. During Fiscal Year 1976-1977, the Bureau of Economic Geology, in cooperation with the U. S. Geological Survey, completed an extensive data

acquisition and preliminary analysis program of all submerged Texas lands from rivers to 10.3 miles (3 leagues) on the continental shelf. The sampling program was coordinated and integrated with similar studies by the U. S. Geological Survey and the U. S. Bureau of Land Management on the adjacent Federal O.C.S. in South Texas.

2. The program initially involved sample collection and preliminary sample and geophysical analyses. Principal elements of sample analysis include textural/sediment studies, biologic assemblage studies, geochemical (trace element, organic carbon, uranium equivalent) determinations, and permanent storage of contingency samples and bathymetric/geophysical data. The geophysical program involves fault interpretation, salt diapir recognition, structural evaluation and seismic-stratigraphic analyses to determine three-dimensional distribution of subsurface compositional and structural units and elements, respectively.

3. By August, 1977, the status of the sample and analysis programs was as follows: 6,697 sediment samples collected on a one-mile grid; 3,197 biologic samples collected on selected 1-to-4-mile grid; and 4,100 nautical miles of high resolution seismic geophysics profiles. Analyses completed by August, 1977, include the following: 3,088 total organic carbon determinations; 1,107 20/30 trace-element analyses; 580 preliminary biologic assemblage analyses; and fault mapping for the entire Texas inner continental shelf.

4. During FY 1977 the Bureau initiated the extensive mapping program that will result in FY 1978-1979 in scores of maps depicting the nature and distribution of basic data, derived data, interpretative results, and recommendations for coastal management. Two base maps with all sample stations

(and numbers) and all geophysical lines, respectively, were prepared to present visually the results of the program.

5. Maps prepared or under preparation in August, 1977, include the following: surface sediment; total organic carbon; biologic assemblages, faults and diapiric structures; sediment textural parameters (analysis only initiated); and nine (of 20/30) most abundant trace elements. Current studies now underway will expand these basic maps toward interpretive and derivative types.

6. Beginning with FY 1978, following the completion of the first comprehensive phase of data acquisition on Texas submerged lands, the Coastal Zone program will enter the second phase of analytical, interpretive, and comprehensive mapping studies. These are designed to provide maximum basic information to support coastal management planning and decision-making. This second phase is designed to process and extract all the information possible from the coastal data system. Continued chemical, biological, geophysical, and geological analyses will provide an exhaustive natural resources data base for coastal management. Coring at selected locations will provide three-dimensional information on geochemistry, composition, and engineering factors that can be extrapolated, using interconnecting seismic records, from beneath the Texas inner continental shelf.

7. The growing geological, biological and geochemical data base during FY 1978-79 will enable the Bureau to respond to the needs of the Coastal Management Program of the General Land Office for natural resource data required in evaluating various coastal development scenarios. Natural limitations or attributes of different parts of the Texas coast for various types of development can be supplied quickly in an easily-applied format.

8. A variety of timely scientific studies are now possible with the growing volume of information about the Texas toastal Zone derived from this program and from other integrated Bureau studies (landsat, Environmental Atlas, Coastal Hazards, Shoreline Erosion, Geothermal Assessment, Coastal Management [NSF-RANN] Alternatives, Land Resource Mapping/Evaluation, among others. These studies of sediment budget, three-dimensional geology, coastal processes research, and the others under Bureau investigation provide the potential for an even greater degree of prediction for not only solving, but for preventing (or, at least, forecasting) future critical natural problems in the coastal zone.

9. The program is providing information that will be published by the Bureau and the General Land Office in an open-ended series of reports and atlases over the next several years, thus providing the public sector with a superior scientific data base for state lands. Furthermore, the data can be utilized by other State and Federal agencies involved in regulation and evaluation of coastal areas. Computer storage in the Natural Resource Information System will provide access to a broad range of individuals and agencies.

10. The Texas submerged lands program, currently in progress at the Bureau of Econic Geology, has reached its first goal--acquisition and preliminary analysis/mapping of data. The program is already entering the next phase of analytical analysis, interpretation, and mapping to provide needed natural resources information for the Coastal Management Program of the General Land Office of Texas. Furthermore, the program is providing both the data and the insights necessary to develop even more accurate forecasting methods for predicting the future of Texas natural coastal systems

SELECTED REFERENCES

Andrews, P. B., 1964, Serpulid reefs, Baffin Bay, southeast Texas; in Field Trip Guidebook, Depositional Environments, South-Central Texas Coast, Oct. 30-31, 1964, Gulf Coast Association of Geological Societies, p. 102-120.

Andrews, P. B., 1970, Facies and genesis of a hurricane-washover fan, St. Joseph Island, central Texas coast: University of Texas, Austin, Bureau of Economic Geology Rept. Inv. 67, 147 p.

Behrens, E. W., 1964, Oolite formation in Baffin Bay and Laguna Madre, Texas; in Field Trip Guidebook, Depositional Environments, South-Central Texas Coast, Oct. 30-31, 1964, Gulf Coast Association of Geological Societies, p. 83-100.

Behrens, E. W., 1969, Hurricane effects on a hypersaline bay; in Coastal Lagoons, A symposium, UNESCO, p. 301-308.

Bernard, H. A., LeBlanc, R. J., and Major, C. F., 1962, Recent and Pleistocene geology of southeast Texas in Geology of the Gulf Coast and central Texas and guidebook of excursions: Houston Geological Society, pp. 175-224.

Braunstein, J., and O'Brien, G. D., 1968, Diapirism and diapirs: American Association of Petroleum Geologists, Memoir 8, Tulsa, Oklahoma, 444 p.

Brown, L. F., Jr., Brewton, J. L., McGowen, J. H., Evans, T. J., Fisher, W. L., and Groat, C. G., 1976, Environmental geologic atlas of the Texas coastal zone -- Corpus Christi area: University of Texas, Austin, Bur. Econ. Geology, 123 p.

Brown, L. F., Jr., McGowen, J. H., Evans, T. J., Groat, C. G., and Fisher, W. L., in press, Environmental geologic atlas of the Texas coastal zone -- Kingsville area: University of Texas, Austin, Bur. Econ. Geology.

Brown, L. F., Jr., Brewton, J. S., Evans, T. J., McGowen, J. H., Groat, C. G., and Fisher, W. L., in preparation, Environmental geologic atlas of the Texas coastal zone -- Brownsville-Harlingen area: Univ. Texas, Bur. Econ. Geology.

Bruce, C. H., 1973, Pressured shale and related sediment deformation: Mechanism for development of regional contemporaneous faults: American Association of Petroleum Geologists Bulletin, v. 57, pp. 878-886.

Bullard, F. M., 1942, Source of beach and river sands on Gulf Coast of Texas: Geological Society of America Bulletin, v. 53, pp. 1021-1043.

Carr, J. T., Jr., 1967, The climate and physiography of Texas: Texas Water Development Board Rept. 53, 35 p.

Carver, R. E., 1968, Differential compaction as a cause of regional contemporaneous faults: American Association of Petroleum Geologists Bulletin, v. 52, p. 414-419.

Curray, J. R., 1960, Sediments and history of Holocene transgression, continental shelf, Northwest Gulf of Mexico in Shepard, F. P., Phleger, F. B., and Van Andel, T. H., eds., Recent sediments, northwest Gulf of Mexico: Tulsa, Oklahoma, American Association of Petroleum Geologists, pp. 221-266.

Dalrymple, D. W., 1964, Recent sedimentary facies of Baffin Bay, Texas: Rice University, Ph.D. dissert., 192 p.

Emery, K. O., 1968, Relicit sediments on the continental shelves of the world: American Association of Petroleum Geologists Bulletin, v. 52, pp. 445-464.

Fisk, H. N., 1959, Padre Island and Laguna Madre flats, coastal south Texas: Second Coastal Geography Conference, p. 103-151.

Frishman, S. A., 1969, Geochemistry of oolites, Baffin Bay, Texas: Univ. Texas, Austin, Master's thesis, 82 p.

Garrison, L. D., and Berryhill, H. L., Jr., 1970, Possible extension of the San Marcos Arch: Geological Society of America, abstract with program, v. 2, no: 4, pp. 285-286.

Goldstein, A., Jr., 1942, Sedimentary petrologic provinces of the northern Gulf of Mexico: Journal of Sedimentary Petrology, v. 12, pp. 77-84.

Grim, R. E., and Johns, W. D., 1954, Clay mineral investigation of sediments in the Gulf of Mexico: Proc. Second National Conference on Clays and Clay Minerals, National Academy of Sciences, Natural Resources Council, Pub. 327, pp. 81-103.

Grime, D. J., and Marranzino, A. P., 1968, Direct current arc and alternating current spark emission spectrographic field methods for the semi-quantitative analysis of geologic materials: U.S. Geol. Survey, Circ. 591, 6 p.

Hoover, R. A., 1968, Physiography and surface sediment facies of a recent tidal delta, Harbor Island, central Texas coast: Univ. Texas, Austin, Ph.D. dissert., 184 p.

McGowen, J. H., and Brewton, J. L., 1975, Historical changes and related coastal processes, Gulf and mainland shorelines, Matagorda Bay area, Texas: Univ. Texas, Austin, Bur. Econ. Geology, Spec. Pub., 72 p.

McGowen, J. H., Brown, L. F., Jr., Evans, T. J., Fisher, W. L., and Groat, C. G., 1976a, Environmental geologic atlas of the Texas coastal zone -- Bay City-Freeport area: Univ. Texas, Austin, Bur. Econ. Geology, 98 p.

McGowen, J. H., Proctor, C. V., Jr., Brown, L. F., Jr., Evans, T. J., Fisher, W. L., and Groat, C. G., 1976b, Environmental geologic atlas of the Texas coastal zone -- Port Lavaca area: Univ. Texas, Austin, Bur. Econ. Geology, 107 p.

Morton, R. A., 1966, Clay mineralogy and boron in some recent sediments, Northwest Gulf of Mexico: M.S. thesis, West Virginia University, Morgantown, 54 p.

Morton, R. A., 1972, Clay mineralogy of Holocene and Pleistocene sediments, Guadalupe delta of Texas: Journal Sedimentary Petrology, v. 42, pp. 85-88.

Munson, M. G., 1975, Tidal delta facies relationships, Harbor Island, Texas: Univ. Texas, Austin, Master's thesis, 126 p.

Murray, G. E., 1961, Geology of the Atlantic and Gulf Coastal Province of North America: Harper and Brothers, New York, 692 p.

Nelson, H. F., and Bray, E. E., 1970, Stratigraphy and history of the Holocene sediments in the Sabine-High Island area, Gulf of Mexico <u>in</u> Deltaic sedimentation, modern and ancient: Society of Economic Paleontologists and Mineralogists Special Publication 15, pp. 48-77.

Nordquist, R. W., 1972, Origin, development, and facies of a young hurricane washover fan on souther St. Joseph Island, central Texas coast: Univ. Texas, Austin, Master's thesis, 103 p.

Parker, R. H., 1960, Ecology and distributional patterns of marine macro-invertebrates, northern Gulf of Mexico <u>in</u> Shepard, F. P., Phleger, F. B. and van Andel, T. H., eds., Recent sediments, northwest Gulf of Mexico, Tulsa, Okla., Am. Assoc. Petroleum Geologists, p. 302-337.

Price, W. A., 1952, Reduction of maintenance by proper orientation of ship channels through tidal inlets: Texas A & M College, Contributions to Oceanography and Meteorology, p. 101-113.

Price, W. A., 1956, Northbeach study for the city of Corpus Christi: Corpus Christi, Texas, Zoning and Planning Dept., City Hall, Rept. on file, 120 p.

Quarles, M. W., Jr., 1953, Salt-ridge hypothesis on origin of Texas Gulf Coast type of faulting: American Association of Petroleum Geologists Bulletin, v. 37, pp. 489-508.

Shelton, J. W., 1968, Contemporaneous faulting during basinal subsidence: American Association of Petroleum Geologists Bulletin, v. 52, pp. 399-413.

Shepard, F. P., 1932, Sediments of the continental shelves: Geological Society of America Bulletin, v. 43, pp. 1017-1040.

Stetson, H. C., 1953, The sediments of the western Gulf of Mexico. Part I The continental terrace of the western Gulf of Mexico: its surface sediments, origin, and development: Papers in Physical Oceanography and Meterology of Massachusetts Institute of Technology and Woods Hole Oceano. Institute, v. 12, 45 p.

Thayer, P. A., LaRocque, A., Tunnell, J. W., Jr., 1974, Relict lacustrine sediments on the inner continental shelf, southeast Texas: Trans. Gulf Coast Assoc. Geol. Society, v. 24, pp. 337-347.

Van Andel, T. H., and Poole, D. M., 1960, Sources of recent sediments in the northern Gulf of Mexico: Journal Sed. Petrology, v. 30, pp. 91-122.

Wadsworth, A. H., Jr., 1941, The lower Colorado River, Texas: Univ. Texas, Austin, Master's thesis, 61 p.

Wadsworth, A. H., Jr., 1966, Historical deltation of the Colorado River, Texas in Shirley, J. L., and Rogedale, J. A., eds., Deltas in their geologic framework: Houston, Texas, Houston Geol. Soc., p. 99-105.

Watson, R. L., and Behrens, E. W., 1976, Hydraulics and dynamics of New Corpus Christi Pass, Texas: A case history, 1973-75: U.S. Army Coastal Engineering Research Center, GITI Rept. 9, 175 p.

Zupan, A. J. W., 1970, Surficial sediments and sedimentary structures: Middle Ground, Padre Island, Texas: Texas A & M University, Dept. Oceanography, Report 71-12-T, May 1970, 71 p.

APPENDIX A

PRELIMINARY BIOLOGIC ASSEMBLAGES

APPENDIX A:

Beaumont-Port Arthur Map Area

SABINE LAKE-NECHES RIVER
Inlet Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		24	24	32.88
Petricola pholadiformis	2		2	2.74
Nuculana concentrica		2	2	2.74
Crassostrea virginica		2	2	2.74
Nuculana acuta		1	1	1.37
Parvilucina multilineata		1	1	1.37
Anadara transversa		1	1	1.37
Pandora trilineata		1	1	1.37
TOTALS	2	32	34	46.58
Gastropoda				
Anachas obesa		19	19	26.03
Nassarius vibex	1	6	7	9.59
Odostomia teres		6	6	8.22
Acteocina canaliculata		3	3	4.11
Epitonium rupicola		2	2	2.74
Littoridina sphinctostoma		1	1	1.37
Teinostoma biscaynense		1	1	1.37
TOTALS	1	38	39	53.43

*Live and paired dead valves were counted as 1; unpaired valves as ½.

SABINE LAKE-NECHES RIVER
River-Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Rangia cuneata	55	111	166	66.13
Mytilopsis leucophaeata	2	33	35	13.94
Macoma mitchelli	8		8	3.19
Brachidontes exustus		5	5	1.99
Mulinia lateralis	2	2	4	1.59
Macoma sp. (juveniles)	3		3	1.19
Crassostrea		2	2	.80
Family Tellinidae (juveniles)	2		2	.80
Brachidontes sp. (juvenile)	1		1	.40
Anomia simplex		1	1	.40
TOTALS	73	154	227	90.43
Gastropoda				
Littoridina sphinctostoma	7	13	20	7.97
Anachas obesa		2	2	.80
Odostomia impressa		1	1	.40
Nassarius vibex		1	1	.40
TOTALS				

*Live and paired dead valves were counted as 1; unpaired valves as ½.

APPENDIX A:

Houston-Galveston Map Area

GALVESTON-TRINITY BAYS
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	8	16	24	61.54
Macoma mitchelli	6		6	15.38
Brachidontes exustus		1	1	2.56
Tagelus plebius	1		1	2.56
Periploma margaritaceum		1	1	2.56
TOTALS	15	18	33	84.60
Gastropoda				
Littoridina sphinctostoma	1	2	3	7.69
Acteocina canaliculata	1	1	2	5.13
Polinices duplicatus		1	1	2.56
TOTALS	2	4	6	15.38

*Live and paired dead valves were counted as 1; unpaired valves as ½.

GALVESTON-TRINITY BAYS
Reef Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		10	10	25.00
Crassostrea virginica		3	3	7.50
Brachidontes exustus		2	2	5.00
Rangia cuneata		2	2	5.00
Ischadium recurvum		1	1	2.50
Tellina texana		1	1	2.50
TOTALS		19	19	47.50
Gastropoda				
Odostomia impressa		8	8	20.00
Crepidula plana		6	6	15.00
Anachas obesa		2	2	5.00
Littoridina sphinctostoma		2	2	5.00
Odostomia teres		1	1	2.50
Mangelia sp. "A"		1	1	2.50
Vitrinella floridana		1	1	2.50
TOTALS		21	21	52.5

*Live and paired dead valves were counted as 1; unpaired valves as ½.

GALVESTON-TRINITY BAYS
Inlet Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	1	52	53	30.64
Petricola pholadiformis	10	3	13	7.51
Anadara transversa		9	9	5.20
Abra aequalis	1	6	7	4.05
Ostrea equestris		6	6	3.47
Crassinella lunulata		5	5	2.89
Pandora trilineata	1	2	3	1.73
Corbula dietziana		2	2	1.16
Semele proficua		2	2	1.16
Donax variabilis		2	2	1.16
Chione cancellata	1	1	2	1.16
Mysella planulata		2	2	1.16
Anadara ovalis		1	1	.58
Nuculana concentrica		1	1	.58
Anomia simplex		1	1	.58
Aligena texasiana		1	1	.58
Lyonsia hyalina floridana	1		1	.58
Dosinia discus		1	1	.58
TOTALS	15	97	112	64.77
Gastropoda				
Anachas obesa	2	11	13	7.51
Natica pusilla		6	6	3.47
Acteocina canaliculata	1	5	6	3.47
Crepidula plana		5	5	2.89
Nassarius vibex		4	4	2.31
Odostomia teres		4	4	2.31
Caecum nitidum		4	4	2.31
Turbonilla interrupta	1	2	3	1.73
Vitrinella floridana		3	3	1.73
Caecum pulchellum		2	2	1.16
Epitonium ripicola		2	2	1.16
Pyramidella crenulata		1	1	.58
Epitonium angulatum		1	1	.58
Polinices duplicatus		1	1	.58
Odostomia laevigata		1	1	.58
Mangelia sp. "B"		1	1	.58
Thais haemastoma canaliculata		1	1	.58
Odostomia impressa		1	1	.58
Teinostoma biscaynense		1	1	.58
TOTALS	4	56	60	34.69
Scaphopoda				
Dentalium texasianum		1	1	.58

*Live and paired dead valves were counted as 1; unpaired valves as ½.

GALVESTON-TRINITY BAYS
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		48	48	81.36
Macoma mitchelli		2	2	3.39
Tagelus divisus		1	1	1.69
Anomia simplex		1	1	1.69
TOTALS		52	52	88.13
Gastropoda				
Odostomia teres		2	2	3.39
Crepidula fornicata		1	1	1.69
Acteocina canaliculata		1	1	1.69
Littoridina sphinctostoma		1	1	1.69
Nassarius vibex		1	1	1.69
Turbonilla interrupta		1	1	1.69
TOTALS		7	7	11.84

*Live and paired dead valves were counted as 1; unpaired valves as ½.

GALVESTON-TRINITY BAYS
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	8	38	46	50.00
Macoma mitchelli	1	14	15	16.30
Crassostrea virginica		6	6	6.52
Rangia cuneata		4	4	4.35
Ostrea equestris		1	1	1.09
Tellina texana	1		1	1.09
Mytilopsis leucophaeata		1	1	1.09
Anomia simplex		1	1	1.09
TOTALS	10	65	75	81.53
Gastropoda				
Littoridina sphinctostoma	1	12	13	14.13
Crepidula plana		1	1	1.09
Vitrinella floridana		1	1	1.09
Odostomia laevigata		1	1	1.09
Vermicularia fargoi		1	1	1.09
TOTALS	1	16	17	18.49

*Live and paired dead valves were counted as 1; unpaired valves as ½.

WEST GALVESTON BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	34	57	91	64.08
Mysella planulata	1	4	5	3.52
Lyonsia hyalina floridana	5		5	3.52
Aligena texasiana		3	3	2.11
Nuculana acuta	1	1	2	1.41
Chione cancellata		1	1	.70
Ostrea equestris		1	1	.70
Nuculana concentrica		1	1	.70
Ensis minor		1	1	.70
TOTALS	41	69	110	77.44
Gastropoda				
Acteocina canaliculata	1	12	13	9.15
Crepidula plana	1	4	5	3.52
Turbonilla interrupta		4	4	2.82
Turbonilla aequalis		3	3	2.11
Acteon punctostriatus	1	2	3	2.11
Odostomia teres		3	3	2.11
Teinostoma biscaynense		1	1	.70
TOTALS	3	29	32	22.52

*Live and paired dead valves were counted as 1; unpaired valves as ½.

WEST GALVESTON BAY
Inlet Influence Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	9	2	11	23.91
Anadara transversa		2	2	4.35
Corbula swiftiana		2	2	4.35
Mysella planulata		2	2	4.35
Tellina texana	1	1	2	4.35
Linga amiantus	1		1	2.17
Nuculana acuta		1	1	2.17
Crassinella lunulata		1	1	2.17
Anadara ovalis		1	1	2.17
Ostrea equestris		1	1	2.17
Aligena texasiana		1	1	2.17
TOTALS	11	14	25	54.33
Gastropoda				
Acteocina canaliculata	3	4	7	15.22
Polinices duplicatus	1	4	5	10.87
Odostomia teres	1	2	3	6.52
Turbonilla interrupta	1	1	2	4.35
Nassarius acutus		2	2	4.35
Turbonilla aequalis		1	1	2.17
Anachis obesa	1		1	2.17
TOTALS	7	14	21	45.65

*Live and paired dead valves were counted as 1; unpaired valves as ½.

WEST GALVESTON BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	22	97	119	56.67
Aligena texasiana		8	8	3.81
Ensis minor	8	3	11	5.24
Periploma margaritaceum	4	2	6	2.86
Tagelus plebius		5	5	2.38
Mysella planulata	1	3	4	1.90
Laevicardium mortoni		3	3	1.43
Macoma mitchelli		2	2	.95
Tellina sp. "A"		2	2	.95
Chione cancellata		1	1	.48
Lyonsia hyalina floridana		1	1	.48
Anomia simplex		1	1	.48
Petricola pholadiformis		1	1	.48
Coralliophaga coralliophaga		1	1	.48
TOTALS	35	130	165	78.59
Gastropoda				
Acteocina canaliculata	4	11	15	7.14
Diastoma varium		9	9	4.29
Acteon punctostriatus	1	5	6	2.86
Credpidula plana		2	2	.95
Turbonilla interrupta		2	2	.95
Odostomia teres	1	1	2	.95
Mitrella lunata		3	3	1.43
Odostomia laevigata		2	2	.95
Crepidula fornicata		2	2	.95
Caecum pulchellum		1	1	.48
Sayella livida		1	1	.48
TOTALS	6	39	45	21.43

*Live and paired dead valves were counted as 1; unpaired valves as ½.

CHRISTMAS BAY
Inlet Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mysella planulata	14	42	56	20.14
Aligena texasiana	20	18	38	13.67
Mulinia lateralis	2	13	15	5.40
Periploma cf. fragile	14	1	15	5.40
Chione cancellata	1	3	4	1.44
Tagelus divisus	2	2	4	1.44
Nuculana acuta		3	3	1.08
Pandora trilineata	1	2	3	1.08
Anadara transversa		2	2	.72
Anadara ovalis		2	2	.72
Corbula swiftiana		2	2	.72
Abra aequalis	1	1	2	.72
Corbula dietziana		2	2	.72
Argopecten amplicostata		1	1	.36
Anomia simplex		1	1	.36
Tellina texana		1	1	.36
Nuculana concentrica		1	1	.36
Ostrea equestris		1	1	.36
Crassinella lunulata		1	1	.36
TOTALS	55	99	154	55.41
Gastropoda				
Diastoma varium		45	45	16.19
Turbonilla interrupta	2	35	37	13.31
Acteocina canaliculata		15	15	5.40
Turbonilla aequalis		6	6	2.16
Mitrella lunata		3	3	1.08
Odostomia laevigata		2	2	.72
Crepidula plana		2	2	.72
Mangelia sp. "A"		2	2	.72
Polinices duplicatus	1	1	2	.72
Triphora nigrocincta		1	1	.36
Cerithium sp.		1	1	.36
Odostomia teres		1	1	.36
Vitrinella floridana		1	1	.36
Caecum pulchellum		1	1	.36
Teinistoma biscaynense		1	1	.36
Littoridina sphinctostoma		1	1	.36
Acteon punctostriatus		1	1	.36
Circulus suppressus		1	1	.36
Anachas obesa		1	1	.36
TOTALS	3	121	124	44.62

*Live and paired dead valves were counted as 1; unpaired valves as ½.

BASTROP BAY
Reef Molluscan Fauna

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	6	7	13	43.33
Mysella planulata		4	4	13.33
Ostrea equestris		2	2	6.66
Ischadium recurvum		1	1	3.33
Abra aequalis		1	1	3.33
Crassostrea virginica		1	1	3.33
Tagelus plebius		1	1	3.33
Numerous Ostrea and Crassostrea fragments				
TOTALS	6	17	23	76.64
Gastropoda				
Acteocina canaliculata	1	2	3	10.00
Acteon punctostriatus		1	1	3.33
Odostomia impressa		1	1	3.33
Turbonilla interrupta		1	1	3.33
Crepidula plana		1	1	3.33
TOTALS	1	6	7	23.32

*Live and paired dead valves were counted as 1; unpaired valves as ½.

APPENDIX A:

Port Lavaca Map Area

ESPIRITU SANTO BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Nuculana acuta		12	12	.73
Chione cancellata		12	12	.73
Anomalocardia auberiana		10	10	.61
Lucina pectinatus	8		8	.48
Parvilucina multilineata		6	6	.36
Carditamera floridana		6	6	.36
Tellina tampaensis		4	4	.24
Brachidontes exustus		2	2	.12
Anadara transversa		2	2	.12
Anomia simplex		2	2	.12
Laevicardium mortoni		2	2	.12
Ostrea equestris		2	2	.12
Corbula swiftiana		2	2	.12
Mulinia lateralis		1	1	.06
Donax variabilis		1	1	.06
Mactra fragilis		1	1	.06
Tagelus plebius		1	1	.06
TOTALS	8	64	72	4.35
Gastropoda				
Cerithium sp.		574	574	34.79
Diastoma varium		456	456	27.64
Caecum pulchellum		176	176	10.67
Vermicularia fargoi		100	100	6.1
Littoridina sphinctostoma		96	96	5.82
Acteocina canaliculata		88	88	5.33
Sayella livida		12	12	.73
Mitrella lunata		12	12	.73
Odostomia laevigata		12	12	.73
Pyramidella sp. "A"	8	4	12	.73
Mangelia sp. "A"		8	8	.48
Truncatella pulchella		4	4	.24
Crepidula fornicata		4	4	.24
Anachis obesa		4	4	.24
Cerithidea pliculosa		4	4	.24
TOTALS	8	1554	1562	94.71
Scaphopoda				
Dentalium texasianum		16	16	1.2

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ESPIRITU SANTO BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Aligena texasiana		45	45	5.36
Mysella planulata		21	21	2.50
Mulinia lateralis	1	18	19	2.26
Nuculana acuta		10	10	1.19
Chione cancellata		8	8	.95
Anomia simplex		7	7	.83
Lyonsia hyalina floridana	7		7	.83
Tagelus sp. (juvenile)	6	1	7	.83
Ostrea equestris		5	5	.60
Abra aequalis		5	5	.60
Brachidontes exustus		4	4	.48
Pandora trilineata		4	4	.48
Nuculana concentrica		3	3	.36
Tellina alternata		3	3	.36
Parvilucina multilineata		3	3	.36
Anomalocardia auberiana		3	3	.36
Anadara transversa		2	2	.24
Corbula swiftiana		2	2	.24
Laevicardium mortoni		2	2	.24
Tagelus divisus		2	2	.24
Trachycardium muricatum		2	2	.24
Tellina tampaensis		2	2	.24
Argopecten amplicostatus		1	1	.12
Anatina anatina		1	1	.12
Diplothyra smithii		1	1	.12
Cyclinella tenuis		1	1	.12
Cyrtopleura costata		1	1	.12
Crassinella lunulata		1	1	.12
Macoma tenta		1	1	.12
Mactra fragilis		1	1	.12
Crassostrea virginica		1	1	.12
Lucina pectinatus	1		1	.12
TOTALS	15	161	176	20.99
Gastropoda				
Diastoma varium		146	146	17.38
Cerithium sp.		118	118	14.05
Acteocina canaliculata	1	66	67	7.98
Turbonilla aequalis	1	45	46	5.48
Turbonilla interrupta	1	42	43	5.12
Vermicularia fargoi		32	32	3.81
Caecum pulchellum		30	30	3.57
Acteon punctostriatus		26	26	3.10
Crepidula plana		23	23	2.74
Odostomia teres	5	17	22	2.62

continued on next page

	Live	Dead	Total	Percent of total fauna
Littoridina sphinctostoma		15	15	1.79
Mitrella lunata		14	14	1.67
Vitrinella floridana		13	13	1.55
Odostomia laevigata		10	10	1.19
Caecum glabrum	1	7	8	.95
Odostomia acutidens		6	6	.71
Crepidula fornicata		6	6	.71
Sayella livida		6	6	.71
Mangelia sp. "A"	1	4	5	.59
Odostomia bushiana		4	4	.48
Polinices duplicatus	1	3	4	.48
Epitonium rupicola		4	4	.48
Cerithidea pliculosa		4	4	.48
Haminoea succinea		3	3	.36
Caecum nitidum		2	2	.24
Diodora cayenensis		2	2	.24
Anachis obesa		1	1	.12
Turbonilla sp. "B"		1	1	.12
Cerithiopsis greeni		1	1	.12
Odostomia impressa		1	1	.12
Teinostoma biscaynense		1	1	.12
TOTALS	11	653	664	79.08

*Live and paired dead valves were counted as 1; unpaired valves as ½.

SAN ANTONIO BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	82	78	160	38.5
Macoma mitchelli		9	9	2.17
Rangia cuneata	1	6	7	1.69
Anomia simplex		6	6	1.45
Brachidontes exustus		3	3	.72
Mysella planulata		2	2	.48
Nuculana acuta		1	1	.24
Aligena texasiana		1	1	.24
Nuculana concentrica		1	1	.24
Crassostrea virginica		1	1	.24
TOTALS	83	108	191	45.97
Gastropoda				
Littoridina sphinctostoma	3	104	107	25.78
Odostomia acutidens		77	77	18.55
Acteocina canaliculata		12	12	2.89
Caecum pulchellum		9	9	2.17
Odostomia impressa		7	7	1.69
Acteon punctostriatus		4	4	.96
Odostomia teres		3	3	.72
Vitrinella floridana		2	2	.48
Teinostoma biscaynense		2	2	.48
Rissoina catesbyana		1	1	.24
Diastoma varium		1	1	.24
TOTALS	3	222	225	54.20

*Live and paired dead valves were counted as 1; unpaired valves as ½.

SAN ANTONIO BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	7	47	54	9.64
Anomalocardia auberiana		19	19	3.39
Rangia cuneata		5	5	.89
Lucina pectinatus		4	4	.71
Donax variabilis		4	4	.71
Tellina tampaensis	3	1	4	.71
Nuculana acuta		3	3	.54
Anadara transversa		2	2	.36
Anomia simplex		1	1	.18
Brachidontes exustus		1	1	.18
Laevicardium mortoni		1	1	.18
Carditamera floridana		1	1	.18
Crassinella lunulata		1	1	.18
Trachycardium sp. (juvenile)		1	1	.18
TOTALS	10	91	101	18.03
Gastropoda				
Littoridina sphinctostoma	68	141	209	37.32
Cerithium sp.		57	57	10.18
Teinostoma biscaynense	1	57	58	10.36
Diastoma varium		57	57	10.18
Odostomia acutidens	1	50	51	9.11
Acteon punctostriatus		5	5	.89
Odostomia teres		4	4	.71
Odostomia laevigata		2	2	.36
Cyclostremella humilis		2	2	.36
Truncatella pulchella		2	2	.36
Pyramidella crenulata		1	1	.18
Circulus suppressus		1	1	.18
Cerithiopsis greeni		1	1	.18
Mitrella lunata		1	1	.18
Vermicularia fargoi		1	1	.18
Polinices duplicatus		1	1	.18
Caecum nitidum		1	1	.18
Caecum pulchellum		1	1	.18
Turbonilla interrupta		1	1	.18
Odostomia impressa		1	1	.18
Epitonium multistriatum		1	1	.18
Neritina virginea		1	1	.18
TOTALS	70	389	459	81.99

*Live and paired dead valves were counted as 1; unpaired valves as ½.

GUADALUPE BAY
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	1	5	6	14.29
Rangia cuneata	1	1	2	4.76
Nuculana acuta		1	1	2.38
TOTALS	2	7	9	21.43
Gastropoda				
Littoridina sphinctostoma	3	21	24	57.14
Odostomia acutidens		5	5	11.90
Acteocina canaliculata		2	2	4.76
Caecum pulchellum		1	1	2.38
Vitrinella floridana		1	1	2.38
TOTALS	3	30	33	78.56

*Live and paired dead valves were counted as 1; unpaired valves as ½.

HYNES BAY
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	238	199	437	19.82
Rangia cuneata	47	53	100	4.54
Macoma mitchelli		22	22	.10
TOTALS	285	274	569	24.46
Gastropoda				
Littoridina sphinctostoma	271	1344	1615	73.24
Amnicola comalensis		11	11	.50
Acteocina canaliculata		6	6	.27
Odostomia teres		3	3	.14
Acteon punctostriatus		1	1	.05
TOTALS	271	1365	1636	74.2

*Live and paired dead valves were counted as 1; unpaired valves as ½.

(Pagination incorrect; text is complete).

AYERS BAY
Small Enclosed Bay Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		3	3	.60
Macoma mitchelli		1	1	.20
TOTALS		4	4	.80
Gastropoda				
Acteocina canaliculata		1	1	.20

*Live and paired dead valves were counted as 1; unpaired valves as ½.

MESQUITE BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		2	2	14.29
Mysella planulata		2	2	14.29
Anomia simplex		1	1	7.14
Macoma mitchelli		1	1	7.14
Crassinella lunulata		1	1	7.14
Nuculana acuta		1	1	7.14
Aligena texasiana		1	1	7.14
TOTALS		9	9	64.28
Gastropoda				
Vermicularia fargoi		1	1	7.14
Caecum pulchellum		1	1	7.14
Odostomia laevigata		1	1	7.14
Odostomia teres		1	1	7.14
Acteocina canaliculata		1	1	7.14
TOTALS		5	5	35.7

*Live and paired dead valves were counted as 1; unpaired valves as ½.

MESQUITE BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		6	6	18.75
Mysella planulata		1	1	3.13
Brachidontes exustus		1	1	3.13
Chione cancellata		1	1	3.13
Parvilucina multilineata		1	1	3.13
Tellina texana		1	1	3.13
Nuculana acuta		1	1	3.13
Anomalocardia auberiana		1	1	3.13
Parvilucina multilineata		1	1	3.13
Anadara transversa		1	1	3.13
TOTALS		15	15	46.92
Gastropoda				
Diastoma varium		4	4	12.50
Tricolia affinis cruenta		4	4	12.50
Acteocina canaliculata		2	2	6.25
Vermicularia fargoi		2	2	6.25
Cerithium sp.		2	2	6.25
Diodora cayenensis		1	1	3.13
Littoridina sphinctostoma		1	1	3.13
Teinostoma biscaynense		1	1	3.13
TOTALS		17	17	53.14

*Live and paired dead valves were counted as 1; unpaired valves as ½.

CARLOS BAY
Small Enclosed Bay Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Macoma mitchelli		1	1	9.09
Mysella planulata		1	1	9.09
Anomia simplex		1	1	9.09
Anomalocardia auberiana		1	1	9.09
TOTALS		4	4	36.36
Gastropoda				
Odostomia impressa		2	2	18.18
Cerithium sp.		2	2	18.18
Caecum pulchellum		1	1	9.09
Vermicularia fargoi		1	1	9.09
Sayella livida		1	1	9.09
TOTALS		7	7	63.63

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ST. CHARLES BAY
Small Enclosed Bay Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Macoma mitchelli		7	7	5.78
Anomalocardia auberiana		6	6	4.96
Mulinia lateralis	1	5	6	4.96
Nuculana acuta		4	4	3.31
Mysella planulata		4	4	3.31
Laevicardium mortoni		3	3	2.48
Anomia simplex		1	1	.83
Ostrea equestris		1	1	.83
Brachidontes exustus		1	1	.83
Crassostrea virginica		1	1	.83
Corbula contracta		1	1	.83
Crassinella lunulata		1	1	.83
Lucina pectinatus		1	1	.83
TOTALS	1	36	37	30.61
Gastropoda				
Caecum pulchellum		17	17	14.05
Cerithium sp.		11	11	9.09
Odostomia laevigata	1	10	11	9.09
Cerithidea pliculosa		8	8	6.61
Diastoma varium		4	4	3.31
Vermicularia fargoi		4	4	3.31
Odostomia impressa		3	3	2.48
Littoridina sphinctostoma	1	2	3	2.48
Turbonilla aequalis		3	3	2.48
Turbonilla interrupta		3	3	2.48
Circulus suppressus		2	2	1.65
Acteocina canaliculata		2	2	1.65
Odostomia teres		2	2	1.65
Odostomia acutidens		2	2	1.65
Teinostoma biscaynense		1	1	.83
Acteon punctostriatus		1	1	.83
Rissoina catesbyana		1	1	.83
Vitrinella floridana		1	1	.83
Haminoea succinea		1	1	.83
Sayella livida		1	1	.83
Caecum nitidum		1	1	.83
Cerithiopsis greeni		1	1	.83
Modulus modulus		1	1	.83
TOTALS	2	82	84	69.45

*Live and paired dead valves were counted as 1; unpaired valves as ½.

APPENDIX A:

Corpus Christi Map Area

COPANO BAY
Grassflat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Macoma mitchelli	19	2	21	23.59
Mulinia lateralis	1	8	9	10.11
Lucina pectinatus	2		2	2.25
Anomalocardia auberiana		1	1	1.12
Ischadium recurvum		4	4	4.49
Amygdalum papyria	2		2	2.25
TOTALS	24	15	39	43.81
Gastropoda				
Odostomia laevigata	6	13	19	21.35
Diastoma varium	6	5	11	12.36
Cerithium sp.		5	5	5.62
Odostomia impressa		4	4	4.49
Odostomia bisuturalis		2	2	2.25
Acteon punctostriatus		2	2	2.25
Acteocina canaliculata	1		1	1.12
Caecum pulchellum		1	1	1.12
Teinostoma biscaynense		1	1	1.12
Mangelia sp.	1		1	1.12
Turbonilla interrupta		1	1	1.12
Sayella livida		1	1	1.12
Odostomia acutidens		1	1	1.12
TOTALS	14	36	50	56.16

COPANO BAY
Bay Center Molluscan Fauna

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	2	22	24	8.48
Nuculana acuta		14	14	4.95
Macoma mitchelli	8	3	11	3.89
Mysella planulata		12	12	4.24
Anomia simplex		4	4	1.41
Aligena texana		5	5	1.77
Brachidontes exustus		1	1	.35
Semele proficua		1	1	.35
TOTALS	10	62	72	25.44
Gastropoda				
Acteocina canaliculata	1	25	26	9.19
Turbonilla interrupta		33	33	11.66
Cerithium sp.		29	29	10.25
Caecum pulchellum		19	19	6.71
Vitrinella floridana		19	19	6.71
Odostomia laevigata		15	15	5.30
Teinostoma biscaynense		16	16	5.65
Diastoma varium		13	13	4.59
Odostomia impressa	9	10	19	6.71
Odostomia bisuturalis		6	6	2.12
Caecum glabrum		5	5	1.77
Turbonilla aequalis		4	4	1.41
Mitrella lunata		2	2	.71
Crepidula plana		2	2	.71
Mangelia sp.		1	1	.35
Acteon punctostriatus	1		1	.35
Melanella jamaicensis		1	1	.35
TOTALS	11	200	211	74.54

*Live and paired dead valves were counted as 1; unpaired valves as ½.

COPANO BAY
Bay Margin Molluscan Fauna

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	2	36	38	15.70
Macoma mitchelli	12	2	14	5.78
Ensis minor	8		8	2.94
Brachidontes exustus		2	2	.83
Ischadium recurvum		2	2	.83
Anomia simplex		2	2	.83
Anomalocardia auberiana		2	2	.83
Trachycardium muricatum		1	1	.41
Chione cancellata		1	1	.41
Cumingia tellinoides		1	1	.41
Nuculana acuta		1	1	.41
Aligena texasiana		1	1	.41
Lucina pectinatus		1	1	.41
TOTALS	22	52	74	30.20
Gastropoda				
Cerithium sp.		48	48	19.83
Caecum pulchellum		23	23	9.50
Diastoma varium		20	20	8.26
Odostomia laevigata	5	14	19	7.85
Teinostoma biscaynense	1	12	13	5.37
Littoridina sphinctostoma		10	10	4.13
Acteocina canaliculata		8	8	3.31
Odostomia impressa		5	5	2.07
Acteon punctostriatus	3	2	5	2.07
Odostomia acutidens		3	3	1.24
Triphora nigrocincta		2	2	.83
Vitrinella floridana		2	2	.83
Tricolia affinis cruenta		2	2	.83
Truncatella pulchella		1	1	.41
Rissoina catesbyana		1	1	.41
Turbonilla aequalis		1	1	.41
Turbonilla interrupta		1	1	.41
Mitrella lunata		1	1	.41
Cerithiopsis greeni		1	1	.41
Caecum nitidum		1	1	.41
Virtinella texana		1	1	.41
TOTALS	9	159	168	69.40

*Live and paired dead valves were counted as 1; unpaired valves as ½.

COPANO BAY
Reef Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Ischadium recurvum	24	133	157	28.6
Mulinia lateralis		64	64	11.7
Anomia simplex		7	7	1.3
Nuculana acuta		4	4	.7
Brachidontes exustus		3	3	.5
Crassostrea virginica	1		1	.2
Macoma mitchelli		1	1	.2
TOTALS	25	212	237	43.2
Crassostrea virginica fragments--very abundant				
Gastropoda				
Odostomia laevigata	12	120	132	24.0
Odostomia impressa	47	61	108	19.7
Odostomia gibbosa		16	16	2.9
Turbonilla aequalis		12	12	2.2
Odostomia bisuturalis		9	9	1.6
Crepidula plana		6	6	1.1
Littoridina sphinctostoma		6	6	1.1
Acteocina canaliculata		5	5	.9
Turbonilla interrupta		4	4	.7
Teinostoma biscaynense		4	4	.7
Mitrella lunata		4	4	.7
Nassarius vibex		2	2	.4
Triphora nigrocincta		2	2	.4
Odostomia acutidens		2	2	.4
Caecum pulchellum		2	2	.4
TOTALS	59	259	318	57.2

*Live and paired dead valves were counted as 1; unpaired values as ½.

COPANO BAY
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Macoma mitchelli	18	2	20	47.62
Mulinia lateralis	1	1	2	4.76
Ischadium recurvum	1	3	4	9.52
Mytilopsis leucophaeata		2	2	4.76
Anomia simplex		2	2	4.76
Chione cancellata		1	1	2.38
TOTALS	20	11	31	73.80
Gastropoda				
Littoridina sphinctostoma	3		3	7.14
Odostomia impressa	1	1	2	4.76
Odostomia laevigata	1	1	2	4.76
Odostomia acutidens	1	1	2	4.76
Acteocina canaliculata		1	1	2.38
Triphora nigrocincta		1	1	2.38
TOTALS	6	5	11	26.18

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ARANSAS RIVER
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda				
Brachidontes sp. fragments				
Gastropoda				
Littoridina sphinctostoma		2	2	67.00
Melampus bidentatus		1	1	33.00
TOTALS		3	3	100.00

MISSION BAY
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Macoma mitchelli	5	15	20	50
Mulinia lateralis		4	4	10
Rangia cuneata		1	1	2.5
Ischadium recurvum		1	1	2.5
TOTALS	5	21	26	65
Gastropoda				
Littoridina sphinctostoma	1	8	9	22.5
Odostomia laevigata		2	2	5
Odostomia impressa		1	1	2.5
Acteon punctostriatus		1	1	2.5
Acteocina canaliculata		1	1	2.5
TOTALS	1	13	14	35

*Live and paired dead valves were counted as 1; unpaired valves as ½.

PORT BAY
Small Enclosed Bay Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	2	9	11	19.64
Anomalocardia auberiana		5	5	8.93
Ischadium recurvum		3	3	5.35
Macoma mitchelli		2	2	3.57
Lucina pectinatus		2	2	3.57
Amygdalum papyria		1	1	1.79
Chione cancellata		1	1	1.79
Nuculana acuta		1	1	1.79
Laevicardium mortoni		1	1	1.79
Mysella planulata		1	1	1.79
Anomia simplex		1	1	1.79
TOTALS	2	27	29	51.8
Gastropoda				
Acteocina canaliculata		6	6	10.71
Cerithidea pliculosa		3	3	5.35
Odostomia laevigata		3	3	5.35
Littoridina sphinctostoma	1	2	3	5.35
Diastoma varium		3	3	5.35
Cerithium sp.		2	2	3.57
Sayella livida		2	2	3.57
Vitrinella floridana		1	1	1.79
Caecum pulchellum		1	1	1.79
Odostomia acutidens		1	1	1.79
Modulus modulus		1	1	1.79
Caecum nitidum		1	1	1.79
TOTALS	1	26	27	48.2

*Live and paired dead valves were counted as 1; unpaired valves as ½.

PORT BAY
Grassflat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Macoma mitchelli	58	5	63	32.14
Mulinia lateralis	1	39	40	20.41
Parvilucina pectinatus		5	5	2.55
Anomalocardia auberiana		2	2	1.02
Tagelus plebius		2	2	1.02
Ischadium recurvum		2	2	1.02
Amygdalum papyria	1		1	.51
TOTALS	60	55	115	58.67
Gastropoda				
Odostomia laevigata		40	40	20.41
Littoridina sphinctostoma		9	9	4.6
Cerithium sp.		9	9	4.6
Odostomia teres		8	8	4.1
Turbonilla interrupta		4	4	2.04
Cerithidea pliculosa		4	4	2.04
Diastoma varium		2	2	1.02
Truncatella pulchella		2	2	1.02
Odostomia gibbosa		1	1	.51
Odostomia impressa		1	1	.51
Acteocina canaliculata		1	1	.51
TOTALS		81	81	41.36

* Live and paired dead valves were counted as 1; unpaired valves as 1/2.

ARANSAS BAY
Grassflat Molluscan Assemblage

Pelecypoda*	Live	Dead	Total	Percent of total fauna
Mysella planulata		5	5	.84
Brachidontes exustus		5	5	.84
Anomia simplex		4	4	.67
Aligena texasiana		3	3	.5
Mulinia lateralis		2	2	.34
Tellina tampaensis		2	2	.34
Cumingia tellinoides		2	2	.34
Ensis minor		2	2	.34
Tagelus plebius		1	1	.17
Macoma brevifrons		1	1	.17
Lyonsia hyalina floridana	1		1	.17
Laevicardium mortoni		1	1	.17
Argopecten amplicostatus		1	1	.17
TOTALS	1	29	30	5.06

Gastropoda	Live	Dead	Total	Percent of total fauna
Diastoma varium		273	273	45.9
Cerithium sp.		254	254	42.69
Acteocina canaliculata	3	7	10	1.68
Mitrella lunata		9	9	1.5
Odostomia impressa		4	4	.67
Caecum pulchellum		3	3	.5
Odostomia laevigata		3	3	.5
Crepidula fornicata		3	3	.5
Acteon punctostriatus		3	3	.5
Turbonilla interrupta		1	1	.17
Odostomia bisuturalis		1	1	.17
Anachis obesa		1	1	.17
TOTALS	3	562	565	94.95

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ARANSAS BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Nuculana acuta		197	197	17.70
Mulinia lateralis		54	54	4.85
Aligena texasiana	4	29	33	2.97
Anomia simplex		33	33	2.97
Laevicardium mortoni		30	30	2.70
Chione cancellata		20	20	1.80
Anadara transversa		14	14	1.26
Macoma mitchelli	6	3	9	.81
Nuculana concentrica		6	6	.54
Trachycardium muricatum		4	4	.36
Pandora trilineata		4	4	.36
Crassinella lunulata		4	4	.36
Anomalocardia auberiana		4	4	.36
Dosinia discus		2	2	.18
Ostrea equestris		2	2	.18
Abra aequalis		2	2	.18
Dosinia elegans		2	2	.18
Parvilucina multilineata		2	2	.18
Mysella planulata		2	2	.18
Ensis minor	1		1	.09
Lyonsia hyalina floridana	1		1	.09
Brachidontes exustus		1	1	.09
Tagelus plebius		1	1	.09
Mactra fragilis		1	1	.09
Carditamera floridana		1	1	.09
Tellina alternata		1	1	.09
Tellina tampaensis		1	1	.09
Lucina pectinatus		1	1	.09
TOTALS	12	421	433	38.93
Gastropoda				
Acteocina canaliculata	2	216	218	19.59
Caecum pulchellum		136	136	12.22
Turbonilla interrupta		68	68	6.11
Crepidula plana	1	47	48	4.31
Turbonilla aequalis		41	41	3.68
Anachis obesa		20	20	1.80
Odostomia impressa		19	19	1.71
Caecum glabrum	7	11	18	1.62
Mitrella lunata		16	16	1.44
Cerithiopsis greeni		11	11	.99
Vitrinella floridana	4	7	11	.99
Acteon punctostriatus	7	4	11	.99
Diastoma varium		10	10	.90
Odostomia laevigata	2	7	9	.81
Odostomia teres		7	7	.63
Odostomia bushiana		7	7	.63

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	Live	Dead	Total	Percent of total fauna
Crepidula fornicata		6	6	.54
Nassarius vibex		5	5	.45
Odostomia bisuturalis		4	4	.36
Diodora cayenensis		4	4	.36
Caecum nitidum		2	2	.18
Odostomia gibbosa	1		1	.09
Episcynia inornata		1	1	.09
Cerithium sp.		1	1	.09
Littoridina sphinctostoma		1	1	.09
Mangelia sp. "A"		1	1	.09
TOTALS	24	652	676	60.67

Scaphopoda

	Live	Dead	Total	Percent of total fauna
Dentalium texasianum		4	4	.36

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ARANSAS BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		15	15	13.27
Nuculana concentrica		16	16	14.16
Nuculana acuta		10	10	8.85
Anomia simplex		7	7	6.19
Aligena texasiana		4	4	3.54
Anadara transversa		3	3	2.65
Pandora trilineata		3	3	2.65
Mysella planulata		3	3	2.65
Chione cancellata		2	2	1.77
Macoma mitchelli		2	2	1.77
Ostrea equestris		2	2	1.77
Abra aequalis		2	2	1.77
Brachidontes exustus		1	1	.88
TOTALS		70	70	61.92
Gastropoda				
Acteocina canaliculata	1	12	13	11.50
Crepidula plana		6	6	5.31
Odostomia teres	1	3	4	3.54
Turbonilla interruptus		5	5	4.42
Nassarius vibex		3	3	2.65
Turbonilla aequalis		3	3	2.65
Odostomia acutidens		2	2	1.77
Caecum pulchellum		2	2	1.77
Acteon punctostriatus	1	1	2	1.77
Anachis obesa		1	1	.88
Vitrinella floridana		1	1	.88
Mitrella lunata		1	1	.88
TOTALS	3	40	43	38.02

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ARANSAS BAY
Inlet Influenced Molluscan Fauna

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Tellina alternata	2	1	3	9.68
Abra aequalis		3	3	9.68
Nuculana acuta		3	3	9.68
Anadara transversa		2	2	6.45
Aligena texasiana		2	2	6.45
Lyonsia hyalina floridana	1	1	2	6.45
Mysella planulata		1	1	3.23
Crassinella lunulata		1	1	3.23
Periploma margaritaceum		1	1	3.23
Lucina pectinatus		1	1	3.23
Argopecten amplicostatus	1		1	3.23
Pandora trilineata		1	1	3.23
Linga amiantus	1		1	3.23
TOTALS	5	17	22	71.00
Gastropoda				
Turbonilla interrupta		2	2	6.45
Mitrella lunata		2	2	6.45
Nassarius vibex		1	1	3.23
Pyramidella crenulata		1	1	3.23
Diastoma varium		1	1	3.23
Bulla striata	1		1	3.23
Odostomia teres		1	1	3.23
TOTALS	1	8	9	29.05

*Live and paired dead valves were counted as 1; unpaired valves as ½.

REDFISH BAY
Inlet Influence Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Nuculana acuta	1	3	4	15.38
Mulinia lateralis	2	1	3	11.54
Aligena texasiana		1	1	3.85
Lucina pectinatus	1		1	3.85
Parvilucina multilineata	1		1	3.85
Mactra fragilis		1	1	3.85
Anadara transversa		1	1	3.85
Pandora trilineata		1	1	3.85
Mysella planulata		1	1	3.85
Dosinia elegans		1	1	3.85
TOTALS	5	10	15	57.72
Gastropoda				
Natica pusilla	2	2	4	15.38
Pyramidella crenulata		1	1	3.85
Mangelia sp. "B"		1	1	3.85
Mitrella lunata		1	1	3.85
Crepidula fornicata		1	1	3.85
Caecum pulchellum		1	1	3.85
Odostomia teres		1	1	3.85
Turbonilla interrupta		1	1	3.85
TOTALS	2	9	11	42.33

*Live and paired dead valves were counted as 1; unpaired valves as ½.

REDFISH BAY
Grass Flat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana		100	100	.86
Lucina pectinatus	5	52	57	.49
Laevicardium mortoni	2	25	27	.23
Chione cancellata		24	24	.21
Tellina tampaensis		8	8	.07
Tagelus plebius		8	8	.07
Cumingia tellinoides		7	7	.06
Mysella planulata		6	6	.05
Brachidontes exustus	1	3	4	.03
Tellina texana	1	3	4	.03
Mulinia lateralis		4	4	.03
Argopecten amplicostatus		2	2	.02
Anomia simplex		2	2	.02
Crassostrea virginica		2	2	.02
Carditamera floridana		2	2	.02
Anadara transversa		2	2	.02
Linga amiantus		1	1	.01
Amygdalum papyria		1	1	.01
Abra aequalis		1	1	.01
TOTALS	9	253	262	2.26
Gastropoda				
Cerithium sp.	2	8598	8600	74.32
Crepidula fornicata	69	943	1012	8.75
Diastoma varium	6	684	690	5.96
Odostomia impressa	8	655	663	5.73
Odostomia laevigata	6	188	194	1.68
Sayella livida	5	32	37	.32
Caecum pulchellum		31	31	.27
Acteocina canaliculata		22	22	.19
Neritina virginea		16	16	.14
Acteon punctostriatus		9	9	.08
Cerithidea pliculosa		7	7	.06
Turbonilla interrupta		5	5	.04
Truncatella pulchella		5	5	.04
Mitrella lunata	1	2	3	.03
Anachis avara	1	2	3	.03
Vitrinella floridana		2	2	.02
Mangelia sp. "A"	1	1	2	.02
Odostomia acutidens		2	2	.02
Haminoea antillarum		2	2	.02
Cyclostremiscus pentagonus		1	1	.01
Triphora nigrocincta		1	1	.01
Haminoea succinea		1	1	.01
Crepidula plana		1	1	.01
TOTALS	99	11,210	11,309	97.76

*Live and paired dead valves were counted as 1; unpaired valves as ½.

REDFISH BAY
Bay Margin Molluscan Assemblage
(continued)

	Live	Dead	Total	Percent of total fauna
Gastropoda				
Cerithium sp.		2742	2742	31.92
Diastoma varium	1	1287	1288	14.99
Crepidula fornicata	7	842	849	9.88
Caecum pulchellum	2	535	537	6.25
Vermicularia fargoi		476	476	5.54
Odostomia impressa		159	159	1.85
Odostomia laevigata	2	133	135	1.57
Acteocina canaliculata	7	123	130	1.51
Caecum nitidum		127	127	1.48
Turbonilla interrupta	4	67	71	.83
Crepidula plana		64	64	.75
Mitrella lunata	7	50	57	.66
Vitrinella floridana		56	56	.65
Turbonilla aequalis	2	42	44	.51
Modulus modulus		43	43	.50
Tricolia affinis cruenta		39	39	.45
Pyramidella crenulata		25	25	.29
Acteon punctostriatus		25	25	.29
Mangelia sp "A"	2	19	21	.24
Odostomia acutidens		20	20	.23
Teinostoma biscaynense		19	19	.22
Sayella livida		18	18	.21
Cerithiopsis greeni		17	17	.20
Nassarius vibex	5	8	13	.15
Anachas avara		11	11	.13
Bulla striata		11	11	.13
Triphora nigrocincta		11	11	.13
Odostomia teres		10	10	.12
Cerithidea pliculosa		6	6	.07
Epitonium rupicola		6	6	.07
Anacha obesa		5	5	.06
Caecum glabrum		4	4	.05
Odostomia bushiana		4	4	.05
Circulus suppressus		4	4	.05
Rissoina catesbyana		4	4	.05
Haminoea antillarium		4	4	.05
Caecum glabrum		3	3	.03
Polinices duplicatus	1	2	3	.03
Diodora cayenensis		3	3	.03
Truncatella pulchella		1	1	.01
Neritina virginea		1	1	.01
Odostomia bisuturalis		1	1	.01
Vitrinella texana	1		1	.01
Pisania tincta		1	1	.01
TOTALS	41	7028	7069	82.27

REDFISH BAY

Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mysella planulata	14	246	260	3.03
Nuculana acuta	1	191	192	2.24
Chione cancellata		184	184	2.14
Laevicardium mortoni	5	167	172	2.00
Mulinia lateralis	4	158	162	1.89
Aligena texasiana		102	102	1.19
Anomalocardia auberiana		92	92	1.07
Brachidontes exustus		58	58	.68
Anomia simplex		40	40	.47
Carditamera floridana		39	39	.45
Anadara transversa		37	37	.42
Lyonsia hyalina Floridana	24	8	32	.37
Lucina pectinatus	8	23	31	.36
Tellina tampaensis		16	16	.19
Tellina texana		13	13	.15
Argopecten amplicostatus		9	9	.10
Cumingia tellinoides		7	7	.08
Abra aequalis		7	7	.08
Ischadium recurvum		7	7	.08
Ostrea equestris		7	7	.08
Parvilucina multilineata		6	6	.07
Tagelus divisus		5	5	.06
Cyclinella tenuis	1	4	5	.06
Mactra fragilis	1	3	4	.05
Macoma mitchelli		3	3	.03
Amygdalum papyria	3		3	.03
Macoma tenta		3	3	.03
Pandora trilineata		2	2	.02
Coralliophaga coralliophaga		2	2	.02
Pandora trilineata		2	2	.02
Nuculana concentrica		2	2	.02
Crassostrea virginica		1	1	.01
Corbula swiftiana		1	1	.01
Periploma margaritaceum		1	1	.01
Ensis minor	1		1	.01
Trachycardium muricatum		1	1	.01
Semele proficua		1	1	.01
TOTALS	62	1447	1509	17.54

REDFISH BAY
Bay Margin Molluscan Assemblage
(continued)

	Live	Dead	Total	Percent of total fauna
Scaphopoda				
Dentalium texasianum		13	13	.15

*Live and paired dead valves were counted as 1; unpaired valves as ½.

CORPUS CHRISTI BAY
Inlet Influenced Molluscan Assemblage

Pelecypoda*	Live	Dead	Total	Percent of total fauna
Nuculana acuta		193	193	24.34
Mulinia lateralis	1	110	111	14.00
Anomalocardia auberiana		82	82	10.34
Anadara transversa		37	37	4.67
Chione cancellata		32	32	4.04
Parvilucina multilineata		19	19	2.40
Abra aequalis		11	11	1.39
Crassinella lunulata		8	8	1.01
Anomia simplex		7	7	.88
Tellina texana	2	5	7	.88
Ostrea equestris		6	6	.76
Anomia simplex		6	6	.76
Linga amiantus		6	6	.76
Polymedosa maritima		6	6	.76
Corbula swiftiana		5	5	.63
Pandora trilineata	2	2	4	.50
Laevicardium mortoni		4	4	.50
Carditamera floridana		4	4	.50
Brachidontes exustus		4	4	.50
Nuculana concentrica		4	4	.50
Tagelus divisus		3	3	.38
Trachycardium muricatum		2	2	.25
Mysella planulata		2	2	.25
Tagelus plebius		2	2	.25
Dosinia elegans		2	2	.25
Lucina pectinatus		2	2	.25
Petricola pholadiformis		2	2	.25
Cyclinella tenuis		1	1	.13
Anadara ovalis		1	1	.13
Dinocardium robustum		1	1	.13
Coralliophaga corralliophaga		1	1	.13
Tellina tampaensis		1	1	.13
Argopecten amplicostatus		1	1	.13
Crassostrea virginica		1	1	.13
Macoma tageliformis		1	1	.13
TOTALS	5	574	579	72.28

Gastropoda	Live	Dead	Total	Percent of total fauna
Caecum pulchellum		57	57	7.19
Acteocina canaliculata		35	35	4.41
Diastoma varium		18	18	2.27
Crepidula plana		13	13	1.64
Turbonilla interrupta	1	11	12	1.51
Cerithium sp.		11	11	1.39

CORPUS CHRISTI BAY
Inlet Influenced Molluscan Assemblage
(continued)

Gastropoda (continued)

Vermicularia fargoi		9	9	1.13
Odostomia teres		9	9	1.13
Caecum nitidum		7	7	.88
Turbonilla aequalis		6	6	.76
Odostomia laevigata		5	5	.63
Odostomia impressa		5	5	.63
Modulus modulus		5	5	.63
Crepidula fornicata		4	4	.50
Mitrella lunata		4	4	.50
Nassarius acutus		2	2	.25
Natica pusilla		2	2	.25
Vitrinella floridana		2	2	.25
Rissoina catesbyana		1	1	.13
Polinices duplicatus	1		1	.13
Acteon punctostriatus		1	1	.13
Cerithiopsis greeni		1	1	.13
Melanella jamaicensis		1	1	.13
Epitonium rupicola		1	1	.13
Triphora nigrocincta		1	1	.13
Odostomia gibbosa		1	1	.13
TOTALS	2	212	214	26.99

*Live and paired dead valves were counted as 1; unpaired valves as ½.

CORPUS CHRISTI BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	42	278	320	69.41
Anomalocardia auberiana		9	9	1.95
Chione cancellata		8	8	1.74
Tellina sybaritica	4	2	6	1.30
Anadara transversa		5	5	1.08
Ostrea equestris		4	4	.87
Anomia simplex		3	3	.65
Laevicardium mortoni	1	2	3	.65
Parvilucina multilineata		3	3	.65
Petricola pholadiformis		3	3	.65
Nuculana acuta		2	2	.43
Linga amiantus		2	2	.43
Argopecten amplicostatus		2	2	.43
Lucina pectinatus		1	1	.22
Polymedosa maritima		1	1	.22
Donax variabilis		1	1	.22
Dosinia elegans		1	1	.22
Tagelus divisus		1	1	.22
Brachidontes exustus		1	1	.22
Cyclinella tenuis		1	1	.22
Macrocallista nimbosa		1	1	.22
Macoma mitchelli		1	1	.22
Cyrtopleura costata		1	1	.22
Nuculana concentrica		1	1	.22
TOTALS	47	334	381	82.66
Gastropoda				
Acteocina canaliculata	2	16	18	3.90
Diastoma varium		18	18	3.90
Cerithium sp.		8	8	1.74
Crepidula fornicata		5	5	1.08
Mitrella lunata		5	5	1.08
Acteon punctostriatus	1	2	3	.65
Nassarius vibex		3	3	.65
Crepidula plana		3	3	.65
Caecum pulchellum		3	3	.65
Odostomia bisuturalis		3	3	.65
Odostomia teres		2	2	.43
Turbonilla interrupta	1	1	2	.43
Triphora nigrocincta		2	2	.43
Odostomia laevigata		1	1	.22
Vitrinella floridana		1	1	.22
Polinices duplicatus		1	1	.22
Tricolia affinis cruenta		1	1	.22
Odostomia bushiana		1	1	.22
TOTALS	4	76	80	17.34

*Live and paired dead valves were counted as 1; unpaired valves as ½.

CORPUS CHRISTI BAY
Bay Center Molluscan Assemblage

Pelecypoda*	Live	Dead	Total	Percent of total fauna
Mulinia lateralis	17	377	394	73.2
Nuculana concentrica		27	27	5.1
Nuculana acuta	1	23	24	4.5
Pandora trilineata		2	2	.4
Cyclinella tenuis		2	2	.4
Mysella planulata		2	2	.4
Macoma tageliformis		1	1	.2
Lyonsia hyalina floridana	1		1	.2
Anomia simplex		1	1	.2
Anadara transversa		1	1	.2
TOTALS	19	436	455	84.8

Gastropoda	Live	Dead	Total	Percent of total fauna
Acteocina canaliculata		40	40	7.4
Odostomia bisuturalis		15	15	2.8
Acteon punctostriatus		11	11	2.0
Turbonilla interrupta		9	9	1.7
Nassarius vibex		3	3	.5
Polinices duplicatus		1	1	.2
Mitrella lunata		1	1	.2
Nassarius acutus		1	1	.2
Odostomia teres		1	1	.2
Turbonilla interrupta		1	1	.2
TOTALS		83	83	15.4

*Live and paired dead valves were counted as 1; unpaired valves as ½.

NUECES BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		16	16	51.61
Macoma mitchelli		2	2	6.45
TOTALS		18	18	58.06
Gastropoda				
Cerithium sp.		3	3	9.68
Odostomia laevigata		3	3	9.68
Teinostoma biscaynense		2	2	6.45
Acteon punctostriatus		2	2	6.45
Rissoina catesbyana		1	1	3.22
Turbonilla interrupta		1	1	3.22
Odostomia bisuturalis		1	1	3.22
TOTALS		13	13	41.92

*Live and paired dead valves were counted as 1; unpaired valves as ½.

NUECES BAY
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		2	2	.40
Macoma mitchelli		1	1	.20
Tagelus plebius		1	1	.20
Brachidontes exustus		1	1	.20
TOTALS		5	5	1.00

*Live and paired dead valves were counted as 1; unpaired valves as ½.

NUECES BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis		101	101	68.24
Macoma mitchelli		5	5	3.38
Anomia simplex		3	3	2.03
Lucina pectinatus		1	1	.67
TOTALS		110	110	74.32
Gastropoda				
Odostomia bisuturalis		7	7	4.73
Acteocina canaliculata	1	6	7	4.73
Cerithium sp.		6	6	4.05
Odostomia laevigata		5	5	3.38
Odostomia impressa		4	4	2.70
Odostomia acutidens		2	2	1.35
Diastoma varium		1	1	.67
Caecum pulchellum		1	1	.67
Turbonilla interrupta		1	1	.67
Teinostoma biscaynense		1	1	.67
Acteon punctostriatus		1	1	.67
Cerithiopsis greeni		1	1	.67
Triphora nigrocincta		1	1	.67
Mitrella lunata		1	1	.67
TOTALS	1	38	38	26.30

*Live and paired dead valves were counted as 1; unpaired valves as ½.

OSO BAY
Small Enclosed Bay Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda				
Mulinia lateralis	1	114	115	77.70
Anomalocardia auberiana	1	6	7	4.73
Tagelus divisus		2	2	1.35
Nuculana acuta		2	2	1.35
Anomia simplex		2	2	1.35
Brachidontes exustus		1	1	.68
Chione cancellata		1	1	.68
Mytilopsis leucophaeata		1	1	.68
TOTALS	2	129	131	88.52
Gastropoda				
Acteon punctostriatus		6	6	4.05
Cerithium sp.		2	2	1.35
Diastoma varium		1	1	.68
Acteocina canaliculata		3	3	2.27
Rissoina catesbyana		1	1	.68
Odostomia bisuturalis		2	2	1.35
Truncatella pulchella		1	1	.68
Odostomia laevigata		1	1	.68
TOTALS		17	17	11.74

*Live and paired dead valves were counted as 1; unpaired valves as ½.

UPPER LAGUNA MADRE
Grassflat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana	4	833	837	27.98
Mulinia lateralis		123	123	4.11
Tellina tampaensis	5	94	99	3.31
Laevicardium mortoni	3	46	49	1.64
Brachidontes exustus	21	14	35	1.17
Tellina texana	4	14	18	.60
Ensis minor	12		12	.40
Mysella planulata	3	5	8	.27
Parvilucina multilineata		5	5	.17
Anadara transversa		5	5	.17
Argopecten amplicostatus	4	1	5	.17
Anomia simplex		3	3	.10
Cumingia tellinoides		2	2	.07
Chione cancellata		2	2	.07
Amygdalum papyria	2		2	.07
Tagelus plebius		2	2	.07
Aligena texana		1	1	.03
Dosinia elegans		1	1	.03
Nuculana acuta		1	1	.03
Abra aequalis		1	1	.03
Trachycardium muricatum		1	1	.03
Crassostrea virginica		1	1	.03
TOTALS	58	1155	1213	40.55
Gastropoda				
Diastoma varium	428	586	1014	33.91
Crepidula fornicata	35	446	481	16.08
Odostomia impressa	31	75	106	3.54
Odostomia laevigata	8	51	59	1.97
Acteocina canaliculata		20	20	.67
Acteon punctostriatus		19	19	.63
Sayella livida	1	17	18	.60
Turbonilla interrupta	3	11	14	.47
Trunchatella pulchella		9	9	.30
Mitrella lunata	2	7	9	.30
Caecum pulchellum	1	6	7	.23
Odostomia acutidens	2	5	7	.23
Pyramidella crenulata		2	2	.07
Neritina virginea		2	2	.07
Bulla striata	1	1	2	.07
Turbonilla aequalis		2	2	.07
Haminoea antillarum		2	2	.07
Crepidula plana		2	2	.07
Epitonium rupicola		1	1	.03
Triphora nigrocincta		1	1	.03
Tricolia affinis cruenta		1	1	.03
TOTALS	512	1266	1778	59.44

*Live and paired dead valves were counted as 1; unpaired valves as ½.

UPPER LAGUNA MADRE
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of Total fauna
Pelecypoda*				
Anomalocardia auberiana		2216	2216	67.98
Mulinia lateralis	7	247	254	7.79
Tellina tampaensis	1	103	104	3.19
Laevicardium mortoni		44	44	1.35
Tellina texana	11	32	43	1.32
Brachidontes exustus	10	4	14	.43
Argopecten amplicostatus	2	9	11	.34
Mysella planulata	2	8	10	.31
Cumingia tellinoides		4	4	.12
Ensis minor	4		4	.12
Chione cancellata		3	3	.09
Lyonsia hyalina floridana	2		2	.06
Parvilucina multilineata		1	1	.03
Aligena texana		1	1	.03
Modiolus americanus		1	1	.03
TOTALS	39	2673	2712	83.19
Gastropoda				
Diastoma varium		287	287	8.80
Crepidula fornicata	8	83	91	2.79
Acteocina canaliculata	5	38	43	1.32
Acteon punctostriatus	1	32	33	1.01
Turbonilla interrupta	3	23	26	.80
Mitrella lunata	21	5	26	.80
Odostomia laevigata		10	10	.31
Odostomia impressa		8	8	.25
Sayella livida		6	6	.18
Caecum pulchellum	1	4	5	.15
Vitrinella floridana		2	2	.06
Haminoea antillarum	2		2	.06
Èpitonium rupicola		1	1	.03
Truncatella pulchella		1	1	.03
Odostomia teres		1	1	.03
Anachas semiplicata		1	1	.03
Triphora perversa nigrocincta		1	1	.03
Odostomia acutidens		1	1	.03
Bulla striata	1		1	.03
Mangelia sp.	1		1	.03
Haminoea succinium	1		1	.03
TOTALS	44	504	548	16.8

*Live and paired dead valves were conted as 1; unpaired valves as ½.

UPPER LAGUNA MADRE
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana		4730	4730	84.01
Tellina tampaensis	1	211	212	3.77
Mulinia lateralis	7	113	120	2.13
Laevicardium mortoni	11	96	107	1.90
Amygdalum papyria	20	8	28	.50
Mysella planulata		22	22	.39
Ensis minor	15		15	.27
Argopectin amplicostatus	11	2	13	.23
Tellina texana	3	10	13	.23
Brachidontes exustus		7	7	.12
Polymesoda maritima		3	3	.05
Anomia simplex		1	1	.02
Aligena texasiana		1	1	.02
TOTALS	68	5204	5272	93.64
Gastropoda				
Diastoma varium	3	135	138	2.45
Crepidula fornicata	34	65	99	1.76
Caecum pulchellum	21	15	36	.64
Acteocina canaliculata		35	35	.62
Odostomia laevigata	9	4	13	.23
Sayella livida	1	10	11	.20
Acteon punctostriatus		10	10	.18
Turbonilla interrupta	1	4	5	.09
Odostomia impressa		4	4	.07
Anachis obesa	2		2	.04
Turbonilla aequalis		2	2	.04
Haminoea antillarum		1	1	.02
Bulla striata		1	1	.02
Caecum nitidum		1	1	.02
TOTALS	71	287	358	6.34

*Live and paired dead valves were counted as 1; unpaired valves as ½.

APPENDIX A:

Kingsville Map Area

BAFFIN BAY
Bay Margin Molluscan ASSEMBLAGE

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	14	826	840	47.06
Anomalocardia auberiana		747	747	41.85
Brachidontes exustus	4	33	37	2.07
Tellina tampaensis		8	8	.45
Tagelus plebius	4	1	5	.28
Mysella planulata	1	3	4	.22
Amygdalum papyria	1	3	4	.22
Laevicardium mortoni		3	3	.17
Lyonsia hyalina floridana	2	1	3	.17
Tellina texana		2	2	.11
Cumingia tellinoides		1	1	.05
Macoma tenta		1	1	.05
TOTALS	26	1629	1655	92.7
Gastropoda				
Acteon punctostriatus	7	56	63	3.53
Acteocina canaliculata	7	9	16	.90
Odostomia laevigata	3	15	18	1.01
Mitrella lunata	4	4	8	.45
Diastoma varium		6	6	.34
Truncatella pulchella		5	5	.28
Caecum pulchellum	2	2	4	.22
Crepidula fornicata	1	2	3	.17
Odostomia acutidens		2	2	.11
Odostomia bisuturalis		1	1	.05
Epitonium rupicola		1	1	.05
Sayella livida		1	1	.05
Pyramidella crenulata		1	1	.05
Cerithium sp.		1	1	.05
TOTALS	24	106	130	7.26

*Live and paired dead valves were counted as 1; unpaired valves as ½.

BAFFIN BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	13	262	275	79.94
Anomalocardia auberiana		18	18	5.23
Brachidontes exustus	1	2	3	.87
TOTALS	14	282	296	86.04
Gastropoda				
Acteon punctostriatus	4	25	29	8.43
Acteocina canaliculata	2	14	16	4.65
Diastoma varium		2	2	.58
Mitrella lunata		1	1	.29
TOTALS	6	42	48	13.95

*Live and paired dead valves were counted as 1; unpaired valves as ½.

BAFFIN BAY
Serpulid Reef and Serpulid Reef Margin

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	9	357	366	52.8
Brachidontes exustus	61	81	142	20.49
Anomalocardia auberiana	1	122	123	17.75
Lyonsia hyalina floridana	3		3	.43
Tellina texana		1	1	.14
Tellina tampaensis		1	1	.14
Mactra fragilis		1	1	.14
Mysella planulata		1	1	.14
TOTALS	74	564	638	92.03
Gastropoda				
Acteon punctostriatus	4	26	30	4.3
Acteocina canaliculata		17	17	2.45
Odostomia laevigata		2	2	.29
Sayella livida		2	2	.29
Odostomia bisuturalis		1	1	.14
Nassarius vibex		1	1	.14
Diastoma varium		1	1	.14
Mitrella lunata		1	1	.14
TOTALS	4	51	55	7.89

*Live and paired dead valves were counted as 1; unpaired valves as ½.

BAFFIN BAY
GrassFlat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana	1	407	408	44.15
Mulinia lateralis	13	160	173	18.72
Laevicardium mortoni	9	12	21	2.27
Lyonsia hyalina floridana	13		13	1.41
Tellina tampaensis		12	12	1.3
Tellina texana	6	3	9	.97
Brachidontes exustus	3	5	8	.87
Mysella planulata	4	2	6	.65
Tagelus divisus		1	1	.11
Argopecten amplicostatus		1	1	.11
TOTALS	49	603	652	70.56
Gastropoda				
Crepidula fornicata	11	77	88	9.5
Diastoma varium	2	52	54	5.84
Acteocina canaliculata	3	25	28	3.03
Caecum pulchellum	1	21	22	2.4
Anachis avara	21		21	2.27
Mitrella lunata	11	7	18	1.95
Acteon punctostriatus	1	13	14	1.5
Sayella livida	1	10	11	1.19
Odostomia laevigata		8	8	.87
Cerithium sp.		4	4	.43
Vitrinella floridana	1		1	.11
Turbonilla interrupta		1	1	.11
Nessarius vibex	1		1	.11
Pyramidella crenulata		1	1	.11
TOTALS	53	219	272	29.42

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ALAZAN BAY
Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Mulinia lateralis	13	366	379	80.47
Anomalocardia auberiana		32	32	6.79
Amygdalum papyria	2		2	.43
Brachidontes exustus		1	1	.21
TOTALS	15	399	414	87.90
Gastropoda				
Acteon punctostriatus	8	25	33	7.01
Acteocina canaliculata	3	15	18	3.82
Odostomia laevigata		5	5	1.06
Mitrella lunata		1	1	.21
TOTALS	11	46	57	12.10

*Live and paired dead valves were counted as 1; unpaired valves as ½.

ALAZAN BAY
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana		1163	1163	64.57
Mulinia lateralis	18	537	555	30.82
Brachidontes exustus	4	6	10	.55
Tagelus plebius	4	1	5	.28
Mysella planulata	1		1	.05
Tellina texana		1	1	.05
Tellina tampaensis		1	1	.05
Lyonsia hyalina floridana	1		1	.05
Parvilucina multilineata		1	1	.05
TOTALS	28	1710	1738	96.47
Gastropoda				
Acteocina canaliculata	4	25	29	1.61
Acteon punctostriatus	3	13	16	.89
Crepidula fornicata		6	6	.33
Odostomia laevigata	1	5	6	.33
Mitrella lunata		1	1	.05
Sayella livida		1	1	.05
Truncatella pulchella		1	1	.05
Caecum pulchellum		2	2	.11
Odostomia bisulturalis		1	1	.05
TOTALS	8	55	63	3.45

*Live and paired dead valves were counted as 1; unpaired valves as ½.

APPENDIX A:

Brownsville-Harlingen Map Area

LOWER LAGUNA MADRE
Grassflat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana		409	409	12.63
Mulinia lateralis	19	124	143	4.41
Laevicardium mortoni	13	112	125	3.86
Tellina tampaensis	4	83	87	2.69
Chione cancellata	8	46	54	1.67
Tellina texana	10	36	46	1.42
Ensis minor	42		42	1.30
Cumingia tellinoides		32	32	.99
Mysella planulata	2	20	22	.68
Tagelus plebeius	16	4	20	.62
Lyonsia hyalina floridana	10	3	13	.40
Anadara transversa	4	9	13	.40
Brachidontes exustus		11	11	.34
Amygdalum papyria	5		5	.15
Argopecten amplicostatus		5	5	.15
Polymesoda maritina		4	4	.12
Mactra fragilis		3	3	.09
Tagelus divisus	1	2	3	.09
Lucina multilineata		3	3	.09
Anomia simplex		3	3	.09
Aligena texasiana	1	1	2	.06
Lucina pectinatus	1	1	2	.06
Nuculana acuta		1	1	.03
Ostrea equestris		1	1	.03
Abra aequalis		1	1	.03
Macoma brevifrons		1	1	.03
TOTALS	136	915	1051	32.43
Gastropods				
Diastoma varium	5	1130	1135	35.04
Crepidula fornicata	46	555	601	18.55
Caecum pulchellum	9	145	154	4.75
Odostomia laevigata		63	63	1.94
Mitrella lunata	11	26	37	1.14
Turbonilla interrupta	2	30	32	.99
Anachas semiplicata	14	16	30	.93
Sayella livida	1	28	29	.89
Acteon punctostriatus	4	20	24	.74
Cerithidea pliculosa		21	21	.65
Odostomia impressa		16	16	.49
Acteocina canaliculata	1	9	10	.31
Crepidula plana		9	9	.28
Neritina virginea		7	7	.22
Truncatella pulchella	1	6	7	.22
Mangelia sp.		3	3	.09
Diadora cayenensis	1	1	2	.06
Bulla striata		2	2	.06
Vitrinella floridana		1	1	.03
Cerithiopsis greeni		1	1	.03

continued

	Live	Dead	Total	Percent of total fauna
Pyramidella crenulata		1	1	.03
Odostomia acutidens	1		1	.03
Anachas obesa		1	1	.03
Polinices duplicatus		1	1	.03
TOTALS	96	2092	2188	67.56

*Live and paired dead valves were counted as 1; unpaired valves as ½.

Bay Margin Molluscan Assemblage

		Live	Dead	Total	Percent of total fauna
Pelecypoda*					
Anomalocardia auberiana			4	4	10.00
Mulinia lateralis			4	4	10.00
Laevicardium mortoni			3	3	7.50
Amygdalum papyria		3		3	7.50
Tellina texana			2	2	5.00
Cumingia tellinoides			2	2	5.00
Mysella planulata			2	2	5.00
Carditamera floridana			1	1	2.50
Anomia simplex			1	1	2.50
Tellina tampaensis			1	1	2.50
Lyonsia hyalina floridana		1		1	2.50
	TOTALS	4	20	24	60.00
Gastropoda					
Diastoma varium			4	4	10.00
Sayella livida		1	3	4	10.00
Acteon punctostriatus			1	1	2.50
Mangelia sp.			1	1	2.50
Turbonilla interruptus			1	1	2.50
Neritina virginea			1	1	2.50
Anachis semiplicata			1	1	2.50
Crepidula fornicata			1	1	2.50
Caecum pulchellum			1	1	2.50
Mitrella lunata			1	1	2.50
	TOTALS	1	15	16	40.00

*Live and paired dead valves were counted as 1; unpaired valves as ½.

LOWER LAGUNA MADRE
River Influenced Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana		9	9	31.03
Gastropoda				
Littoridina sphinctostoma		14	14	48.28
Potamopyrgus sp.		4	4	13.79
Diastoma varium		1	1	3.45
Caecum pulchellum		1	1	3.45
TOTALS		20	20	68.97

*Live and paired dead valves were counted as 1; unpaired valves as ½.

LOWER LAGUNA MADRE

Bay Center Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana		2459	2459	29.77
Mulinia lateralis	99	797	896	10.85
Nuculana acuta	174	343	517	6.26
Lyonsia hyalina floridana	168	2	170	2.06
Mysella planulata		164	164	1.99
Laevicardium mortoni	25	84	109	1.32
Chione cancellata	2	91	93	1.13
Tellina texana	5	81	86	1.04
Aligena texasiana		37	37	.45
Brachidontes exustus		35	35	.42
Abra aequalis		22	22	.27
Poymesoda maritima	1	19	20	.24
Tellina tampaensis		13	13	.16
Ensis minor	10	2	12	.15
Cumingia tellinoides	1	9	10	.12
Anomia simplex		7	7	.08
Ostrea equestris		5	5	.06
Anadara transversa		5	5	.06
Carditamera floridana		5	5	.06
Tagelus plebeius		4	4	.05
Petricola pholadiformis		1	1	.01
Argopecten amplicostatus		1	1	.01
Coralliophaga coralliophaga		1	1	.01
Varicorbula operculata		1	1	.01
TOTALS	485	4188	4673	56.58
Gastropoda				
Diastoma varium	1	1798	1799	21.78
Caecum pulchellum	6	600	606	7.34
Vitrinella floridana		230	230	2.78
Acteocina canaliculata	10	204	214	2.59
Turbonilla interrupta	10	148	158	1.91
Odostomia laevigata		121	121	1.47
Crepidula fornicata	3	101	104	1.26
Mitrella lunata	4	98	102	1.24
Acteon punctostriatus		72	72	.87
Anachas obesa		37	37	.45
Crepidula plana		33	33	.40
Caecum nitidum		26	26	.31
Bulla striata		10	10	.12
Sayella livida		10	10	.12
Odostomia acutidens		8	8	.10
Vermicularia fargoi		6	6	.07
Teinostoma biscaynense		5	5	.06
Odostomia bisuturalis		5	5	.06
Mangelia sp.		5	5	.06
Epitonium rupicola		5	5	.06
Pyramidella crenulata		5	5	.06
Cerithidea pliculosa		4	4	.05
Odostomia impressa		3	3	.04

continued

	Live	Dead	Total	Percent of total fauna
Tricolia affinis cruenta		2	2	.02
Anachas semiplicata		2	2	.02
Turbonilla aequalis		2	2	.02
Marginella apicina		2	2	.02
Modulus modulus		2	2	.02
Rissoina catesbyana		1	1	.01
Polinices duplicata		1	1	.01
Gastrocopta rupicola		1	1	.01
TOTALS	34	3547	3581	43.33

Scaphopoda

	Live	Dead	Total	Percent of total fauna
Dentalium texasianum		5	5	.06

*Live and paired dead valves were counted as 1; unpaired valves as ½.

LOWER LAGUNA MADRE
Inlet Influenced Molluscan Assemblage

		Live	Dead	Total	Percent of total fauna
Pelecypoda*					
Anomalocardia auberiana			586	586	70.43
Mulinia lateralis		1	24	25	3.0
Carditamera floridana			14	14	1.68
Tellina tampaensis			13	13	1.56
Parvilucina multilineata			4	4	.48
Laevicardium mortoni			3	3	.36
Brachidontes exustus			3	3	.36
Polymesoda maritima			3	3	.36
Petricola pholadiformis			2	2	.24
Ostrea equestris			2	2	.24
Tagelus plebeius			1	1	.12
Cyrtopleura costata			1	1	.12
Lyonsia hyalina floridana		1		1	.12
Mysella planulata		1		1	.12
Nuculana concentrica			1	1	.12
Nuculana acuta			1	1	.12
Tellina texana			1	1	.12
Chione cancellata			1	1	.12
Abra aequalis			1	1	.12
Aligena texana			1	1	.12
	TOTALS	3	662	665	79.91
Gastropoda					
Diastoma varium			53	53	6.37
Modulus modulus			31	31	3.72
Caecum pulchellum			19	19	2.28
Odostomia impressa			11	11	1.32
Odostomia laevigata			8	8	.96
Caecum nitidum			6	6	.72
Tricolia affinis cruenta			5	5	.60
Cerithidea pliculosa			5	5	.60
Acteon punctostriatus			4	4	.48
Acteocina canaliculata			4	4	.48
Vermicularia fargoi			3	3	.36
Turbonilla aequalis			3	3	.36
Turbonilla interrupta			3	3	.36
Rissoina catesbyana			2	2	.24
Sayella livida			2	2	.24
Odostomia bisuturalis			1	1	.12
Crepidula fornicata			1	1	.12
Crepidula plana			1	1	.12
Mitrella lunata			1	1	.12
Neritina virginea			1	1	.12
Teinostoma biscaynense			1	1	.12
Vitrinella floridana			1	1	.12
Anachas obesa			1	1	.12
	TOTALS		167	167	19.09

*Live and paired dead valves were counted as 1; unpaired valves as ½.

SOUTHERN LAGUNA MADRE
Bay Margin Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana	3	17,934	17,937	86.03
Mulinia lateralis	35	301	336	1.61
Tellina tampaensis	31	197	228	1.09
Polymesoda maritima		132	132	.63
Laevicardium mortoni	1	68	69	.33
Tagelus plebius	21	33	54	.26
Tellina texana		30	36	.17
Lyonsia hyalina floridana	10	13	23	.11
Chione cancellata		17	17	.08
Mysella planulata		14	14	.07
Cumingia tellinoides		13	13	.06
Brachidontes exustus		10	10	.05
Amygdalum papyria	6	2	8	.04
Aligena texasiana		6	6	.03
Ostrea equestris		6	6	.03
Ensis minor	6		6	.03
Mytilopsis leucophaeta		6	6	.03
TOTALS	119	18,782	18,901	90.65
Gastropoda				
Diastoma varium		1195	1195	5.73
Caecum pulchellum	2	189	191	.92
Acteon punctostriatus		133	133	.64
Acteocina canaliculata	6	98	104	.50
Odostomia laevigata		67	67	.32
Cerithidea pliculosa		63	63	.30
Crepidula fornicata		59	59	.28
Sayella livida	7	44	51	.24
Turbonilla interrupta		45	45	.22
Mitrella lunata		14	14	.07
Vitrinella floridana		13	13	.06
Anachas semiplicata		12	12	.06
Epitonium rupicola		1	1	.005
TOTALS	15	1933	1948	9.34

*Live and paired dead valves were counted as 1; unpaired valves as ½.

SOUTHERN LAGUNA MADRE
Grassflat Molluscan Assemblage

	Live	Dead	Total	Percent of total fauna
Pelecypoda*				
Anomalocardia auberiana	5	18,573	18,578	57.27
Chione cancellata	14	587	601	1.85
Mysella planulata	54	434	488	1.50
Mulinia lateralis	2	442	444	1.37
Tellina tampaensis	68	359	427	1.32
Laevicardium mortoni	9	347	356	1.10
Polymesoda maritima	2	350	352	1.08
Cumingia tellinoides	14	152	166	.51
Brachidontes exustus	2	135	137	.42
Tellina texana	6	129	135	.42
Mytilopsis leucophaeta		75	75	.23
Aligena texasiana	3	63	66	.20
Tagelus plebeius	30	31	61	.19
Nuculana acuta	1	34	35	.11
Mactra fragilis		17	17	.05
Ostrea equestris		12	12	.04
Amygdalum papyria	2	10	12	.04
Lyonsia hyalina floridana	1	6	7	.02
Anomia simplex		5	5	.01
Corbula swiftiana		4	4	.01
Argopecten amplicostatus		1	1	.003
Coralliophaga coralliophaga?		1	1	.003
Cyrtopleura costata		1	1	.003
Parvilucina multilineata		1	1	.003
Abra aequalis		1	1	.003
TOTALS	212	21,771	21,983	67.75
Gastropoda				
Diastoma varium	80	5898	5978	18.43
Caecum pulchellum	95	2229	2324	7.16
Crepidula fornicata	32	473	505	1.56
Odostomia laevigata	9	249	258	.79
Sayella livida	8	240	248	.76
Vitrinella floridana	10	197	207	.64
Acteocina canliculata	4	191	195	.60
Cerithidea pliculosa		174	174	.54
Mitrella lunata	3	129	132	.41
Turbonilla interrupta		107	107	.33
Acteon punctostriatus		107	107	.33
Anachas simplicata	5	89	94	.29
Odostomia sp. "A"		35	35	.11
Neritina virginea		14	14	.04
Anachas obesa		14	14	.04
Truncatella pulchella		12	12	.04
Odostomia weberi		11	11	.03
Mangelia sp.		11	11	.03
Crepidula plana		8	8	.02
Bulla striata	1	7	8	.02

continued

	Live	Dead	Total	Percent of total fauna
Odostomia teres		6	6	.02
Polinices duplicatus		4	4	.01
Odostomia gibbosa		2	2	.006
Epitonium novangliae		1	1	.003
Haminoea antillarum		1	1	.003
Epitonium rupicola		1	1	.003
TOTALS	247	10,210	10,457	32.21

*Live and paired dead valves were counted as 1; unpaired valves as ½.