**DRAFT**

# MARSH SEDIMENTATION
# COLORADO AND TRINITY RIVER DELTAS
# TEXAS GULF COAST

## Field Studies

by

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### Field Studies

## INTRODUCTION

The most extensive losses in coastal wetlands in the United States over the last two decades have occurred along the Gulf Coast. Wetlands are disappearing at the alarming rate of more than 100 $km^2$ per year (39 $mi^2/yr$) on the Mississippi River Delta, indicating a reversal in the trend of net progradation of the delta that characterized much of the past 5,000 years (Gagliano and others, 1981). The land-loss rates have accelerated geometrically during the 20th century, apparently as a result of natural and artificial processes, the latter including artificial levees and control structures that have harnessed the Mississippi River and virtually eliminated the deltaic sedimentation processes of overbank flooding, crevassing, and upstream diversion; extensive canalization and accelerated subsidence related to mineral extraction compound the problem (Gagliano and others, 1981). Investigations of marsh losses in Louisiana indicate that marsh aggradation (vertical accretion) rates are not keeping pace with relative (apparent) sea-level rise (DeLaune and others, 1983; Hatton and others, 1983; Baumann and others, 1984; Boesch and others, 1984).

Although less extensive than in Louisiana, losses in wetlands along the Texas coast have also been documented (McGowen and Brewton, 1975; Gosselink and others, 1979; Johnston and Ader, 1983; White and others, 1984, 1985, 1987). Some of the most dramatic changes have occurred in fluvial-deltaic areas such as near the mouths of the San Jacinto and Neches Rivers where wetland losses totaled more than 4,000 hectares (10,000 acres) between the mid 1950's and the late 1970's (White and others, 1985; 1987). The losses are characterized by submergence and displacement of marshes, swamps, and fluvial woodlands by shallow subaqueous flats and open water, indicating as in Louisiana, that marsh aggradation rates are not keeping pace with relative sea-level rise. Relative sea-level rise as used here, refers to a rise in sea level with respect to the surface of the land; the components of this relative change are a combination of actual sea-level rise and land-surface subsidence.

The high rates of wetland loss in Louisiana have made it the center of wetlands research, including studies in marsh sedimentation. There have been few studies of sedimentation in Texas marshes. Investigations have principally focused on shoreline changes in an effort to document erosion and accretion (advancement of the shoreline) (McGowen and Brewton, 1875; Morton, 1977; Morton and Paine, 1984; Paine and Morton, 1986; White and Morton, 1987). This field investigation, which has as a primary objective of documenting local marsh aggradation (vertical accretion) rates, is apparently the first of its type in Texas coastal marshes.

Rivers discharging into the bays and estuaries along the Texas coast have constructed deltas that are the sites of extensive marshlands. Fluvial sediments delivered by the rivers help maintain these valuable natural resources. Marshes are dependent upon sediment deposition not only for nutrient supply, or fertilization, but also in order to remain in their intertidal position. Accordingly, comparisons of marsh aggradation rates with rates of relative sea-level rise provide critical information for predicting marsh vegetation survival. If sediment deposition is such that marsh aggradation rates can keep pace with rates of relative sea-level rise the marsh can survive and even flourish. But, if aggradation rates fall behind, the marsh will drown and be replaced by open water.

A major objective of this field investigation is to document marsh aggradation rates using artificial marker horizons similar to those used in Louisiana (DeLaune and others, 1983; Baumann and others, 1984). Two deltaic areas were selected for study: the Colorado River delta and the Trinity River delta. Both areas have significantly extended their deltas within historic times, and both are fed by rivers whose sediment loads have, more recently, been significantly reduced (figs. 1 and 2).

## DESCRIPTION OF STUDY AREAS

A more thorough discussion of the Colorado and Trinity River deltas and their respective estuaries, including their historical development and current state, is presented in the literature synthesis draft report (White and Calnan, 1988).

### Colorado River Delta

The Colorado River delta (fig. 3) has had a relatively unique history of development. Its progradation across the eastern arm of Matagorda Bay (a distance of about 6 km) occurred over approximately six years after removal of a log raft along the channel in 1929 (Wadsworth, 1966). Selection of the Colorado River delta for field studies is an outgrowth of a proposal to investigate the effects of the Colorado River diversion project. Efforts are currently underway to divert the Colorado River into Matagorda Bay (USACE, 1981). The increase in sediment load delivered to the bay is expected to promote delta progradation at the mouth of the diversion channel. It is anticipated that the prograding delta will be the site of marsh development as smooth cordgrass (Spartina alterniflora) and other salt-water and brackish-water marsh plants colonize the new land, which is expected to amount to approximately 2,000 acres in 50 years (USACE, 1981; van Beek and others, 1980). Tiger Island Cut, an

Question: Will the final report have better quality graphics?

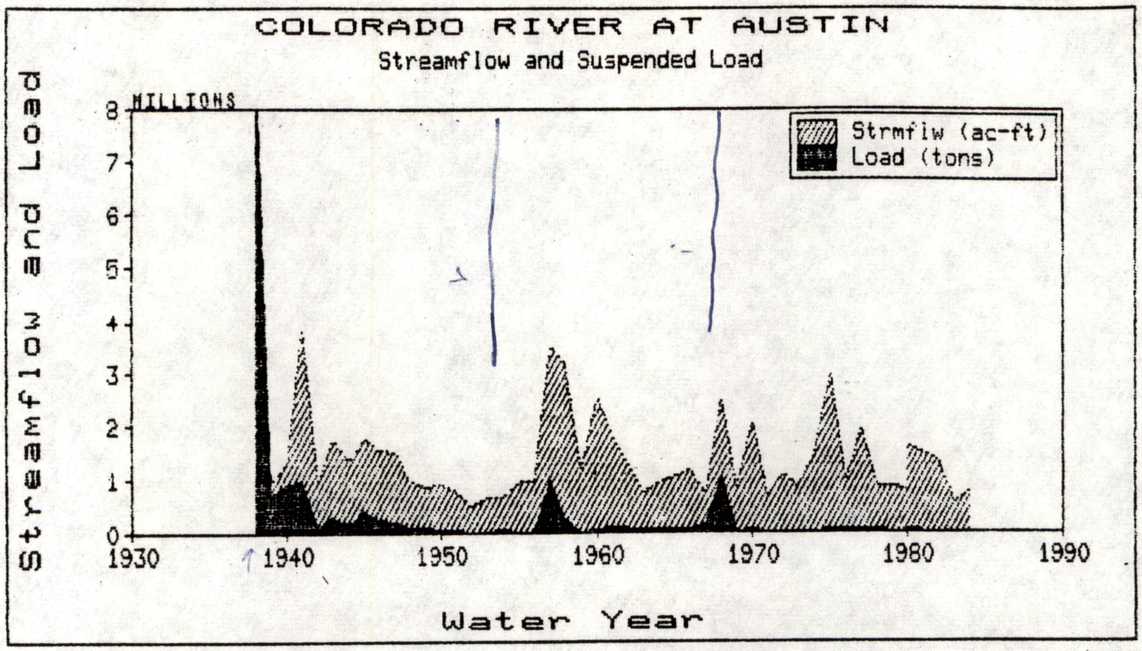



Figure 1. Annual streamflow and suspended sediment load of the Colorado River. (Data from Stout and others, 1961; Adey and Cook, 1964; Cook, 1967; Cook, 1970; Mirabal, 1974; Dougherty, 1979; and unpublished records from Texas Water Development Board, available through TNRIS.)

Possible to mark and annotate the operational date of selected reservoirs?

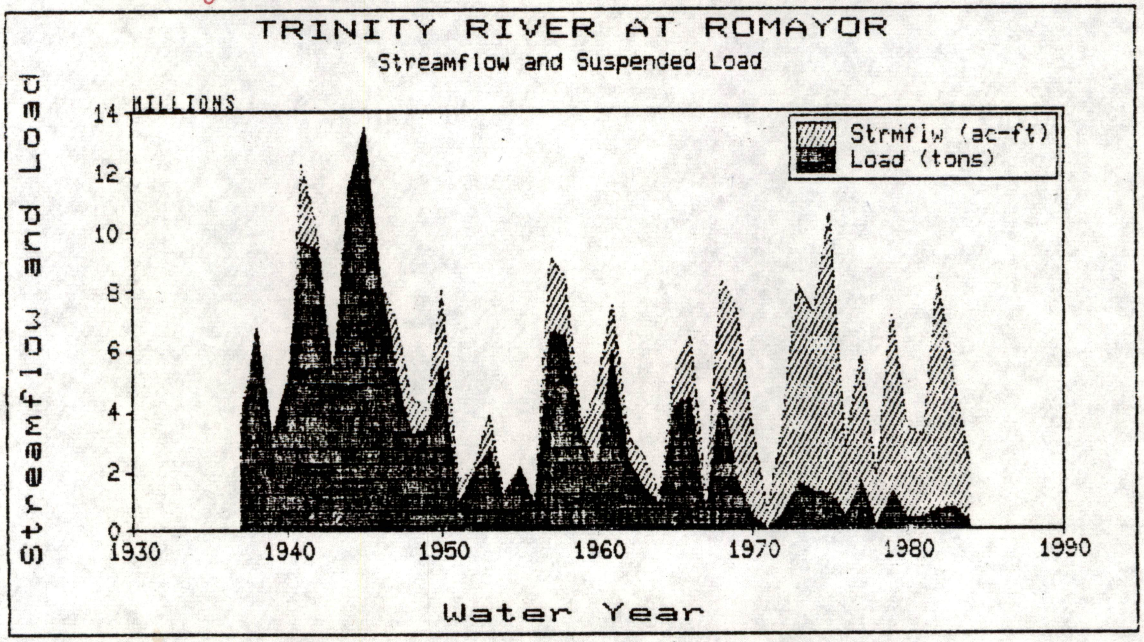



Figure 2. Annual stream flow and suspended load of the Trinity River. (Source of data same as for figure 1.)

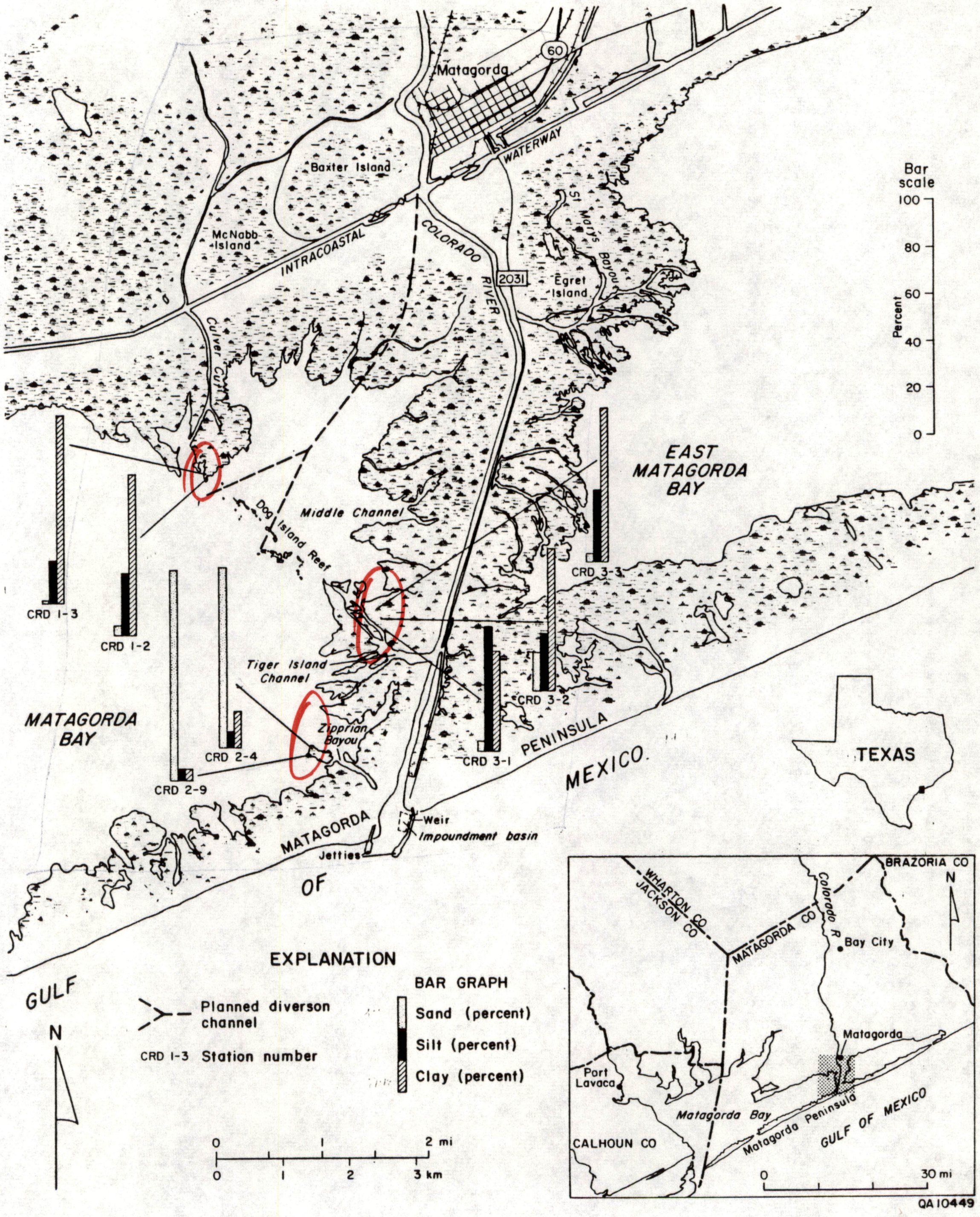



Figure 3. Index map of the Colorado River delta showing locations of profiling and vegetation transects and the distribution of textural data.

artificial distributary channel that supplies sediment to the only currently active delta lobe, will be closed as part of the design recommendations. Thus, the locus of sediment deposition on the Colorado River delta will shift as a result of the diversion project.

These planned modifications at the mouth of the Colorado River provide a unique opportunity to investigate changes in fluvial sedimentation, and to document marsh aggradation rates in a river system whose sediment regime is principally suspended load composed of silt and clay. Most bedload (sand) transported by the river (along its lower drainage basin) is trapped upstream from the delta in a shallow draft navigation channel and silting basin that is periodically dredged (USACE, 1977). Sediment supplied to the deltaic area is derived from less than 10 percent of the river drainage basin, the remainder of the drainage basin lies above the Highland Lakes chain, which effectively traps sediment delivered to it (Ward and others, 1980).

Does the Highland Lakes really trap the major source of sediment or has it been a matter of slowing flow

The Colorado River delta marsh is primarily a proximal salt-water marsh community (a community in relatively close proximity to the estuarine system and thus more frequently flooded than higher salt marshes such as along natural levees, White and others, 1983; 1985). ~~The~~ This (?) proximal marsh is composed principally of *Spartina alterniflora*, mixed locally with *Scirpus maritimus*, grading at slightly higher elevations into species such as *Distichlis spicata*, *Batis maritima*, *Salicornia* spp., and *Lycium carolinianum* as well as patches of *Borrichia frutescens* and *Monanthocloe littoralis*. More common at higher elevations, such as on berms and levees, are *Spartina patens*, *Spartina spartinae*, *Iva frutescens*, and *Borrichia frutescens*. Specific vegetation assemblages for the different marsh transects are presented in later sections, as is sediment distribution.

Hydrological studies of the delta indicate complex interactions among several channels (Colorado River channel, Intracoastal Waterway, Culver Cut, and Tiger Island Cut; fig. 3) that cross the delta plain (TDWR, 1978b). Computer Model computations indicate that only rarely (because of high artificial levees) is any part of the Colorado River delta west of the river inundated by freshwater overbanking during floods (TDWR, 1978b). Computations indicate that about 80 percent of river flow along the Colorado River channel above Tiger Island Cut is diverted through the cut at flows of 2,000 cubic feet per second (cu$^3$/sec), but the percent of diversion through the cut diminishes as river flow increases to 8,000 cu$^3$/sec, above which diversion through Tiger Island Cut levels off and remains at a constant 62 percent (TDWR, 1978b; 1980). As pointed out by Ward and others (1980), however, these results, which indicate decreasing flow through Tiger Island Cut with increasing river flow, do not agree with results of an earlier computer model (the conflict apparently has not yet been resolved). "Thus, the Colorado Delta exhibits a unique and complicated hydrodynamic regime influenced by tidal fluctuations, the degree of river mouth shoaling, and the magnitude of freshwater inflows in the Colorado. Field studies have yet to adequately define the flow regime, and the mathematical model representations of the system give conflicting results" (Ward and others, 1980, p. 49).

What about flows down the ICW

~~Should any mention be made of plans to divert river mouth?~~

!

The astronomical tidal range in Matagorda Bay averages 0.7 ft (0.2 m) (Diener, 1975). The tidal period varies from diurnal to semi-diurnal generally twice during each 30 day period (Holliday, 1973). The diurnal tide has one high and one low tide about 12 hours apart over a 24 hour period. A diurnal tide continues for eight days followed by up to six days of semi-diurnal tides having two highs and two lows in 24 hours (Holliday, 1973). Holliday (1973) reports that as the tide approaches a semi-diurnal period a slack tide can persist for up to nine hours. The slack tide decreases the fluctuation from ebb to flood to 0.2 to 0.5 ft (0.06 to 0.15 m). Satellite photographs taken during this period show confused bay turbidity patterns, suggesting a reduction in current velocities and duration (Holliday, 1973).

!

Wind tides in Matagorda Bay greatly affect the extent of marsh inundation in the delta. The Texas Department of Water Resources (TDWR, 1980) reports that flooding of marshes within the delta is "largely the result of tidal activity, or a combination of high bay and Gulf tides and southerly winds." Most of the marshes on the delta north of Tiger Island Cut and east of Culver Cut may be inundated as a result of the interaction of high tides and wind set up (TDWR, 1980).

confusing

? How about ~~by~~ persistent winds from ~~the~~ southerly directions

## Trinity River Delta

The Trinity River delta (fig. 4) has had a history of less rapid progradation compared to the Colorado River delta, however, it has the distinction of being the only other estuarine delta along the Texas coast to have significantly grown, or prograded, into its estuary (Trinity Bay) since the mid 1800's (Shepard, 1953). Among many human modifications that affect the hydrodynamics of the delta and its environments are dredging of the Trinity River channel and extension of the channel (Anahuac Channel) into Trinity Bay beyond the delta, and partial construction of Wallisville Lake dam (shown in fig. 4 as a levee) along the southern margin of Old River Lake and Old River. (The quantity of sediment periodically dredged from Anahuac Channel is presented in ~~the literature systhesis report,~~ White and Calnan, 1988).

Not in Lit cite?

The Trinity River delta is characterized by considerably lower salinities than the Colorado River delta, and marshes are more reflective of brackish water conditions. Vegetation includes *Alternanthera philoxeroides*, *Phragmites australis*, *Bacopa monnieri*, *Scirpus olneyi*, *Scirpus maritimus*, *Echinochloa* spp. *Typha* spp., *Eleocharis parvula*, *Paspalum lividum*, *Paspalum vaginatum*, *Cyperus* spp., *Aster* spp., *Spartina patens*, *Spartina spartinae*, *Panicum dichotomiflorum*, *Sphenoclea zeylanica*, and *Pluchea* sp.

The astronomical tidal range in Trinity Bay averages 1.0 ft (0.3 m) (Diener, 1975). Marmer (1954) classified the tide at Round Point, Trinity Bay as daily or diurnal in which one high and one low occur in a 24 hour period.

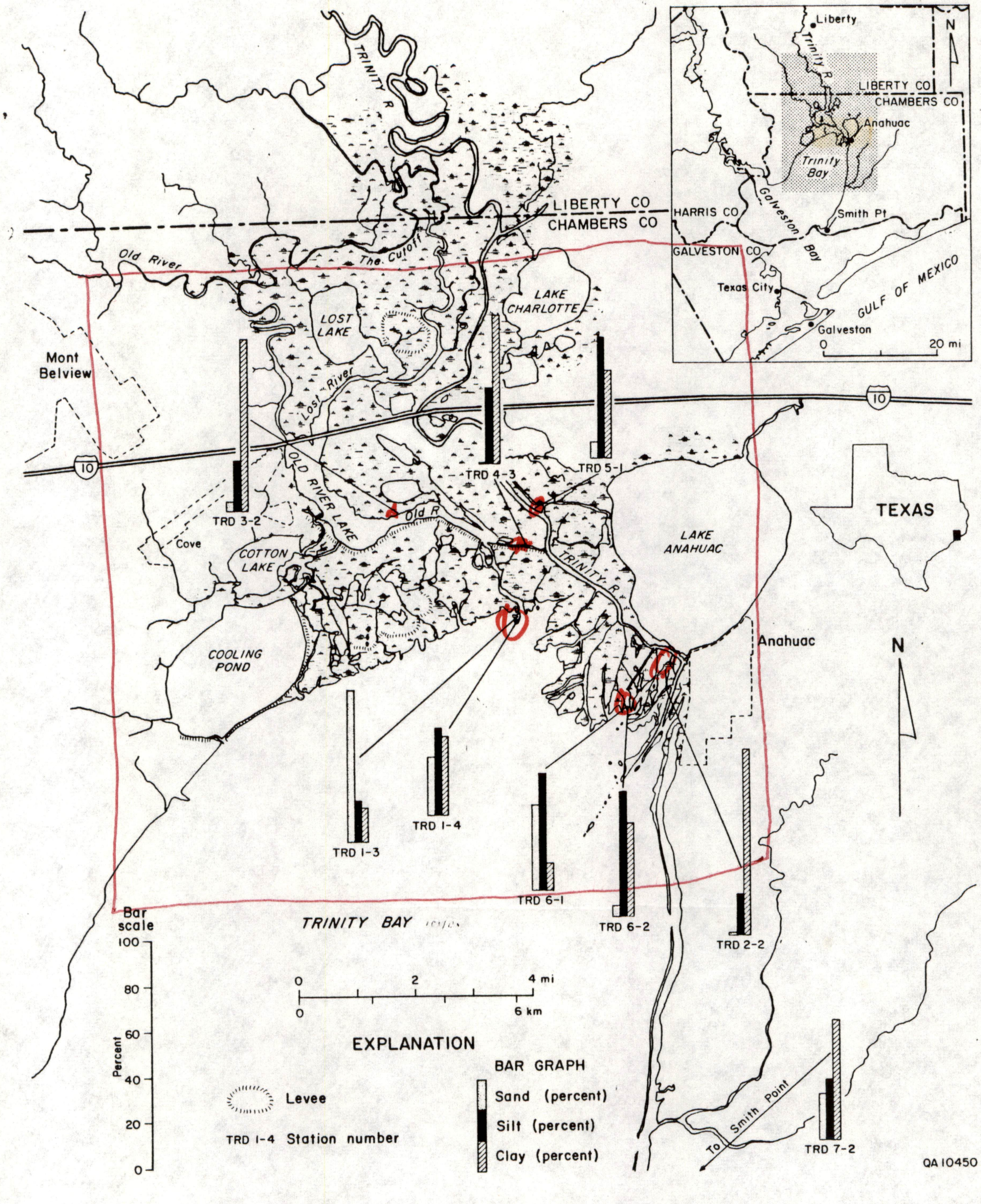



Figure 4. Index map of the Trinity River delta showing locations of profiling and vegetation transects and the distribution of textural data.

Is it Possible to
enlarge sample site
area even more
while retaining guide
in upper right corner?

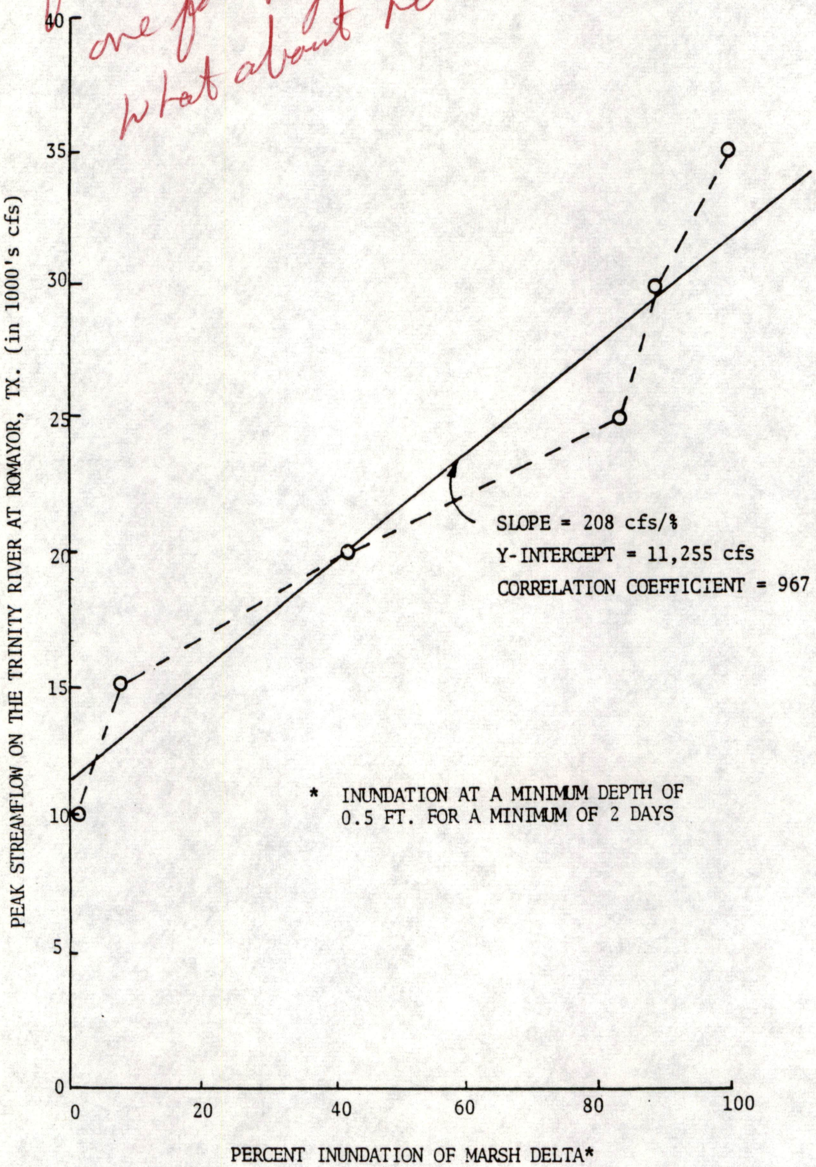
The Texas Department of Water Resources~~, by utilizing~~ used the verified inundation model for the's system, to studied the extent of marsh inundation due to tidal and river floods in the delta (TDWR, 1981). Flooded surface area was determined under both high and low tidal amplitudes for six flood peaks on the Trinity River. Each of the flood cases was simulated with both a high and low driving tide "to differentiate those areas which would be inundated as a result of high flows, and those areas which would be inundated as result of interaction of high freshwater inflow and high tidal amplitude" ) (TDWR, 1981). With low tidal conditions, the model indicates that no inundation will occur within the delta during floods of less than 20,000 ft$^3$/sec. Floods with discharge in excess of 30,000 ft$^3$/sec will sharply increase the percentage of area inundated. With low tides, a 35,000 ft$^3$/sec flood will inundate 79 percent of the marsh (TDWR, 1981). High tides will cause some inundation within the area for all six of the simulated peaks. High tides and floods above 30,000 ft$^3$/sec will completely inundate the area (TDWR, 1981). With average diurnal tides and a peak discharge of 25,000 ft$^3$/sec nearly 85 percent of the marsh is flooded; total inundation, with average diurnal tides, occurs at a peak discharge of 35,000 cu$^3$/sec (fig. 5).

*

along with wind?

## METHODS

Four profiling and vegetation transect sites were established in the area of the Colorado River delta and seven in the Trinity River delta (figs. 3 and 4 show locations of sites in delta areas). Elevations, bearings, vegetation characteristics (vegetation types, densities, and heights), and salinities (where possible) were measured and recorded along the transects. Elevations were surveyed primarily with a planetable and telescopic alidade (fig. 6); at one site in the Colorado River delta a short segment was also surveyed using profiling rods (a method described by Emery, Test indicates two graphs are for low tides and one for high tides. What about here?




* The 500 cfs base flow is not included in this calculation.

Figure 5. Percent inundation of the marsh in the Trinity River delta versus peak discharge of the Trinity River. From Texas Department of Water Resources (1978a).

Figure 6. P~~hotograph of~~ plane table, telescopic alidade, and profiling rod used ~~in~~ to ~~taking~~ elevations along transects.

measure

1961). Distances along transects were measured with a 30 m (100 ft) fiber-glass measuring tape. Artificial marker horizons (1 $m^2$ in size) composed of white Na-Feldspar clay (figs. 7 to 10) were placed along each marsh transect for the purpose of measuring marsh aggradation rates (DeLaune and others, 1983; Baumann and others, 1984). A total of 9 marker horizons in the Colorado River delta area, and 11 in the Trinity River delta were established.

Siting of the transects and markers were determined primarily with regard to (1) spatial relationships ~~between~~ among the marsh, river, channel, and bay environments, (2) representation of various marsh types including relative elevations, (3) relationship with respect to existing and planned artificial modifications of the fluvial-deltaic system, (4) accessibility of the site, and (5) susceptibility to disturbance by human or animal activity. In the Colorado River delta area, three marsh-transect sites were established in June of 1987 (as part of a preliminary interagency aggreement to establish monitoring stations for a proposed investigation of the Colorado River Diversion Project--see Appendix 1), and a fourth site was established in December 1987 (the first month of this contract period). The six marsh-transect sites in the Trinity River delta area were established in December 1987. One site was selected away from the deltas in each area for "control" purposes. In the Trinity Bay area a marsh at Smith Point (TRD-7), approximately 22 km away from the delta, was selected, and in the Colorado River-Matagorda Bay area, a marsh on Matagorda Peninsula (CRD-4), approximately 15 km southwest of the delta, was selected. In addition, a marine grass bed was examined along the Matagorda Peninsula approximately 21 km southwest of the mouth of the Colorado River in July of 1988. Working with Warren Pulich ~~of~~ ~~from~~ ~~the~~ (Texas Parks and Wildlife Department), water depths and species composition (fig. 11) were recorded at stakes placed along a line from the seagrass bed to shore for comparison with future observations.

Are these in priority of selection methodology?

Use 6 of the pictures
and cite as
~~examples of artificial~~
Artificial marker beds just after creation
at TRD 4-3, TRD 1-4 and CRD 2-4.

Figure 7. ~~Photograph of~~ artificial marker bed at station TRD 4-3.

Figure 8. Photograph of artificial marker bed at station TRD 1-4.

Figure 9. Photograph of artificial marker bed at station TRD 5-1.

Figure 10. Photograph of artificial marker bed at station CRD 2-4.

Figure 11. Photograph of the marine grasses Halodule beaudettei and Halophila engelmanni from a grass bed on the bay margin of Matagorda Peninsula.

or wrightii?

Get with Warren and agree which name will be used throughout all B&E reports.

At a few selected sites where artificial marker horizons were established, 1-m long brass rods (3 mm in diameter) were driven into the ground near the marker beds, and the heights of the rods above the marsh surface were carefully measured; these sedimentation/erosion pins serve as partial backups to the marker horizons for estimating sedimentation or erosion. In addition, aluminum pans, 17.5 X 17.5 cm and 5.5 cm deep (fig. 12), were placed at selected marsh sites in both deltaic areas in March 1988; seven pans were established in the Colorado River delta area, and six in the Trinity River delta. The pans were set out primarily for observational purposes, that is, to note gross differences in organic and inorganic accumulation with respect to the relative elevations and marsh type. The contents of only one pan was actually collected for quantitative analysis. ?? why ? ?

Another part of the field investigation included collecting surficial marsh samples near the artificial marker beds for laboratory analyses of organic/inorganic and sand, silt, and clay percentages (methods are presented in Appendix 2). Also moisture content of the sediments was analyzed. Samples were collected from the top 2 to 4 cm of the marsh surface. Sand, silt, and clay percentages determined from collections made in March, 1988, are presented in figures 3 and 4.

Marsh transect profiles and marker beds were located by compass bearings and distances with respect to cedar posts (1.8 m long) driven into the marsh substrate. Compass bearings were also taken on visible structures (channel markers, water towers, tide gauges, etc.) for backup purposes. One site (transect 1 on the Colorado River delta) was tied to a bench mark (Appendix 3).

Sites in both field areas were revisited in March and July, 1988. Selected sites in the Colorado River delta area, some of which were established in June of 1987, were also visited in December of 1987, and February of 1988. Artificial marker beds were inspected or trenched to document the rate of sedimentation that had occurred between periods. To measure sediment deposited above the marker horizons, sediment

Figure 12. Photograph of aluminum sediment pan at station CRD 3-2.

was cut away along a shallow, narrow, vertical trench that intersected the marker bed (fig. 13). The length of the trench was generally from 0.3 to 0.5 m, along which at least 10 measurements were made and averaged to determine the depth of sediment deposited above the horizon. The excavated trench was carefully filled with similar marsh sediment in an effort to lessen disturbance of the remaining marker horizon for future measurements. Initial plans also included examining the sites following significant flood events caused by riverine discharge, tropical storms, or hurricanes, but such events did not occur during the monitoring period.

Vegetation cover and relative species abundance were taken at most stations during the first sampling period, June or December 1987 in the Colorado River delta and December 1987 in the Trinity River delta. Vegetation cover and relative species abundance at most stations in the Colorado River delta are shown in percent in the Appendix 3. General comments on species composition and abundance at stations in the Trinity River delta are also included in the Appendix 3. Representative vegetation heights for each species were measured at each station during the first sampling period in the Colorado River delta. In addition, heights of most species present at each marker bed station in both deltas were recorded during each sampling period or in the winter (December 1987), early spring (March 1988), and summer (July 1988) in the Trinity River delta, and winter (December 1987; February 1988), early spring (March 1988) and summer (June 1987; July 1988) in the Colorado River delta (tables 1 and 2).

Salinities were taken with an S-C-T meter (Salinity-Conductivity-Temperature meter) at most transects in the Trinity and Colorado River deltas during the sampling trips in December 1987, March 1988, and July 1988. Salinity data may only be estimates as the S-C-T meter may not have been functioning properly during some of the sampling trips. In addition to measured salinities, data from Pullen and Trent (1969) on salinities in the Trinity River delta and from Martinez (1974, 1975) on

which trips? Can we know which are right & which are suspect?

Need table on salinities

Figure 13. Photograph of vertical trench intersecting the marker bed at station CRD 2-4.

Table 1. Seasonal vegetation heights at marker beds in Colorado River delta.

| Transect-station and date | Vegetation heights (range in cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Spartina alterniflora | Borrichia frutescens | Batis maritima | Distichlis spicata | Monanthochloe littoralis | Scirpus maritimus | Spartina patens |
| 1-2 June 1987 | | 79-89 | | 64-107 | | 94-109 | |
| 1-2 March 1988 | | 57 | | 39-44 | | 60-64 | |
| 1-2 July 1988 | | 67 | | 49 | | | |
| 1-3 June 1987 | 70-91 | | | | | | |
| 1-3 March 1988 | 50-76 | | | | | | |
| 1-3 July 1988 | 67-76 | | | | | | |
| 1-13 Feb 1988 | | | 55 | 61 | | | |
| 1-14 July 1988 | | 61-79 | 40-41 | | | | 63-72 |
| 2-4 June 1987 | 73 | | | | | | |
| 2-4 March 1988 | 48-59 | | | | | | |
| 2-4 July 1988 | 57-74 | | | | | | |
| 2-9 June 1987 | | | 15 | | 8 | | |
| 2-9 March 1988 | | | 20-36 | | 9-17 | | |
| 2-9 July 1988 | | | | | 15-17 | | |
| 3-1 Dec 1987 | | 69-71 | 74 | 61 | | | |
| 3-1 July 1988 | | 66-72 | 60-64 | Dead | | | |
| 3-2 Dec 1987 | 61-69 | | | 41-48 | | | |
| 3-2 March 1988 | 25-56 | | | 33-53 | | | |
| 3-2 July 1988 | 45-67 | | | 40-48 | | | |
| 3-3 Dec 1987 | 76 | | | | | | |
| 3-3 March 1988 | 50-56 | | | | | | |
| 3-3 July 1988 | 58-63 | | | | | | |
| 4-10 Dec 1987 | 58 | | | | | | |
| 4-10 July 1988 | 39-40 | | | | | | |

How about similar table for salinities?

Table 2. Seasonal vegetation heights at marker beds in Trinity River delta.

| Transect-station and date | Vegetation heights (range in cm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spartina alterniflora | Alternanthera philoxeroides | Echinochloa crusgalli | Bacopa monnieri | Scirpus olneyi | Juncus roemerianus | Panicum dichotomiflorum | Sphenoclea zeylanica | Pluchea sp. | Crinum americanum |
| 1-3 Dec 1987 | | | | | | | 67-140 | | 110 | |
| 1-3 March 1988 | | | | | | | 30-75 | | | |
| 1-3 July 1988 | | | | 15 | 72-152 | | | | | |
| 1-4 Dec 1987 | | | | | | | | 112 | | |
| 1-4 March 1988 | | | | | | | | 51-109 | | |
| 1-4 July 1988 | | | | | 114 | | | | | |
| 2-2 July 1988 | | 91-104 | | | | | | | 122 | 46-61 |
| 3-2 Dec 1987 | | | | | | | | | | <30 |
| 3-2 March 1988 | | | | | | | | | | 17-25 |
| 3-2 July 1988 | | | | | | | | | | short, near surface |
| 3-4 Dec 1987 | | <10 | | | | | 25-70 | | | |
| 3-4 July 1988 | | 61 | 117 | | | | | | 100 | |
| 4-3 Dec 1987 | Mostly bare; vegetation dead | | | | | | | | | |
| 4-3 March 1988 | | <6 | | | | | | | | |
| 4-3 July 1988 | | 61-91 | 152 | | 104-140 | | | | | |
| 4-4 July 1988 | | 61-91 | 152 | | 96-129 | | | | | |
| 6-1 March 1988 | | | | | 5-12 | | | | | |
| 6-1 July 1988 | | | | | 122-135 | | | | | |
| 6-2 July 1988 | | 55-67 | | | | | | | | |
| 7 Dec 1988 | 61 | | | | | 142 (away from marker) | | | | |
| 7 March 1988 | 43-46 | | | | | | | | | |
| 7 July 1988 | 79-89 | | | | | | | | | |

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salinities in Matagorda Bay near the Colorado River delta are used to supplement the measured data. Salinity data for other bay-esturay-lagoon systems can be found in the draft literature synthesis of White and Calnan (1988).

## RESULTS AND DISCUSSION

### Colorado River Delta

#### Sediment Composition

##### Textures

Results of textural analysis at the different marsh transects on the Colorado River delta are illustrated in figures 3 and 14 (based on data from Appendix 2). Sediments collected near the marker beds at the three transects (? which ones show I.D.) show clay to be significantly more abundant (ranging up to 80 %) than silt (maximum of about 30 %) in the low marshes, while in the levee marsh, station CRD 3-1, silt was slightly more abundant (about 50 %) than clay (about 40 %). Sand was not a significant component of the marshes sampled except on nearby Matagorda Peninsula where it was predominant (ranging up to almost 90 %).

Comparisons of the sediment textural distribution along Transect CRD 3, indicates that variations in sediment composition are related, in part, to distances from the Tiger Island Cut distributary channel and to elevations of the sampling sites. Accordingly, sediments from station CRD 3-1, the levee site close to the distributary channel (fig. 3), has a higher silt content than sediments from stations CRD 3-2 and 3-3, which are further from the distributary channel and at lower elevations (fig. 15). The change in texture is indicative of the process of sediment deposition during overbank flooding in which coarser material is deposited nearer the channel (levee) as

unshaded bars less confusing
different colors or different shades for the two deltas

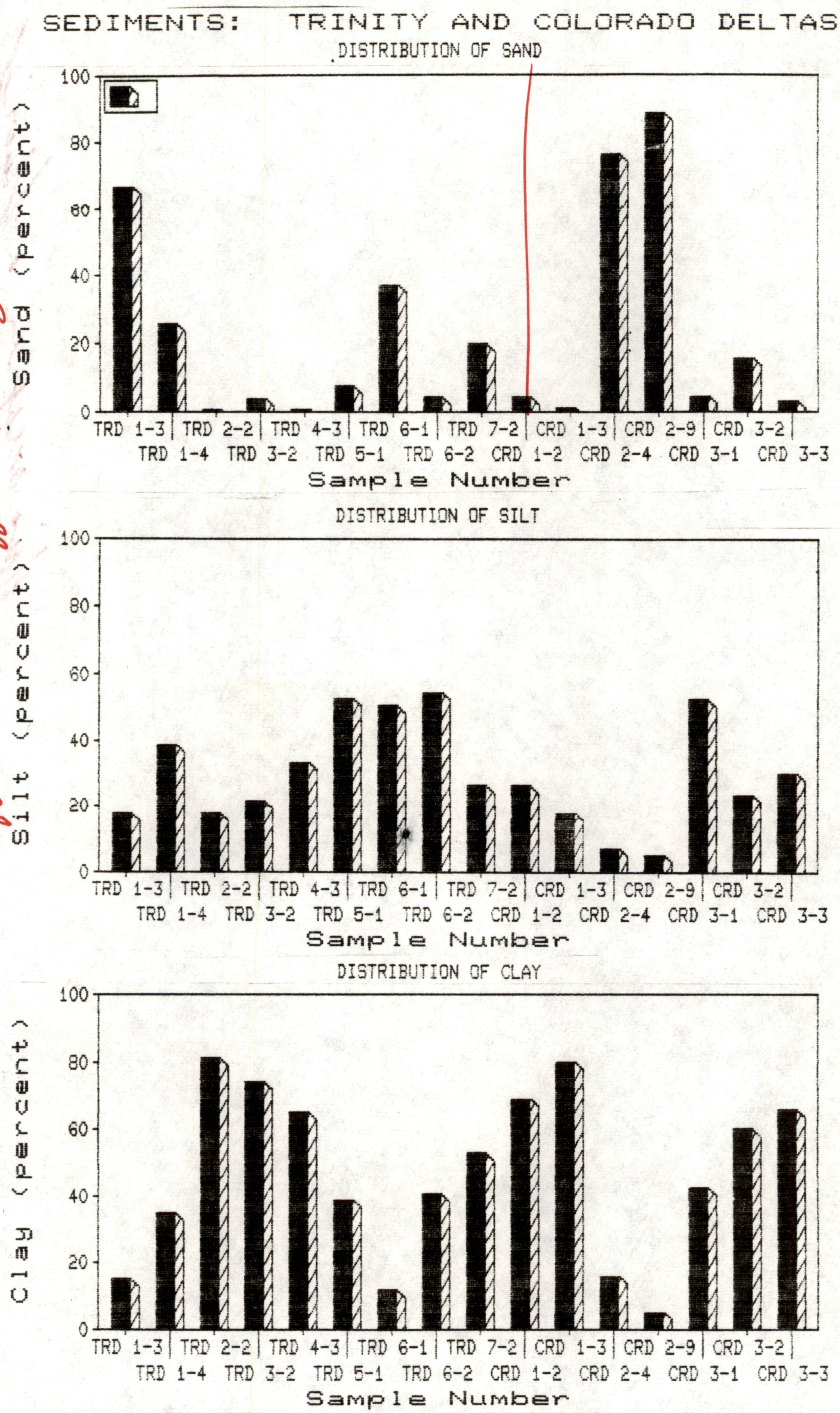



Figure 14. Percentages of sand, silt, and clay measured in sediments from each station in the Colorado and Trinity River delta.

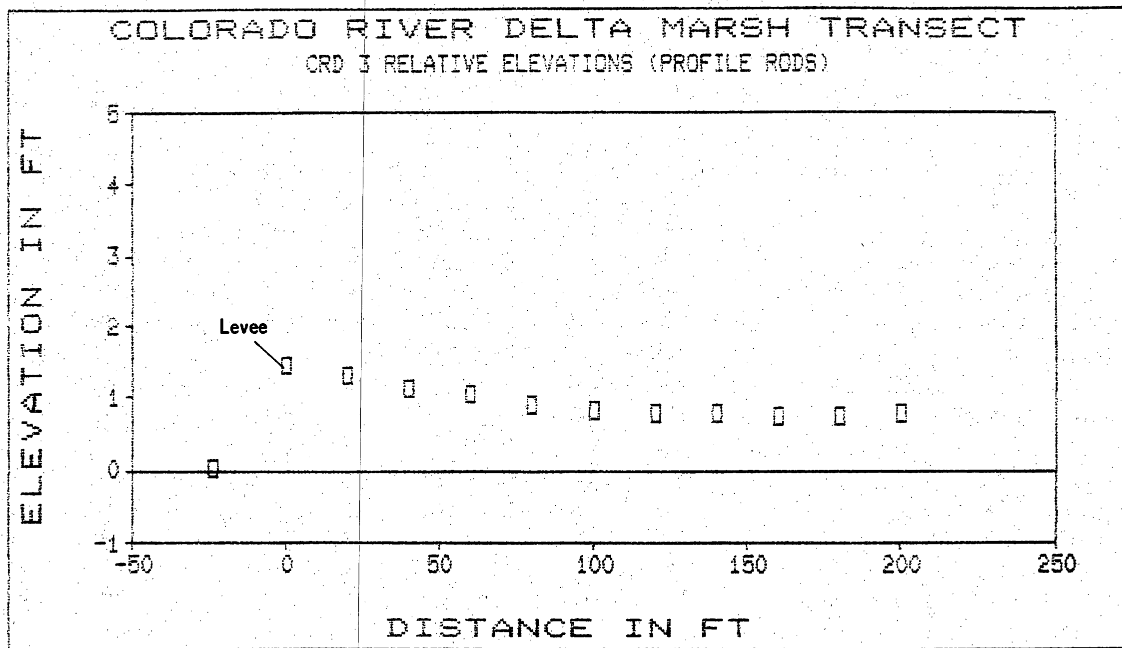
flood velocities and sediment carrying capacities recede as the flood water leaves the channel. In a study of a delta lobe on the eastern half of the Colorado River delta, Kanes (1970) reported that the low-marsh sediments were characteristically finer grained than the higher marsh. He suggested that the sediments on the higher marsh were derived from the river during floods, while the low-marsh sediments were derived from turbid bay waters. concentrated in high marsh dispersed in low areas and mixed with marine sediments

The sand-rich marsh substrates at stations CRD 2-4 and 2-9 near Zipprian Bayou on the edge of Matagorda Peninsula reflect the predominantly sandy composition of the barrier peninsula (fig. 3). The higher concentrations of silt and clay at station CRD 2-4 indicates a bayward source of mud that is deposited in this intertidal *Spartina alterniflora* marsh zone (fig. 16). Sediments collected from stations CRD 1-2 and CRD 1-3 near Culver Cut have clay concentrations ranging from 70 to 80 percent, which are the highest of any sediment samples collected from the Colorado River delta (fig. 14). The high clay content is related to the location of these sites in topographically low marshes (away from distributary channels) where fine inorganic sediments are deposited in low energy environments (fig. 17).

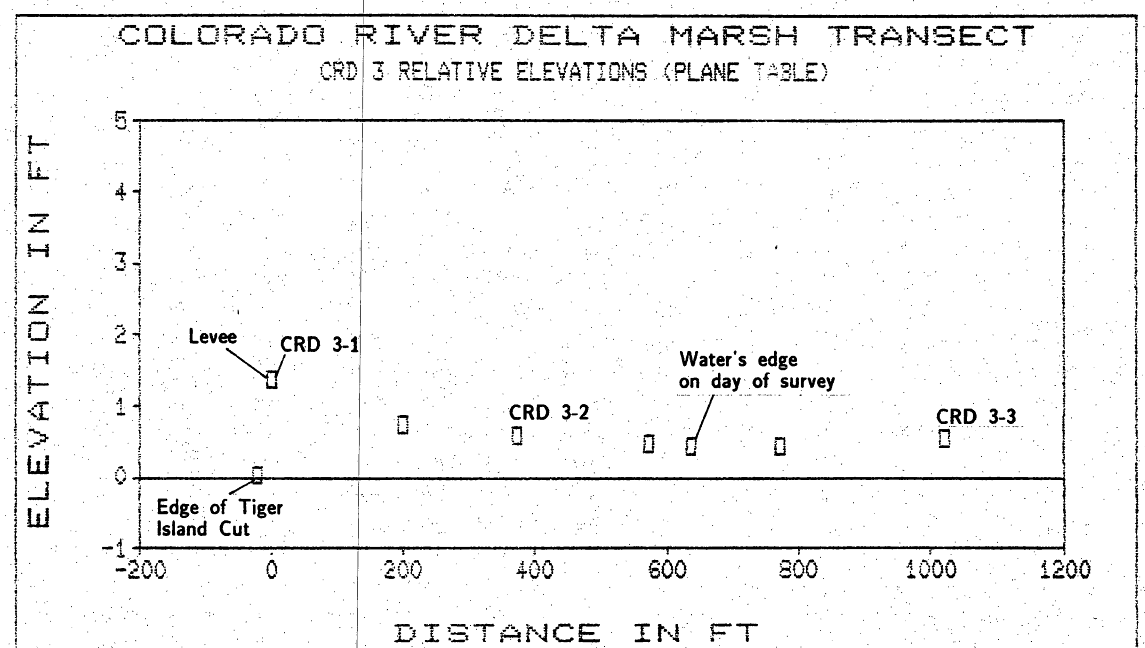
Sediments from station CRD 4-10 (located in a *Spartina alterniflora* marsh on Matagorda Peninsula approximately 15 km to the southwest of the delta) have not yet been analyzed (analyses are in progress), but qualitative descriptions indicate high sand composition similar to sediments from station CRD 2-4. will these be analyzed for final report

## Organics

Total organic carbon (TOC) concentrations in marsh sediments of the Colorado River delta ranges from highs of 4 to 5 percent at stations along transect CRD 1 near Culver Cut, to lows of less than 1 percent at stations CRD 1-2 and 1-3 on Matagorda Peninsula (fig. 18). There is a high positive correlation between percentage of clay and TOC (correlation coefficient, r, = 0.95) (fig. 19). Gross organics

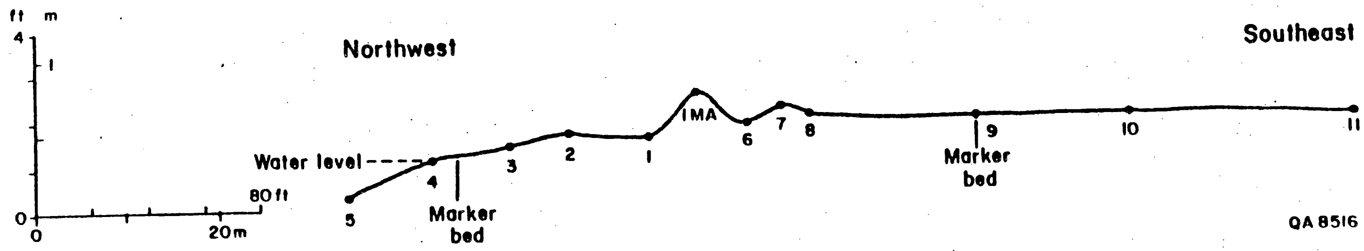



(A)



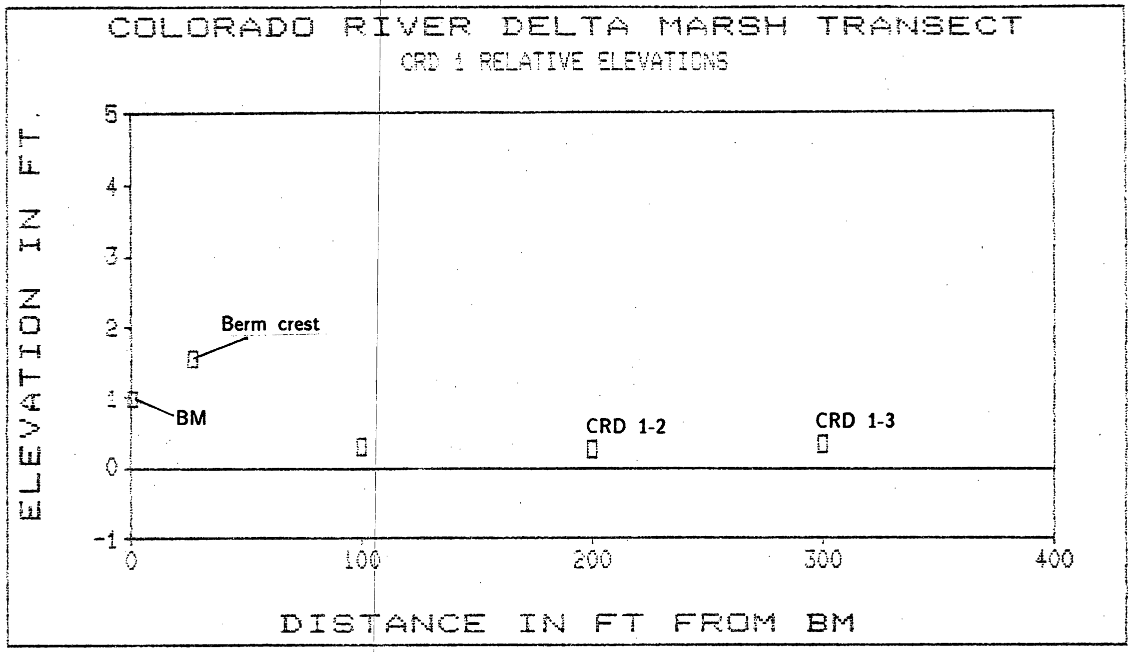

(B)

Figure 15. Relative elevations (not adjusted to sea-level datum) along transect CRD 3. Elevations determined with profiling rods along the initial 200 ft (60 m) of the transect are shown in (A); elevations based on a survey using a plane table along about 1000 ft (300 m) of the transect are shown in (B).

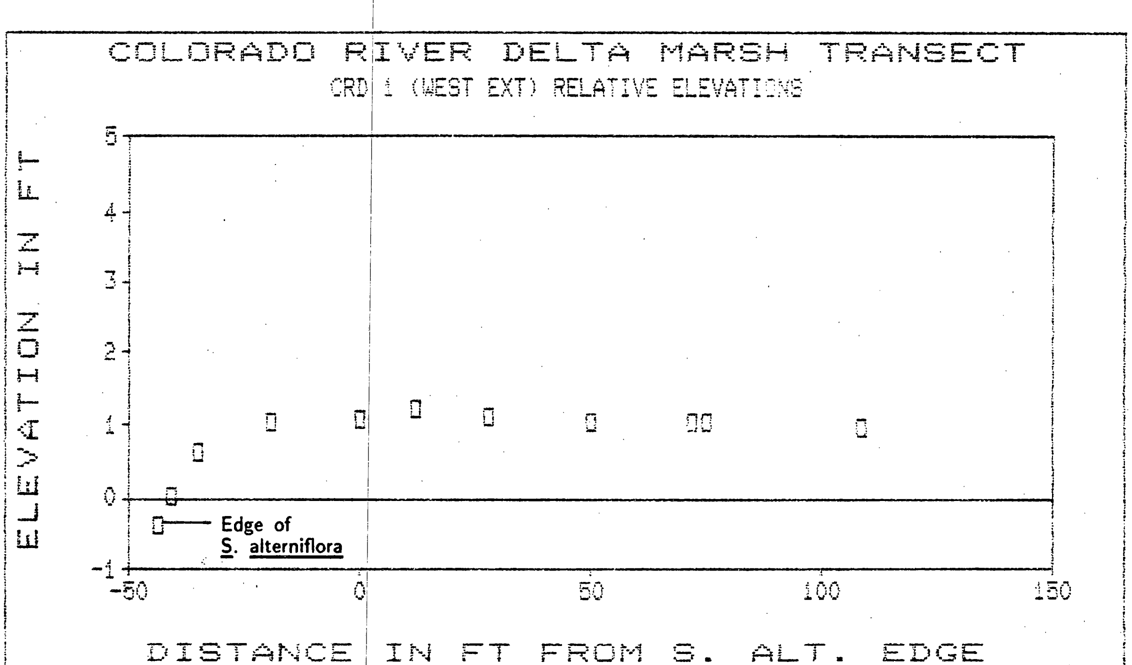



| Station # | Vegetation types |
|---|---|
| 1MA | Borrichia frutescens and Spartina patens codominant |
| 1 | Edge of Borrichia frutescens and Spartina patens, beginning of Batis maritima (composes 90% of community between 1 and 2) |
| 2 | Distichlis spicata dominant; scattered Borrichia frutescens and Spartina alterniflora |
| 3 | Edge of Spartina alterniflora dominance; scattered Distichlis spicata, Salicornia virginica and Batis maritima |
| 4 | Spartina alterniflora, about 60% cover |
| 5 | Edge of marsh; Spartina alterniflora, about 20% cover |
| 6 | Batis maritima dominant; scattered Spartina patens, Salicornia virginica, and Borrichia frutescens |
| 7 | Spartina patens dominant (75%), Borrichia frutescens subdominant (25%) |
| 8 | Edge of Spartina patens, beginning of Batis maritima dominance; scattered Borrichia frutescens and Avicennia germinans |
| 9 | Monanthochloe littoralis dominant (80%), Batis maritima subdominant (20%); scattered Salicornia virginica |
| 10 | Batis maritima dominant (80%); scattered Salicornia virginica, Distichlis spicata, and Spartina alterniflora |
| 11 | Distichlis spicata and Batis maritima codominant; edge of patch of Scirpus maritimus |

Figure 16. Profile and vegetation types along one leg (approximately 360 ft or 110 m) of marsh transect CRD 2 on Matagorda Peninsula.




**(A)**




**(B)**

Figure 17. Profile showing relative elevations along marsh transect CRD 1. Elevations along a line from a Bench Mark (BM) near the edge of the bay toward stations CRD 1-2 and CRD 1-3 shown in (A)(the "0" line does not represent mean sea level, but is only a reference line representing the water level at the time of the survey); elevations along a western extension of the transect from the edge of Culver Cut shown in (B).

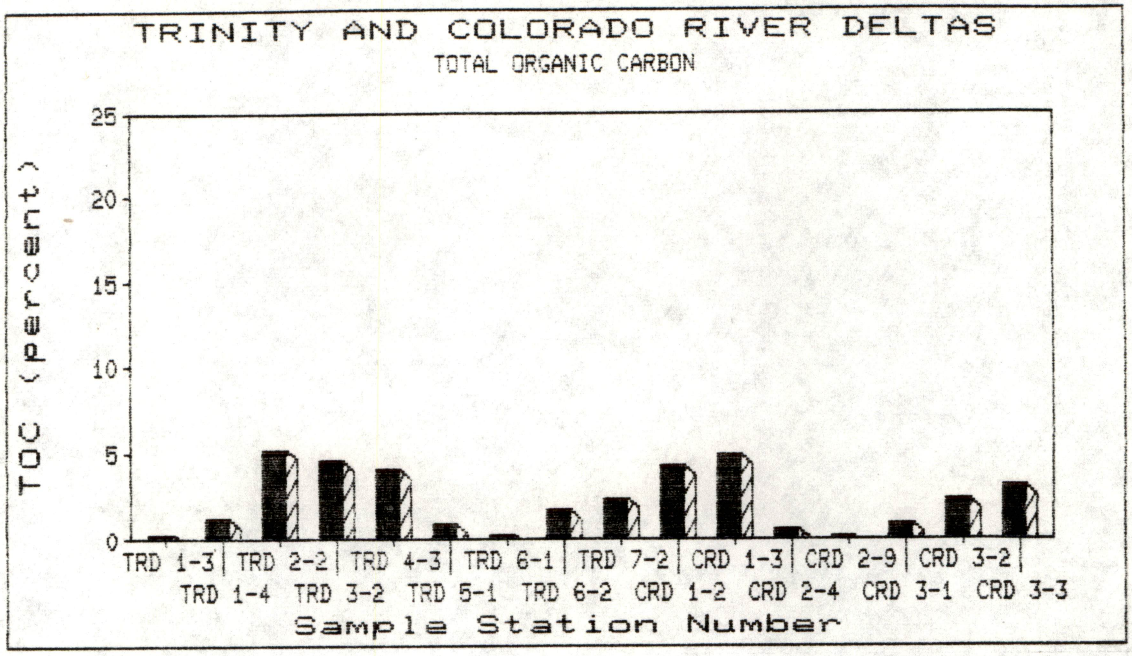
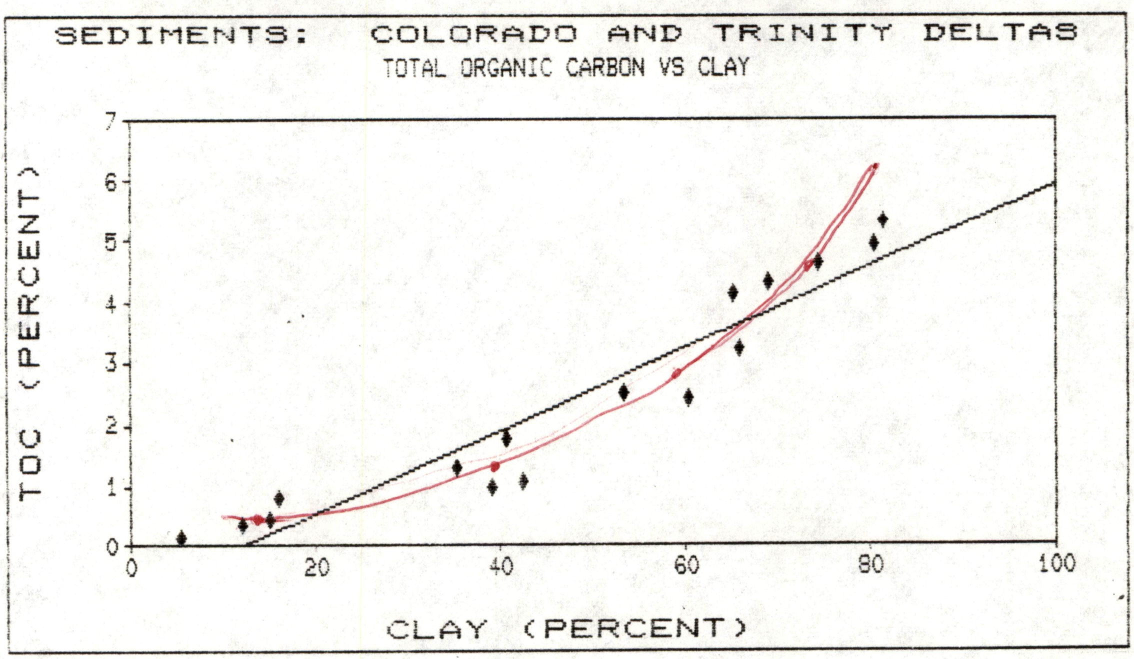



Figure 18. Percentage of total organic carbon (TOC) in sediment at stations in the Colorado and Trinity River deltas.




This is not linear!

TOC vs ~~clay~~

This may indicate not only adherence but trapping?

Figure 19. Scattergram and linear regression line for total organic carbon (TOC) and clay in sediment at stations in the Colorado and Trinity River deltas. Correlation coefficient (r) = 0.95

(roots, leafs, stems, etc.) were physically removed from the samples before analysis of TOC; percentages are presented in figure 20. In Colorado River delta sediments, the highest amount of TOC and gross organics, combined, is approximately 13 percent at station CRD 1-3. 2 Because the collection of gross organics in a sample did not follow standardized procedures, ~~however,~~ therefore these measurements must be considered more qualitative than quantitative when making comparisons between samples. 3 Nevertheless, one should expect a positive correlation between TOC and gross organics, which is the case as shown in figure 21.

No

No Confusing statement

## Moisture Content

Moisture or water content of the sediments correlates positively with sediment texures. Sediments with high concentrations of mud (silt and clay) have higher amounts of water than sediments with high concentations of sand. The percent water in the sandy sediments collected at station CRD 2-9 is the lowest (< 20 %) of all sediments sampled (fig. 22). A positive correlation coefficient of 0.89, indicates a strong linear relationship between water and clay percentages (fig. 23).

## Salinity

Measured salinities ranged from 17.5 ppt at transect 1 in February 1988 to 34 ppt at transect 2 and transect 4 in July 1988. Salinities at transects 2 and 4 were generally the highest and transect 1 the lowest. Martinez (1974, 1975) took surface salinities at a station near Dog Island Reef (an oyster reef near the delta). Salinities averaged 17.3 ppt in 1974 and 16.0 ppt in 1975. High salinities were recorded in July (24.0 ppt) and October (22.0 ppt), and lows were recorded in May (11.0 ppt) and June (0 ppt).

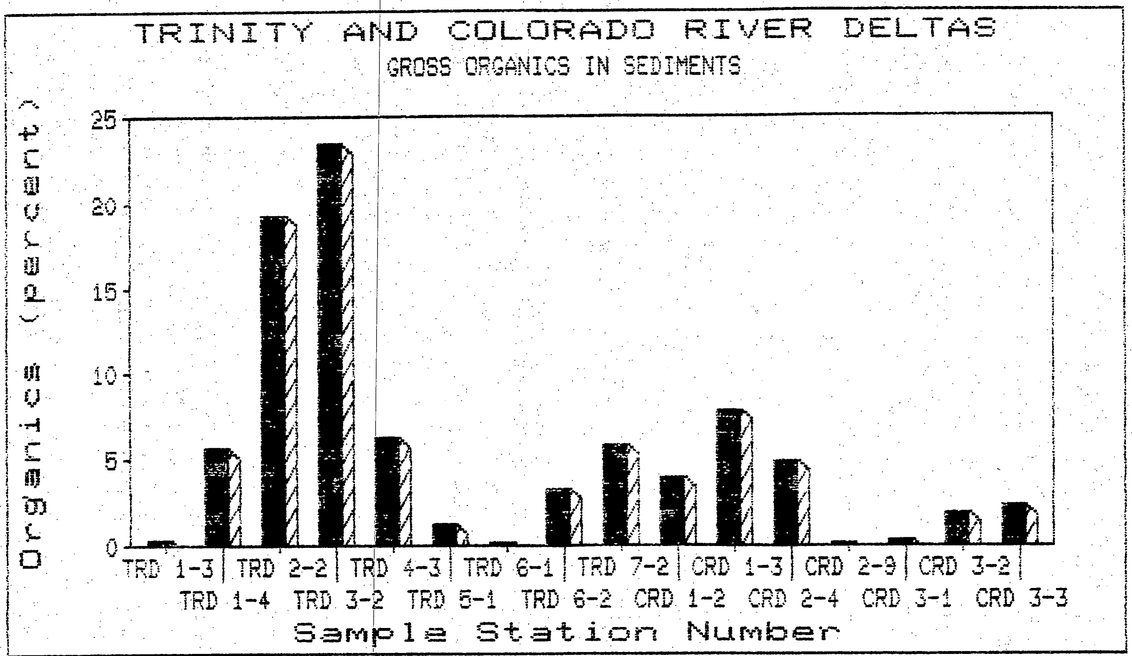



Figure 20. Percentage of gross organics in sediment at stations in the Colorado and Trinity River deltas.

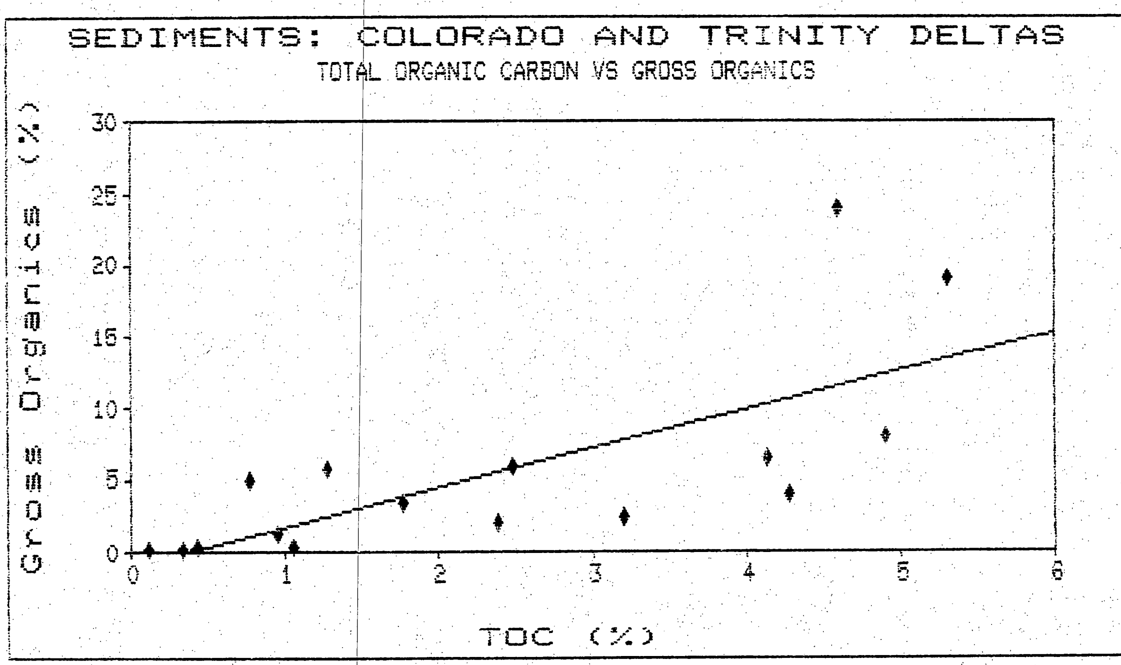



Figure 21. Scattergram and linear regression line for total organic carbon (TOC) and gross organics in sediment at stations in the Colorado and Trinity River deltas. Correlation coefficient (r) = 0.72.

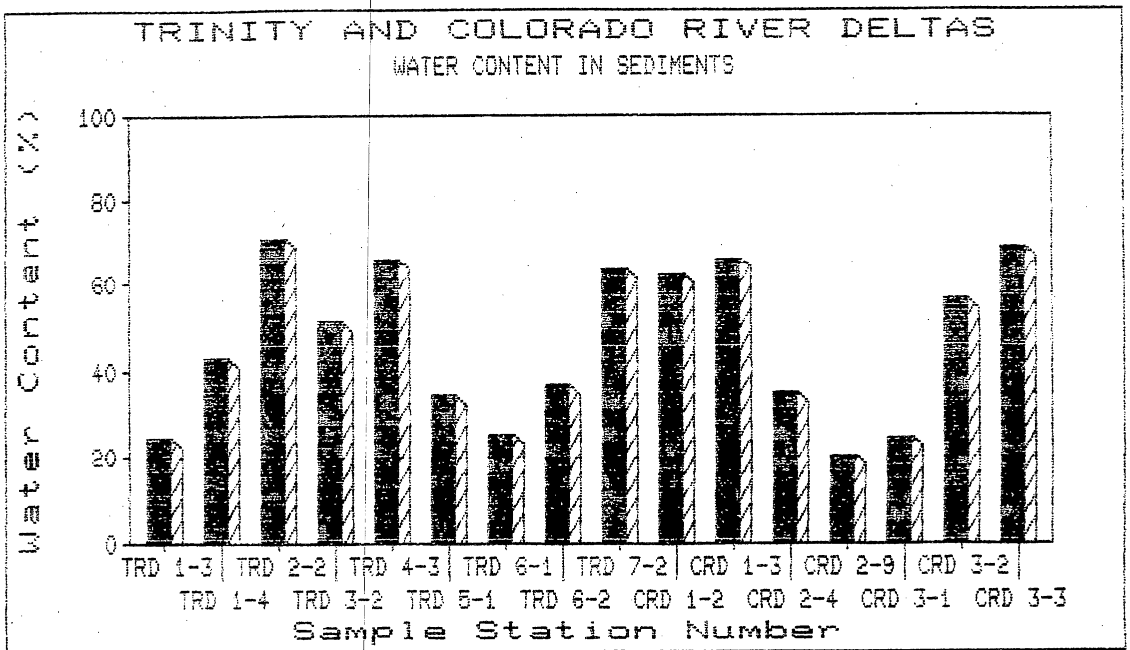



Figure 22. Percent water content in sediment at stations in the Colorado and Trinity River deltas.

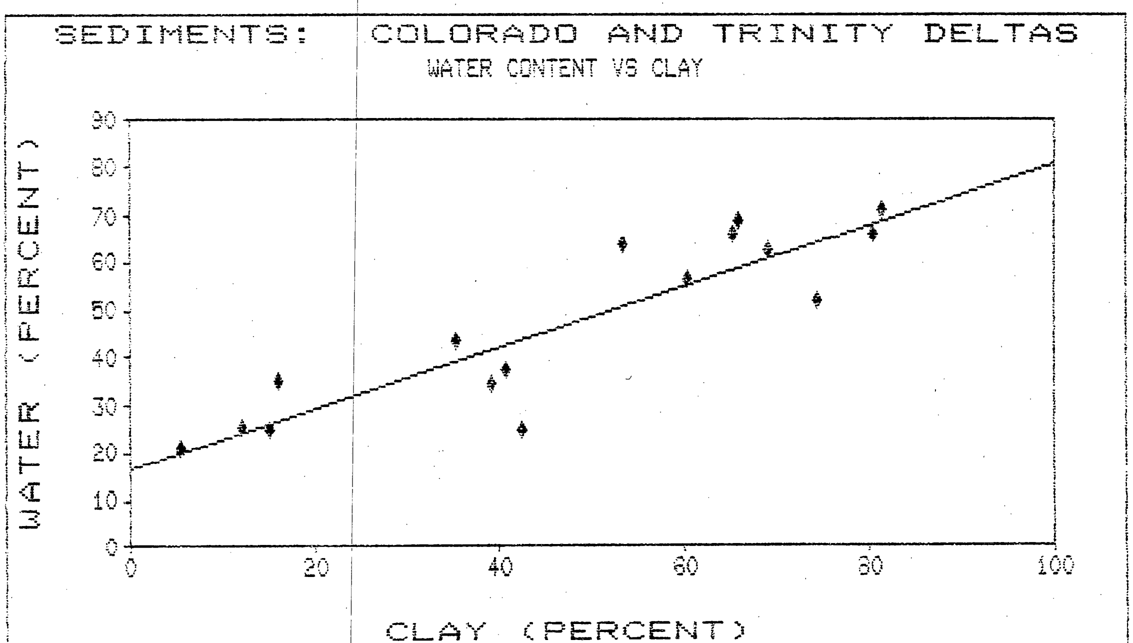



Figure 23. Scattergram and linear regression line for water content and clay in sediment at stations in the Colorado and Trinity River deltas. Correlation coeffiecient (r) = 0.89

## Seasonal Changes in Vegetation

Changes in species cover, species composition, and vegetation height were not as striking in the Colorado River delta as in some areas of the Trinity River delta. Species that were first noted at a station, usually in June or December 1987, were also present in the same relative abundance in March and July 1988. Vegetation at marker bed stations on transect 1 was generally tallest in June and shortest in March (table 1). Spartina alterniflora at marker bed stations on transects 2, 3, and 4 was tallest in June, July, and December and generally shortest in March. Heights of the other species on transects 2, 3, and 4 were either about the same during the study period or not enough measurements were taken to determine differences (table 1).

More at end ?

## Marsh Aggradation Rates

Rates of sediment deposition (aggradation) in the Colorado River delta area range from < 1 mm/yr to about 10 mm/yr (table 3). As shown in table 3, some markers have not yet been monitored for an entire year and the annual rates are based on a fraction of a year (5.5 to 7 months). Even where 13 months of data are available, the rates are still tentative; longer periods of time are desirable to include infrequent meteorlogical events that have an important role in sediment deposition. In addition, longer periods of time help to "equilibrate" the aggradation rate with respect to burrowing organisms (primarily crabs on the Colorado River delta) that redistribute sediment on the marker horizons.

The highest rates of marsh aggradation, 8 to 10 mm/yr, occurred at stations CRD 1-3, 2-4, and 3-3. The lowest rates, < 1 mm/yr, were documented at stations CRD 1-13 and 3-1. The three marsh areas with the highest rates (CRD 1-3, 2-4, and 3-3) are intertidal Spartina alterniflora marshes (figs. 13 and 24); sediment

!!!

Table 3. Aggradation rates in salt-water marshes of the Colorado River and Matagorda Bay study area.

| MARKER BED STATION # | DATE ESTABLISHED | DATE TRENCHED | TIME (months) | RATE/YR (mm) | |
|---|---|---|---|---|---|
| CRD 1-2 | June 26, '87 | ~~July 20~~ June, '88 89 | ~~13~~ 24 | 6 | 8.9 |
| CRD 1-3 | June 26, '87 | July June ~~20~~, '88 89 | ~~13~~ 24 | 8 | 9.2 |
| CRD 1-13 {1-14 | Feb. 9, '88 | ~~July~~ June 20, '88 89 | ~~5.5~~ 16.3 | < 1 | 5.4 |
| CRD 2-~~3~~ 4 | June 26, '87 | ~~July~~ June 19, '88 9 | ~~13~~ 24 | 10 | 11.7 |
| CRD 2-9 | June 26, '87 | July June 19, '88 9 | ~~13~~ 24 | 3 | 1.9 |
| CRD 3-1 | Dec. 17, '87 | ~~July 18~~ June, '88 9 | ~~7~~ 18 | < 1 | 11.9 |
| CRD 3-2 | Dec. 17, '87 | ~~July 18~~ June, '88 9 | ~~7~~ 18 | 5 | 8.5 |
| CRD 3-3 | Dec. 17, '87 | ~~July 18~~ Mar 15, '88 9 | ~~7~~ 15 | 10 | ~~4.3~~ 9.4 (9.3 from [illegible]) |
| CRD 4-10 | Dec. 16, '87 | ~~July 19~~ June, '88 9 | ~~7~~ 18 | 5 | 5.7 |

deposition at these sites during the monitoring period was apparently related to estuarine intertidal processes because no significant riverine flooding occurred during this period. The low amount of deposition at stations CRD 1-13 and 3-1, was expected because these are topographically high levee sites (figs. 15, 17, and 25), which apparently were not inundated during the monitoring period. Differences in inundation and inorganic sediment accumulations at the intertidal sites and levee sites is shown by water and materials trapped in sediment pans (figs. 26 and 27). The sediment pan at CRD 3-1 (levee site) contained no observable water or inorganic sediments but rather organic debris from surrounding plants (fig. 26). In contrast, the pan at CRD 3-3 was filled with water and contained about 4 mm of sediment (fig. 27).

Among the lowest rates of sediment accumulation documented (besides the levee marshes) was in a sparsely vegetated marsh of predominantly Monanthochloe littoralis on Matagorda Peninsula (station 2-9). The low rate of accumulation is attributed more to the apparent infrequent inundation of this site than to the sparseness of vegetative cover (fig. 28). The substrate at this site is composed of almost 90 percent sand (fig. 1) derived principally from gulfward environments. Transport of the sand apparently occurs through hurricane washover and eolian processes (McGowen and Brewton, 1975; White and others, 1985).

A core taken of sediments from Matagorda Bay northwest of this site (CRD 2-9) as part of the reconnaissance work preceding this study (Appendix 1), penetrated a sand horizon that probably was deposited by Hurricane Carla in 1961 (see fig. 2 in Appendix 1). Approximately 30 cm of mud has accumulated above this sand horizon, indicating a rate of deposition of about 12 mm/yr (averaged over 26-year period) at this shallow bay-bottom site. The rate is almost identical to estimates of relative sea-level rise based on Swanson and Thurlow's (1973) subsidence rates at Freeport and Port Aransas, and supports Rusnak's (1967) hypothesis that sediment accumulation in estuaries is equal to sea-level rise. !!!

Figure 24. Photograph of vertical trench intersecting the artificial marker bed at station CRD 1-3.

Figure 25. Photograph of plane table on levee at transect CRD 3 near station CRD 3-1.

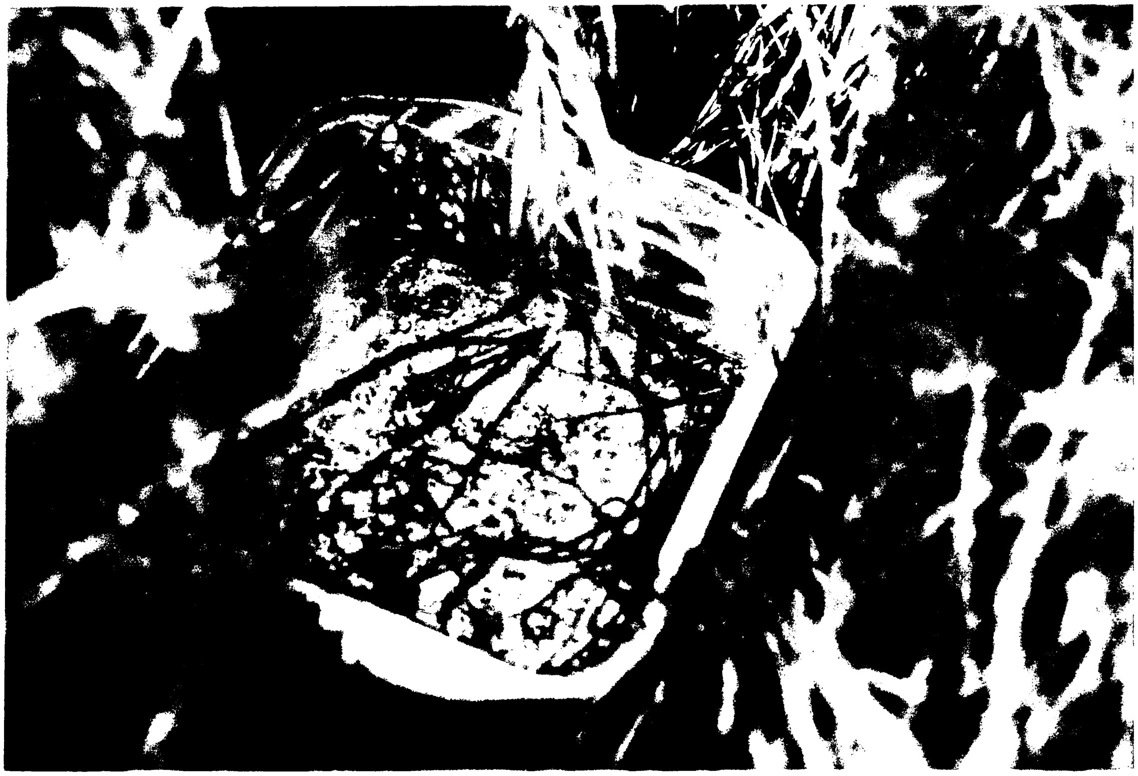
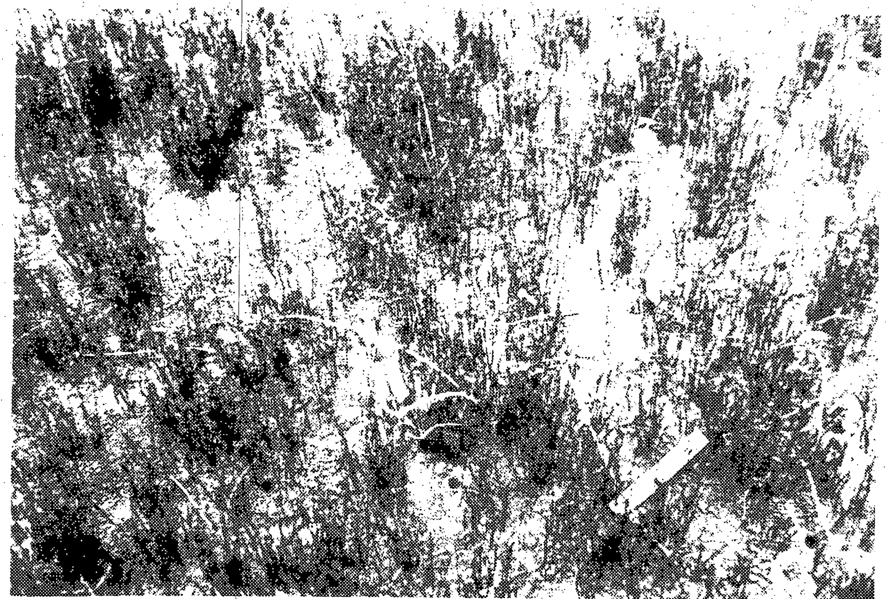


Figure 26. Photograph of aluminum sediment pan at station CRD 3-1.

Figure 27. Photograph of aluminum sediment pan at station CRD 3-3.



(A)

(B)

Figure 28. Photographs of Monanthochloe littoralis marsh at station CRD 2-9 during July showing (A) marsh surface at marker bed and (B) vertical trench exposing artificial marker horizon.

Seasonal variations in sediment deposition could not be adequately quantified from the data, but at two sites (CRD 1-3 and 2-3) about as much sediment accumulated from March 1988 to July 1988 (4 mo) as from June 1987 to March 1988 (9 mo) indicating a higher rate of deposition during the spring and early summer than from summer through winter. Additional observations are necessary to provide better quantitative data on seasonal variation. ??

## Trinity River Delta

### Sediment Composition

#### Textures

Sediment samples collected from the brackish-water marsh system on the Trinity River delta (fig. 4) have a somewhat more variable textural composition than those from the Colorado delta. Maximum concentrations of clay and silt are about 80% and 20 % in low (back) marshes; high marshes along levees had higher silt content ranging to a maximum of near 55 %, while maximum content for clay was near 40%. Marshes with sandier substrates were located on progradationally active delta lobes (based on aerial photographic analysis) near the bay margin. Near the distributary channel connecting Old River to Trinity bay (fig. 4), the concentrations of sand, silt, and clay were 67, 18, and 15, respectively (station TRD 1-3). The marsh at this latter site was only partly vegetated; sediment samples contained less than 0.5 % organic carbon. The station with the highest clay content is located west of Anahuac Channel (west of Anahuac, station TRD 2-2, fig. 4). The sediments in this marsh, where vegetation is predominantly *Alternanthera philoxeroides* (alligator weed) and *Crinum americanum* (swamp lilly), is composed of about 80 percent clay and less than 1 percent sand (fig. 14). This marsh area is probably supplied by both overbank flooding from the Trinity River along the Anahuac channel, and tidal flooding from a nearby tidal channel. Its distance from the river channel helps explain the low silt and sand content of the sediments.

High silt and sand content at stations TRD 1-3, 1-4, 5-1, 6-1 and 6-2 indicates higher energy environments near active channel and bay margin sites. Sediment collected at station 1-3 had the highest sand content of almost 70 percent. The marsh substrate at Smith Point (TRD 7-2), away from the delta, is composed of approximately 53 percent clay, with the remaining percentage composed of nearly equal proportions of silt (26 percent) and sand (20 percent) (figs. 4 and 14).

**Organics**

Highest percentages of TOC occur in sediments with high clay percentages (TRD 2-2, 3-2, and 4-3; fig. 18). As noted in the Colorado River delta, there is a high positive correlation between percent clay and TOC (fig. 19). The lowest concentrations of TOC (< 0.5 percent) are in sediments with the highest percentages of sand (stations TRD 1-3 and 6-1, fig. 18). Gross organics (discussed in the preceding section of the Colorado delta) are very high in two sediment samples collected from the Trinity River delta. Sediments from stations TRD 2-2 and 3-2 contain about 20 percent gross organics (fig. 20). Sediments from these two sites also contained the highest TOC concentrations. Percentages of gross organics were lowest in sandier sediments (TRD 1-3 and 6-1) where they composed less than 1 percent. Again, as mentioned previously, sediment samples were not collected in a standardized manner to allow a quantitative comparison of gross organics from sample to sample. These data must, therefore, be viewed as qualitative, although there is a positive correlation between gross organics and TOC.

Edit: or refer to Colorado discussi

**Moisture Content**

The water or moisture content of sediments from the Trinity delta marsh, follow trends similar to those in the Colorado delta. There is a strong positive correlation with percent clay in the sample (fig. 22). Thus, the highest water content was in sediments collected at stations TRD 2-2 and 4-3, and the lowest water content was in sediments from stations 1-3 and 6-1, which have the highest sand concentrations.

## Salinity

Measured salinities at all transects except transect 7 during the three sampling trips were near 0 parts per thousand (ppt). Salinities at transect 7 (Smith Point transect) ranged from 12 to 19 ppt and averaged 15.5 ppt. Pullen and Trent (1969) took salinities during 1965 in Anahuac Channel of the Trinity River near the USGS tide guage at Anahuac. The 29 salinity measurements averaged 6.2 ppt and ranged from less than 1 to 17.7 ppt. Salinities were also taken at a station in Lost River near Wallisville during 1965 (Pullen and Trent, 1969). The 88 measurements averaged 3.6 ppt and ranged from near 0 to 18.8 ppt.

## Seasonal Changes in Vegetation

Changes in vegetation cover and species composition were much more dramatic in the Trinity River delta than in the Colorado River delta. For example, Alternanthera philoxeroides was present at several transects during all three sampling periods, December 1987, March 1988, and July 1988, but it was generally sparse and not very tall until the July sampling trip when it became very dense and over 3 ft (91cm) tall in some areas (table 2). Also, Scirpus olneyi was either not noted or was very sparse during December and March at transects 1 and 6; in July, it was one of the tallest and most abundant species. In contrast, several species that were most abundant in the winter (December), died back and were not present in the summer (July). Vegetation changes were especially evident at transects 1 and 6, and these changes will be discussed in detail.

Transect 1 - Vegetation in December was dominated by Panicum dichotomiflorum, Pluchea sp. and Sphenoclea zeylanica. All three species were tall, ranging from over 2 to over 4.5 ft (67 to 140 cm) in height (table 2 and fig. 29A). Some Bacopa monnieri was noted at marker bed station 3 but no measurements were taken. Vegetation in March was sparse and characterized by a die-back of Panicum dichotomiflorum, Pluchea sp., and Sphenoclea zeylanica (fig. 29B). Both P. dichotomiflorum and S. zeylanica were much shorter and less dense than in December. Vegetation changes in July were especially striking, as there was no evidence of Panicum or Sphenoclea, and Scirpus olneyi was the dominant species. Dense stands of Scirpus, ranging from 3 to 5 ft (72 to 152 cm) in height, were present over much of the area (fig. 29C). Scirpus olneyi was not noted in December or March. In July, Bacopa monnieri grew in dense, mounded, circular areas near marker bed station 4 and was in flower. Eleocharis parvula accompanied the Bacopa at marker bed station 4 and was also present at marker bed station 3.

Transect 6 - Vegetation was very sparse in December. Marker bed station 1 was located in a wet, barren area with no vegetation. Some very sparse, short Alternanthera philoxeroides was located near marker bed station 2. In March, A. philoxeroides was still low and fairly sparse, and shoots of Scirpus olneyi (heights of less than 1 ft [30 cm]) were noted at marker bed station 1 (fig. 30A). Vegetation changes in July were dramatic. Tall, dense stands of S. olneyi were present at marker bed station 1 (fig. 30B), and dense stands of A. philoxeroides were dominant at marker bed station 2. Scirpus olneyi ranged from 4 to 4.5 ft (122 to 135 cm) in height (table 2).

## Marsh Aggradation Rates

The field investigation of the Trinity River delta was begun in December 1987, thus, a full year of data on aggradation rates has not yet been collected. The rates

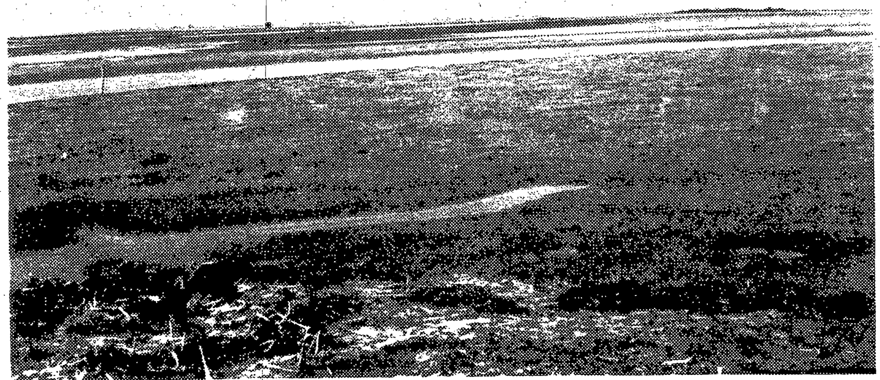
Good series!

(A)

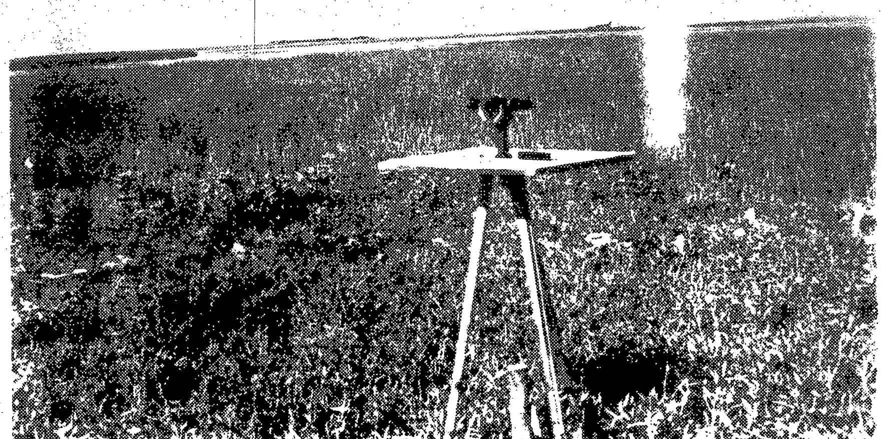
(B)

(C)

Figure 29. ~~Photographs~~ showing seasonal changes in vegetation at transect TRD 1 during (A) December, (B) March, and (C) July.



(A)



(B)

Figure 30. Photographs showing seasonal changes in vegetation at transect TRD 6 during (A) March and (B) July.

presented here are preliminary and should be refined as observations of artificial-marker horizons continue over the next year. Streamflow records from the Romayor gauging station upstream along the Trinity River indicate that only during one week in January 1988, were flows sufficient to flood part of the deltaic marshes by riverine discharge during this field monitoring period. Discharge exceeded 15,000 $ft^3$/sec during a 5-day period in early January (USGS discharge data sheets, unpublished). It is estimated that about 10 to 20 percent of the delta is flooded at these flow rates (TDWR, 1978a; fig. 5). Inspection of the artificial marker horizons in March indicated that all markers had apparently been inundated at least once.

Sediment accumulation rates in the Trinity delta are variable, ranging from one site that eroded (TRD 6-2) to another where more than 28 mm of sediment accumulated in less than 8 months (TRD 4-3). In addition, organic sediments had a larger role in the aggradation process in this brackish-water marsh system than was observed in the salt-water marsh system on the Colorado River delta. Organic debris accounted for most of the aggradation at stations TRD 3-2, 3-4, and 5-1. In fact, examination of the marker horizon at station 3-4, in March of 1988 (3.5 months after it was established), revealed that a drift line of organics, approximately 13 cm thick (primarily composed of plant stems), covered much of the marker horizon. (The driftline apparently marked the boundary of the high water associated with river discharges in January). The marker bed was still visable in patches indicating little or no inorganic sediment deposition. A second marker horizon along this marsh transect (station 3-2; fig. 31) was also still exposed at the surface. The artificial marker at station TRD 5-1, located in a fluvial woodland assemblage on a natural levee of the Trinity River, was also still exposed at the surface although partly covered with organic material (figs. 9 and 32). In July, accumulation of material at these three sites (TRD 3-2, 3-4, and 5-1) was still limited mostly to organics. The approximately 13 cm of relatively "fresh", loosely assembled organic debris deposited

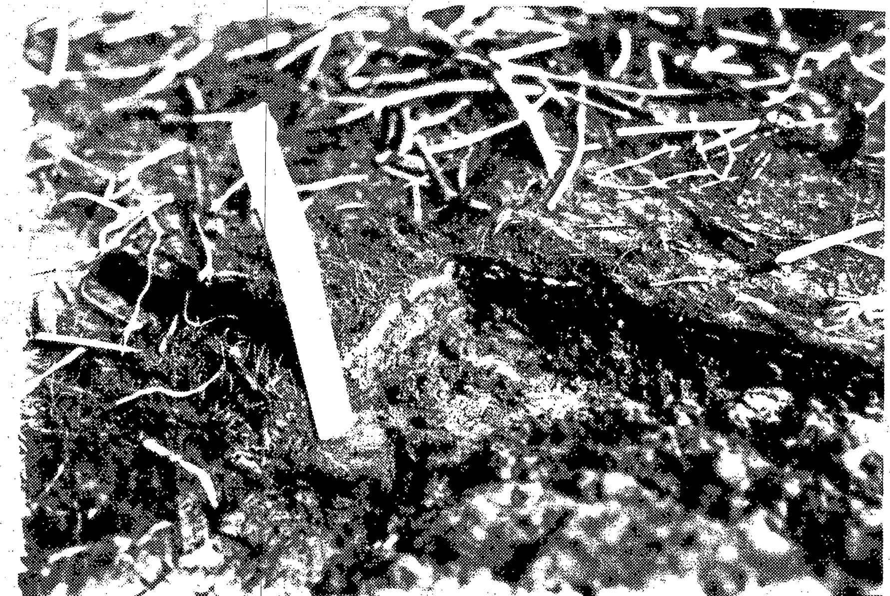
Figure 31. Photograph of exposed artificial marker bed at station TRD 3-2.

Figure 32. Photograph of artificial marker bed at station TRD 5-1.

on marker 3-4 (observer in March) had decomposed and compacted to a layer approximately 1 to 2 cm in thickness by July 1988.

The largest amount of inorganic sediment deposition was measured at stations TRD 1-3, 1-4, and 4-3 (fig. 4). As previously described, transect 1 underwent extensive changes in seasonal vegetation (fig. 29). The marker bed at station 1-3 was affected by nutria-burrowing activity between December and March, and although the marsh surface had been smoothed by natural processes by July 1988 (when the marker was trenched) the accuracy of the accumulation rate, although reasonable for this area, is uncertain. The high rate of aggradation of 22 mm in 7.5 months at nearby station TRD 1-4 (fig. 33) is apparently related to estuarine sedimentary processes and perhaps the redistribution of sediments eroded from adjacent areas. (? ? ? why differ't some stations show erosion) Figures 34A and 34B are trenches through the TRD 1-4 marker made in March and July of 1988. Sediment deposited is primarily sand that was stabilized, and probably partially trapped, by <u>Eleocharis</u> <u>parvula</u> (dwarf spikerush). This site is near a distributary channel that connects to Old River. However, the source of the sand appears to be from existing adjacent deltaic deposits rather than from bed-load transport along the distributary. Erosion of the channel shoreline near this site is indicated from distance measurements made in March and July of 1988. The shoreline and adjacent vegetation line moved landward indicating erosion. (? Is largely movement or deposition) Sampling of bottom sediments upstream along the distributary showed a fining of sediment grain size (sand to sandy mud to mud) toward Old River suggesting that the source of the sand, while undoubtedly fluvial originally, was probably not from upstream segments of this distributary channel. It is possible that previously deposited fluvial sand is being reworked into the mouth of the distributary by estuarine processes (tides, waves, and associated currents) and perhaps redistributed over the marsh surface through a combination of fluvial and estuarine processes. Extremely stong currents have been observed moving up Old River channel cutoff from the Trinity River. In fact attempts

Figure 33. Photograph of post at station TRD 1-4. The artificial marker horizon, which is a few meters beyond the post, is not visible because of burial by sediment.



(A)

(B)

Figure 34. Photographs of trenches intersecting artificial marker horizon at station TRD 1-4 during (A) March and (B) July. Note the thicker layer of sediment above the white marker horizon in July.

to sample bottom sediments with a Ponar grab sampler along this channel were unsuccessful, apparently because of armoring of the bottom with shell material as a result of the strong currents. ? ? Clean sands were sampled along the bottom of Old River channel near Old River Lake suggesting that part of the Trinity bed load is deposited in this channel and perhaps in the lower reaches of Old River Lake. Bottom sediments in this area have not been systematically sampled, however. not consistent with location Nos.

Another site along the margin of the delta is marsh transect 6, which is near the mouth of a modified (dredged along its upper reaches) and probably inactive distributary channel. Two marker horizons were established at this site (fig. 4) in December 1987. Inspections of the site in March 1988 indicated that the topographically higher marker horizon (TRD 6-2) had been eroded (fig. 35). Other evidence at the site, specifically organic debris snagged on Sesbania (fig. 36), indicated bayward moving currents had progably eroded the bed. Measurements of an erosional scarp bayward of the marker showed about 1 m of lateral erosion (retreat of the shoreline) had occurred during this 3.5 month period. The marker at station 6-1 was still visible at the surface indicating neither erosion or significant deposition. Parts of the marker had been disturbed by nutria burrows, but most of it was still usable as a horizon to measure aggradation. Trenching of the horizon in July 1988 indicated 4.3 mm of sediment had been deposited. This site had undergone extensive seasonal changes in vegetation (figs. 30A and 30B). A temporary marker of red aluminum glitter, which had been established in March 1988 near the marker that had been eroded (TRD 6-2) indicated about 1 mm of deposition by July 1988, at this slightly higher marsh (relative to station TRD 6-1) dominated by alligator weed. (A marker of white feldspar clay was reestablished in this area in July 1988.) Measurements of the erosional scarp that had retreated (eroded) near this site between December and March showed no change in position between March and July, indicating a seasonal

Figure 35. Photograph of trench at station TRD 6-2 during March. Artificial marker was established in December, and because of erosion, marker horizon was not encountered in March.

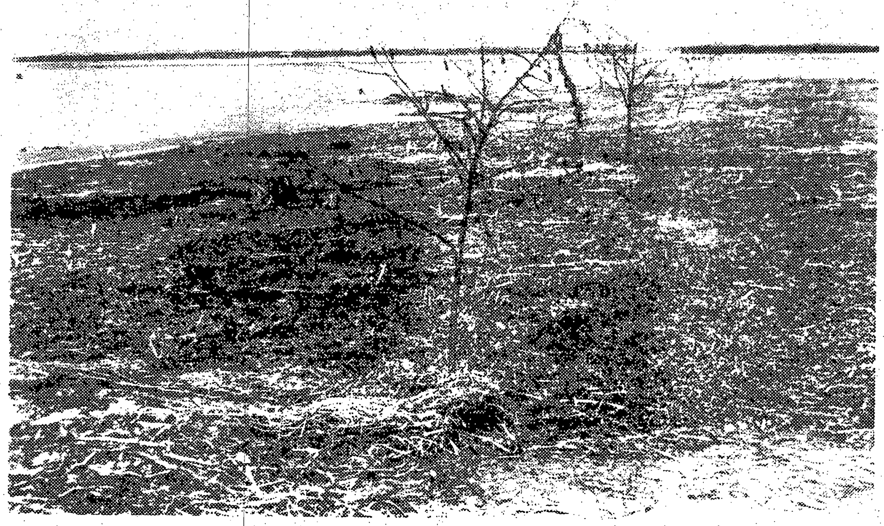


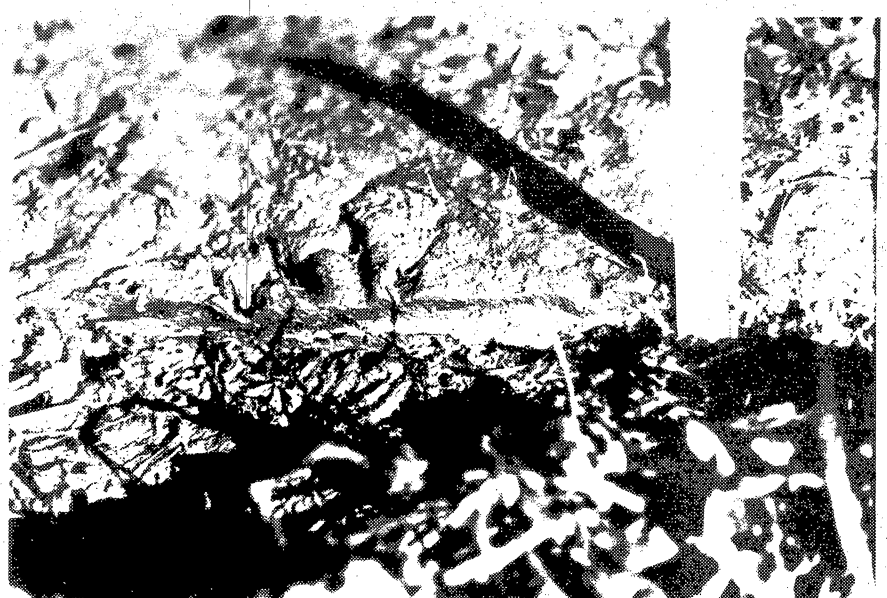
Figure 36. Photograph of organic debris snagged on Sesbania.

component to the erosion. This suggests that winter storms may have been responsible for the erosion, although the relative high river discharge in January (mentioned previously) cannot be ruled out as a contributory erosional event.

The marker horizon documenting the highest rate of sediment accumulation in the Trinity River delta is at station TRD 4-3 north of Old River Cutoff (figs. 7 and 37). Approximately 2.8 cm of sediment was deposited at this site over the 7.5 month period of observation. This site is on the margin of a pond near a levee along the Old River Cutoff channel. The reason for the high rate of deposition is probably related to the location of this site near these features. The flank of the levee is highly burrowed by nutria, and although heavily vegetated with Phragmites and other plants, this topographically high feature (fig. 38) probably is a local source of the sediments that are deposited near the base of the levee on the margin of the pond. This site is also subject to inundation and sediment deposition, as water in the pond rises and falls. The high clay content of the soil at this site indicates the deposition of fine particualte matter during the waning stages of each inundation. Still the higher silt content of the sediments compared to stations TRD 3-2 and 2-2 (fig. 14) perhaps reflects the proximity of this site to the levee. This area is hydrogically connected to Old River, however, and does not require overbanking of the levee to be flooded. In July, another marker bed was established on the levee across the channel from this site to assist in recording deposition associated with any flood events that occur during the upcoming year.

Station TRD 2-2 is further away from the natural levee along the Trinity River. Approximately 4 mm of sediment accumulated at this location during the 7.5 months of observation. More sediments accumulated during the period from March to July than from December to March. Visual inspection of the accumulating sediment at this site indicated a high percentage of organics. Laboratory analysis of the marsh sediment near the marker horizon showed it to contain the highest percentage of

(A)



(B)

Figure 37. Photographs of station TRD 4-3 in July 1988, showing (A) vegetation at site and (B) vertical trench of artificial marker. Compare photo (A) with figure 7 (taken in December) to see difference in vegetation growth between December 1987 and July 1988.

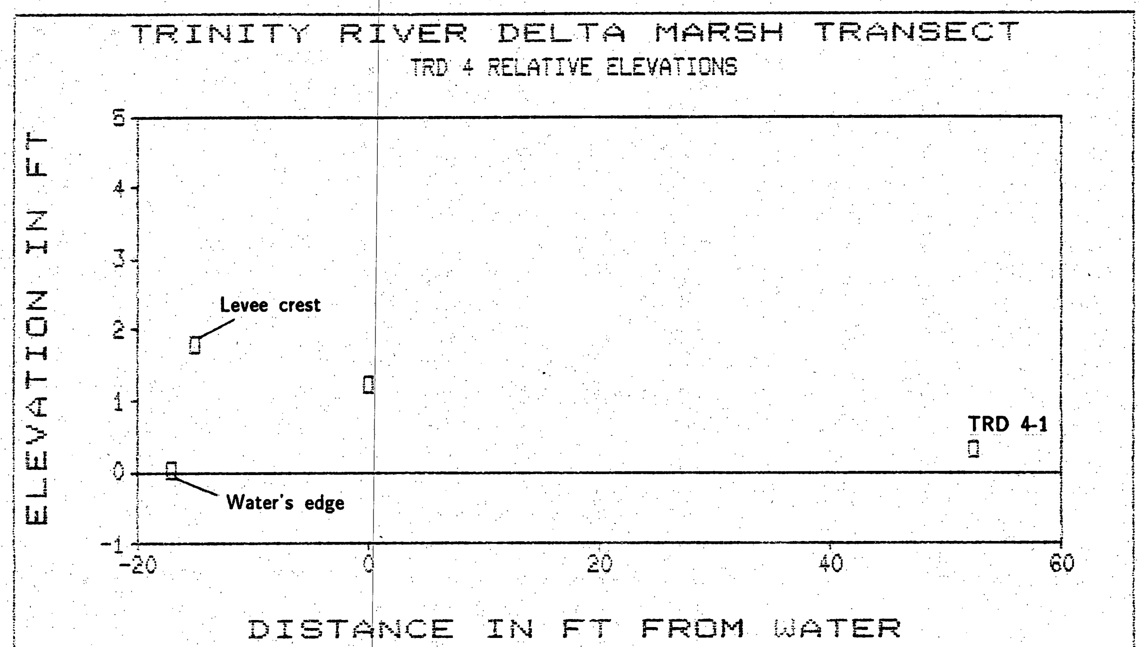



Figure 38. Profile of marsh transect TRD 4.

organics of any sediment sample analyzed (fig. 20). The plant biomass (as visually estimated from plant density) increases toward the levee from the marker bed (figs. 39A and 39B). Thick mats of living and dead plant material, composed predominantly of alligator weed, characterize the vegetative zone between the artificial marker and the river channel.

At the Smith Point salt-water marsh, located about 35 km south of the Trinity River delta, approximately 3 mm of sediment accumulated above the artificial marker horizon during a 7.5-month period. This rate is lower than the rates of Spartina alterniflora marshes monitored on the Colorado River delta. However, sediment accumulation as measured at a brass rod placed near the marker indicated a higher rate than the marker horizon at the Smith Point site. Continuation of measurements at this site during future months will provide more data on which to determine an average rate of sediment deposition.

## SUMMARY AND PRELIMINARY CONCLUSIONS

The following conclusions are preliminary because marsh sites have not been monitored for an adequate period of time. Although a year of data has been collected at some sites on the Colorado River delta, less than 8 months of data are available for the Trinity River delta. In addition, no significant flood event, which can play an important role in sediment deposition, occurred during the monitoring period.

Salt-water marshes on the Colorado River delta, and brackish-water marshes on the Trinity River delta were monitored over a period of 7.5 to 13 months to document sediment accumulation rates; vegetation types, vegetation heights, elevations, and sediment composition were among the other types of information collected during periodic surveys. Marsh aggradation rates were determined primarily by using artificial-marker horizons established at selected sites along marsh transects. Eleven

(A)

(B)

Figure 39. Photographs of transect TRD 2 showing seasonal increase in plant density. (A) December 1987 near artificial marker; (B) July 1988 near levee (views in both photos are toward Trinity River).

markers were placed in wetlands in the Trinity River delta study area, and nine in the Colorado River delta study area.

Marsh aggradation rates on the Colorado River delta, with the exception of levee sites, are similar to those in salt marshes reported for other areas of the Gulf Coast (table 4). These rates, which are commonly higher than those recorded along the Atlantic Coast are apparently related to higher rates of relative sea-level rise that characterize the Gulf coast in Louisiana and Texas (table 4). (These relationships are discussed in the draft literature synthesis report, White and Calnan, 1988). The highest rates (8 to more than 10 mm) in the Colorado River delta occurred in <u>Spartina</u> <u>alterniflora</u> marshes. The location of these marshes in the intertidal zone contributed to the higher aggradation rate by increasing the frequency of inundations and the period of time during which deposition could occur. The insignificant sediment deposition (< 1 mm) at higher levee marshes supported the fact that no flood events with a magnitude sufficient to inundate these marshes occurred during the monitoring period. Significant deposition can take place on levees during flood events, however, if riverine flood waters are carrying large sediment supplies (van Heerden and others, 1981).

Rates of marsh aggradation in the Trinity River delta area were more variable and less predictable. Thicknesses of sediment that accumulated above marker horizons during a 7.5 month period ranged from 2.8 cm to 0. The marker bed at one site was removed by erosion. The estuarine shoreline near this site retreated (moved landward) approximately 1 m during a 3.5 month period (December 1987 to March 1988) indicating both vertical and lateral erosion of this area. Erosion did not occur during the succeeding four month period (March to July) indicating that there is a seasonal factor, at least locally, in the deposition and erosion of marsh sediments. Letzsch and Frey (1980) found a seasonal variation in deposition on Georgia marshes; minimum deposition occured in autunm, through winter and spring, and maximum

Table 4. Marsh aggradation (vertical accretion) rates measured in coastal Louisiana and along the U. S. Atlantic coast (from Boesch and others, 1983).

| Location | Marsh type | Marsh accretion rate (mm/yr) | Mean sea-level rise (mm/yr) | Source |
|---|---|---|---|---|
| Louisiana Deltaic Plain | Freshwater | | 11.0 | Hatton and others (1983) |
| | streamside | 10.6 | | |
| | backmarsh | 6.5 | | |
| | Intermediate (*Spartina patens*) | | | " " |
| | streamside | 13.5 | | |
| | backmarsh | 6.4 | | |
| | Brackish (*S. patens* | | | " " |
| | streamside | 14.0 | | |
| | backmarsh | 5.9 | | |
| | Saline (*S. alterniflora*) | | 13.0 | DeLaune and others (1978); Baumann (1980) |
| | streamside | 13.5 | | |
| | backmarsh | 7.5 | | |
| Chenier Plain | Salt-brackish (*S. patens*) | 7.0 | 12.0 | Baumann and and DeLaune (1982) |
| Georgia | *S. alterniflora* | 3-5 | | Summarized by Hatton and others (1983) |
| Delaware | *S. alterniflora* | 5.0-6.3 | 3.8 | " " |
| New York | *S. alterniflora* | 2.5-6.3 | 2.9 | " " |
| Conn. | *S. alterniflora* | 8-10 | 2.5 | " " |
| | *S. patens* | 2-5 | | |
| Mass. | *S. alterniflora* | 2-18 | 3.4 | Redfield (1972) |

deposition occurred in summer. The differences apparently correlate, to some degree, with the seasonality of storm-wind incidence. A high rate of sediment accumulation (2.2 cm over 7.5 months) at one site was apparently related to a combination of fluvial and estuarine processes in which existing deltaic sediment was redistributed through erosion and redeposition. Three marker horizons, further away from estuarine waters and nearer fluvial channels, recorded no measurable inorganic-sediment deposition, but did record patchy deposition of organic material. Apparently, only one minor flood event occurred (based on USGS stream discharge records) along the Trinity River during the monitoring period.

Organics were a more significant component of the marsh sediments in the brackish-water marshes of the Trinity River delta than the salt-water marshes of the Colorado River delta. (This subject, organic and inorganic deposition, is treated more thoroughly in the literature synthesis). However, thick peat deposits that characterize marshes in the Mississippi River delta are apparently not a part of the Trinity River delta, probably for several reasons. Frey and Basan (1985) noted that very few marshes along the Gulf Coast have been studied in detail geologically, and suggest that the marsh sediments (except for the Mississippi delta complex) seem to be similar to those of the southeastern Atlantic coast, which were described as dominantly inorganic with insignificant amounts of peat. Suggested reasons for the absence of thick peat deposits are (1) tidal flushing, (2) rapid degradation of plant material by intense biologic activity, and (3) extremely slow rates of coastal warping or submergence. Comparison of total organics in sediments in Texas brackish marshes and salt marshes indicate lower concentrations than reported by Frey and Basan (1985) for Georgia salt marshes. Table 2 In addition, textural composition of inorganic sediments in these Texas deltaic marshes differ somewhat from the Georgia marshes. Inorganic sediments of a representative southern Coastal Plain salt marsh (near Sapelo Island) contained approximately equal (?) constant proportions of silt and clay, where maximum amounts, respectively, were 60 percent and 55 percent; sand is uniformly low in the low marsh with sand and muddy sand predominant in the high marsh (Frey and Basan, 1985). In the Colorado River delta study area, both intertidal and higher marshes located near sand rich Matagorda Peninsula were expectably high in sand with concentrations near 80 percent. A levee marsh away from the peninsula along an active distributary channel (Tiger Island Cut), however, while siltier than lower marshes in the area, had a low sand content (< 5 percent). In the Trinity delta study area, marsh sediments near the bay margins and levees were rich in sand and/or silt. Clay, which is most abundant in low-energy backmarsh environments, had a concentration at one site that is nearly 5-times higher than the combined sand and silt content at the site.

A seasonal change in vegetation type and cover is a significant process in some brackish marsh areas in the Trinity River delta. Relatively barren intertidal flats at one site, had become thickly vegetated with a seasonal bullrush Scirpus olneyi (Olney bullrush) by July. At another site, a seasonal plant that is dominant during the fall, Panicum dichotomiflorum (fall panic), had declined and almost disappeared by March and was totally replaced by S. olneyi, Bacopa sp. and other species by mid summer. This seasonal variation can affect both organic and inorganic erosion, transport, and deposition.

How? Explain statement

Continuation of the field studies into next year should provide additional data on marsh aggradation rates, and hopefully allow us to document the depositional or erosional effects of a flood event Longer term data should also allow a more meaningful comparison of marsh aggradation rates with respect to relative sea level rise. According to subsidence rates reported by Swanson and Thurlow (1973) and Gabrysch (1984), marsh aggradation rates in these deltaic areas may have to average more than 10 to 11 mm per year to remain emergent. Predicted increases in global sea-level rise (Barth and Titus, 1984) may increase these minimal rates for marsh survival in the more distant future.

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APPENDIX I

# COLORADO RIVER DIVERSION PROJECT
# RECONNAISSANCE WORK TO ESTABLISH MONITORING STATIONS IN MATAGORDA BAY NEAR THE MOUTH OF THE COLORADO RIVER

William A. White and Thomas R. Calnan

Prepared for the Texas Parks and Wildlife Department
in accordance with Interagency Contract (86-87)-1756

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# COLORADO RIVER DIVERSION PROJECT RECONNAISSANCE WORK TO ESTABLISH MONITORING STATIONS IN MATAGORDA BAY NEAR THE MOUTH OF THE COLORADO RIVER

William A. White and Thomas R. Calnan

This report is submitted to the Texas Parks and Wildlife Department in accordance with Interagency Contract (IAC)(86-87)-1756. Field work specified in the contract was conducted during June 22 to June 27, 1987. All tasks listed in the IAC as well as additional tasks not specified were completed. The tasks outlined in the IAC are preparatory to a proposed longer-term study designed to monitor the effects of the Colorado River Diversion Project on Matagorda Bay.

## Bay Monitoring Stations

Fifteen monitoring stations were established in the eastern arm of Matagorda Bay west of the Colorado River Delta in the area where the river is to be diverted by the U.S. Army Corps of Engineers (fig. 1). All stations shown on figure 1 were located by triangulation and their positions recorded with respect to features existing on nautical chart 11319 or with respect to features located and plotted on the chart during the field survey. Twenty-foot sections of 2.5-inch PVC pipe were driven into the sediments at eight stations (table 1) to mark selected deep-water and bay-center sites. The PVC pipes extend about 3 ft above the water. Six cedar posts 2-inches in diameter by 6-ft long were placed on land at strategic locations along the bayward side of Matagorda Peninsula. The locations of the posts were confirmed with reference to aerial photographs and were plotted on the nautical chart. The posts were used as reference markers to locate bay-margin sampling sites. The tops of the PVC pipes and fence posts were painted and flagged with orange fluorescent paint and tape. Because the

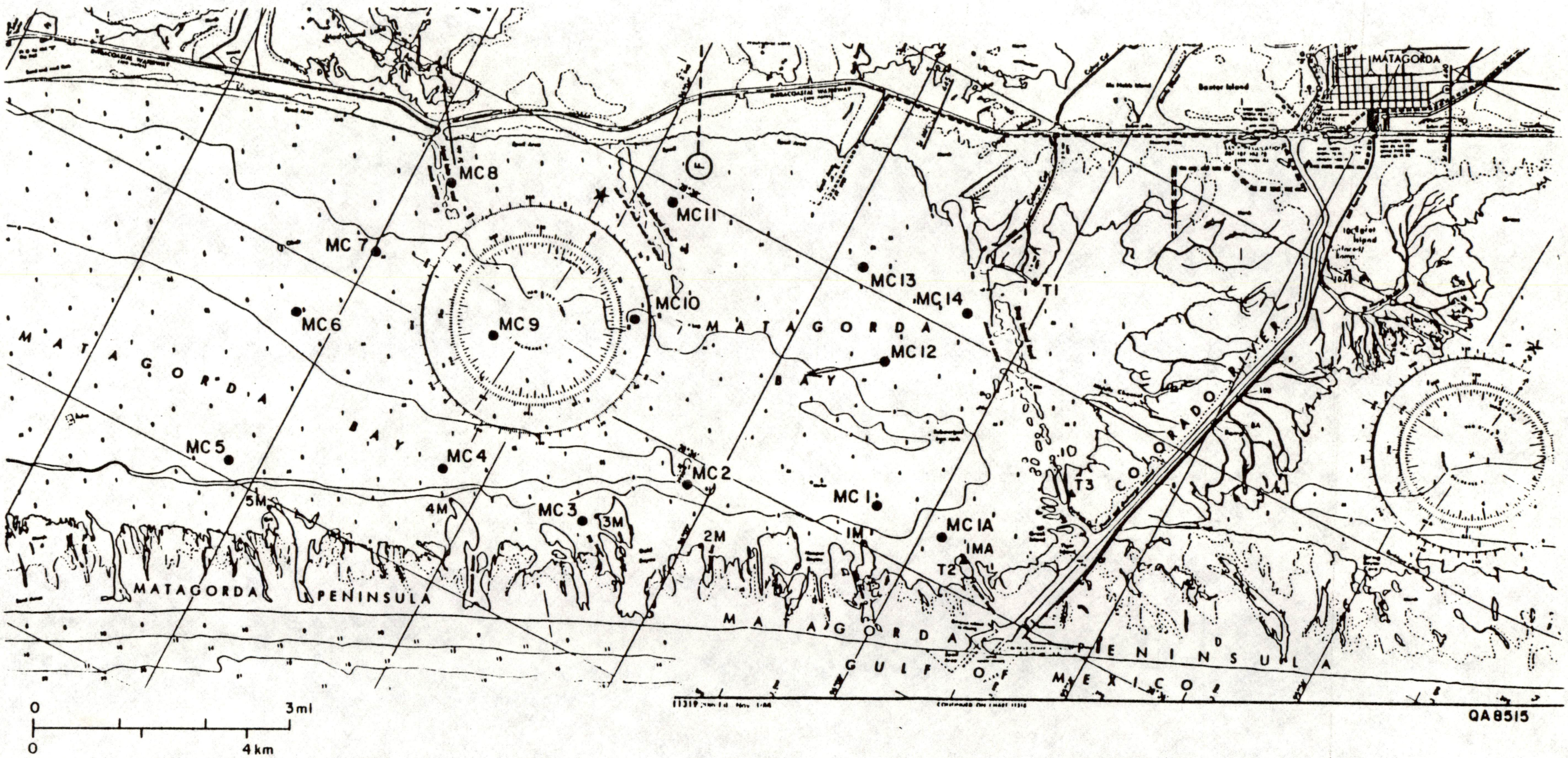



Figure 1. Map of the eastern arm of Matagorda Bay near the Colorado River showing the locations of (1) sample stations (●). (2) cedar-post markers on Matagorda Peninsula (•). and (3) marsh transects (▲).

Table 1. List of sample stations, site-location markers, and data collected at established stations.

| Sample station | Types of markers PVC pipe | Cedar post | Hydrographic data collected* | Sediments collected for analysis** | Cores collected |
|---|---|---|---|---|---|
| MC1A | | X | X | X | X |
| MC1 | | X | X | X | X |
| MC2 | | X | X | X | X |
| MC3 | | X | X | X | |
| MC4 | X | X | X | X | X |
| MC5 | | X | X | X | |
| MC6 | X | | X | X | |
| MC7 | X | | X | X | |
| MC8 | *** | | X | X | |
| MC9 | X | | X | X | |
| MC10 | X | | X | X | |
| MC11 | *** | | X | X | X |
| MC12 | X | | X | X | X |
| MC13 | X | | X | X | X |
| MC14 | X | | X | X | X |

*Temperature, salinity, conductivity, depth
**Biological, geochemical, textural
***Located with reference to oyster reef markers

sampling stations were also located by triangulation using more permanent navigation aids such as water tanks, radio antennas, houses, and bay markers, they can be relocated should the PVC pipes or cedar posts be removed.

## Benthic Sediments

Benthic sediments were collected at each station using a Ponar grab sampler. At each station, depth of water, temperature, salinity, and conductivity were measured. Sediments were visually described, placed in containers, and stored for future reference and possible analysis. Sediments for geochemical analysis were placed on ice and are now stored in a freezer at the Bureau's Mineral Studies Laboratory.

Three grab samples were taken at each station for macroinvertebrate analyses. Sediment samples were washed through a 1-mm screen, and the benthic fauna were narcotized in a solution of magnesium sulfate. Samples thus processed were stored in a neutral solution of 10 percent formalin containing rose bengal. Laboratory processing will include further washing of the samples and storage in 70 percent ethanol.

## Cores

Eight cores were collected at selected sites (table 1) to test our coring methods and to recover some cores for study in the laboratory. In accordance with our plans, we collected cores that were approximately 3 ft (1 m) in length using 2.5-inch PVC pipe. Most of the cores were taken using a customized core-barrel handle and a piston specifically designed for the irregular inner diameters that characterize PVC pipe. The piston, in addition to preventing the core from falling out of the tubing when it was pulled out of the sediment, allowed us to penetrate as much as 2 ft of sand, which is very difficult to penetrate with pipe. For example, the core taken at station MC1 (fig. 1), includes about 1 ft of mud, approximately 2 ft of sand, and underlying mud. The cores were taken to the Bureau's Core Research Center (CRC) where they were sawed in half lengthwise, described, and photographed. Half of each core was placed in plastic protectors and sealed; these cores are stored in the CRC repository.

Some cores provided useful information. For example, the sand bed in the core taken at station MC1 (fig. 2) appears to be part of a washover fan deposited by Hurricane Carla in 1961. If this is the case, it means that the mud above the sand was deposited after Hurricane Carla and the rate of sedimentation can be calculated. This kind of information will help provide baseline data for comparing with sedimentation rates after diversion. Additional cores taken near MC1 would allow us to further define the extent of the sand horizon, including its distribution and thickness farther out in the bay. According to a long-term Matagorda resident who owns a local charter-fishing business, Hurricane Carla destroyed marine grassbeds (grassflats) along Matagorda Peninsula near the Colorado River Delta. The core from station MC1 offers partial documentation of this event. During the storm surge associated with Hurricane Carla, a substantial amount of sand was washed through washover channels into the bay and grassbeds, burying the marine grasses. This transport of sand across the peninsula is also documented in part by aerial photographs taken soon after Hurricane Carla.

Was this done

Other cores show promise in helping to establish markers for determining future sedimentation rates after diversion. The cores collected at stations MC13 and MC14 are laminated with alternating layers of brown and gray mud (silt and clay) and have distinct sediment horizons near their base. The core from station MC14 was collected near the point where the mouth of the diversion channel will be located. If cores taken at these sites in the future show similar correlatable

Figure 2. Photograph of core taken at station MC1.

horizons, they could help define future bay sedimentation and delta progradation rates.

## Marsh Transects

Three marsh-transect sites were established in the proposed diversion area (table 2). Elevations and bearings of two of the transects were surveyed using a plane table (fig. 3), and one site was surveyed using profiling rods. Vegetation types and heights were recorded, and percentage of cover was estimated at selected sites along the transects. Two 1-$m^2$ marker beds of white feldspar clay, which will be used to determine sedimentation rates, were established along each of marsh transects 1 and 2. Elevations along marsh transect 1 were tied to a Corps of Engineers bench mark located at the edge of the bay. A profile constructed along part of transect 2 is shown in figure 4. Cedar posts were placed along the marsh transects at strategic locations, including the marker beds, and a 3-ft (1-m) brass rod was driven into the ground near the upper marker bed on transect 2 to serve as a backup sedimentation/erosion marker.

## Conclusions

All tasks outlined in IAC(86-87)-1756 have been completed and final invoices for expenses are being prepared. This brief effort helped establish a well-defined network of sediment-sampling and hydrographic-data-collection stations, some of which are near Corps of Engineers fisheries-sampling sites, and marsh transects. The stations, transects, and collected data provide a sound foundation on which to base an expanded sampling program designed to monitor the temporal and spatial effects of Colorado River diversion on benthic sediment textures, geochemistry, benthic macroinvertebrates, delta progradation, and wetlands in Matagorda Bay near the mouth of the Colorado River.

Table 2. Marsh transects

Transect 1

Location: deltaic marsh near Culver Cut
Survey method: plane table and telescopic alidade (tied to Corps of Engineers bench mark)
Length: 300 ft (91.5 m)
Marker beds: 1-$m^2$ layers of white feldspar clay in:
(1) Scirpus maritimus (100%)
(2) Spartina alterniflora (90%), Scirpus maritimus (10%)

Transect 2

Location: Matagorda Peninsula near Zipprian Bayou
Survey method: plane table and telescopic alidade
Length: 637.9 ft (194.6 m)
Marker beds: 1-$m^2$ layers of white feldspar clay in:
(1) Spartina alterniflora (100%)
(2) Monanthochloe littoralis (80%), Batis maritima (20%)
Brass pin also set adjacent to clay marker 2

Transect 3

Location: active delta along margin of Parker's Cut
Survey method: profiling rods
Length: 400 ft (122 m)
Marker beds: none
Predominant vegetation along transect:
On levee and levee flank of distributary channel:
Batis maritima and Distichlis spicata codominant, with scattered Borrichia frutescens, Lycium carolinianum, Salicornia virginica, Scirpus maritimus, and Iva frutescens
Grading from levee flank bayward:
Spartina alterniflora (makes up complete marsh community 400 ft [122 m] from beginning of transect at edge of distributary channel)

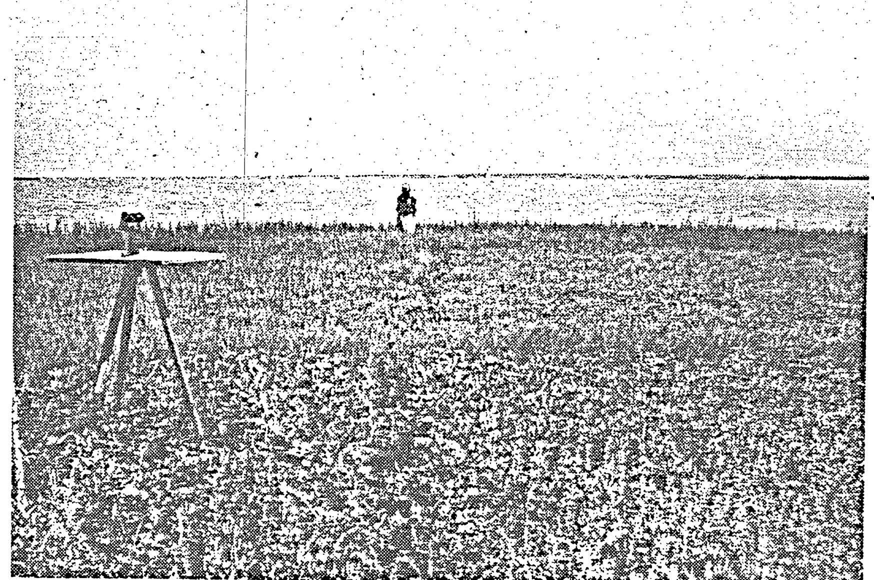
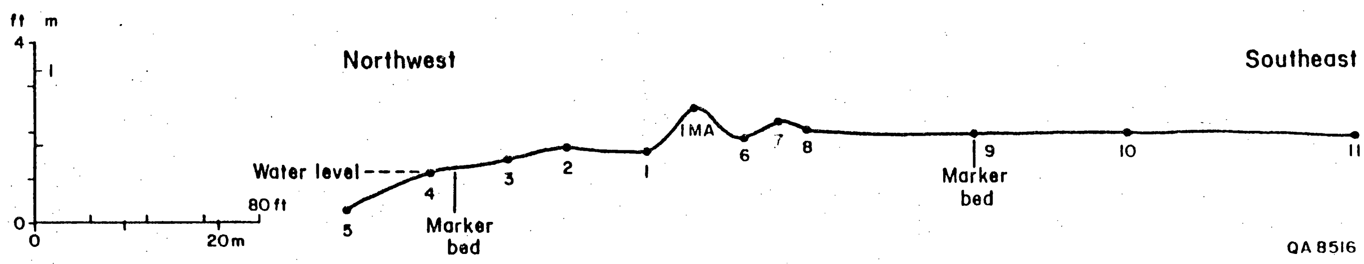


Figure 3. Plane table and telescopic alidade set up at station 1MA on marsh transect 2.




| Station # | Vegetation types |
|---|---|
| 1MA | Borrichia frutescens and Spartina patens codominant |
| 1 | Edge of Borrichia frutescens and Spartina patens, beginning of Batis maritima (composes 90% of community between 1 and 2) |
| 2 | Distichlis spicata dominant; scattered Borrichia frutescens and Spartina alterniflora |
| 3 | Edge of Spartina alterniflora dominance; scattered Distichlis spicata, Salicornia virginica and Batis maritima |
| 4 | Spartina alterniflora, about 60% cover |
| 5 | Edge of marsh; Spartina alterniflora, about 20% cover |
| 6 | Batis maritima dominant; scattered Spartina patens, Salicornia virginica, and Borrichia frutescens |
| 7 | Spartina patens dominant (75%), Borrichia frutescens subdominant (25%) |
| 8 | Edge of Spartina patens, beginning of Batis maritima dominance; scattered Borrichia frutescens and Avicennia germinans |
| 9 | Monanthochloe littoralis dominant (80%), Batis maritima subdominant (20%); scattered Salicornia virginica |
| 10 | Batis maritima dominant (80%); scattered Salicornia virginica, Distichlis spicata, and Spartina alterniflora |
| 11 | Distichlis spicata and Batis maritima codominant; edge of patch of Scirpus maritimus |

Figure 4. Profile and vegetation types along one leg (approximately 360 ft or 110 m) of marsh transect 2 on Matagorda Peninsula near Zipprian Bayou.

# APPENDIX 2



## ANALYSIS REPORT

UNIVERSITY STATION, BOX X
AUSTIN, TEXAS 78713-7508
(512) 471-7721 (ext. 426)

MINERAL STUDIES LABORATORY
BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN

DWK
DAVID W. KOPPENAAL, Ph.D
CHIEF CHEMIST

| INVESTIGATOR: | PROJECT/ACCOUNT: | DATE: | REPORT #: |
|---|---|---|---|
| Bill White | Texas Parks-Wildlife | May 11, 1988 | R-036-88 |

**SAMPLE PREPARATION / TREATMENT**

The samples were air dried initially. Upon inspection of the dry samples the decision was made to wet sieve the samples to remove the large amounts of gross organic matter associated with the solid fraction of the sample. The remaining solid fraction was dried again, ground to a course product, and split using a sample splitter to yield a homogeneous starting material. One split ( approx. 20 g) was dried at 105 C for 24 hours to determine the moisture content of the dried solids. A second subsample (approx. 70 g) was treated with hydrogen peroxide for several days until no further reaction could be observed. The remaining solids were then wet sieved to separate the sand fraction from the silt/clay fraction. The silt/clay fraction was then centrifuged to remove the majority of the water, transfered to a volumetric cylinder, and the analysis for particle size determination by hydraulic separation (pipet method) was performed. The organic/inorganic carbon determinations were done on the initial split which was used to determine the moisture content

**SAMPLE ANALYSIS METHODS**

| Constituents | Technique | MSL Procedure # |
|---|---|---|
| Texture | Hydraulic Separation | --------- |
| Organic Cabon | Coulometric Titration | SWI 1.7 |

**RESULTS**

Table 1 contains the requested data for the samples.
Table 2 contains the gross sample data by weight.
Table 3 contains the replicate and reference data collected for the sample set.

< less than indicated value
* reported value near detection limit
nd - not determined
ins - insufficient sample

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**COMMENTS**

The textural data is related only to the solid fraction of the sample. This fraction does not include the gross organic material or the water associated with the samples as recieved.

insert comment on others and delete here.

**SAMPLE DISPOSITION:**

The samples are to be archived.

**ANALYSTS:**

T. Pinkston TP
S. Tweedy SWT

# ANALYSIS REPORT

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CHIEF CHEMIST

**Table 1**

White/Calnan Textural Data
(percentage)

| MSL ID#/ SPL ID # | SAND | SILT | CLAY | ORG. CARBON | INORG. CARBON |
|---|---|---|---|---|---|
| 88-480 / TRD 1-3 | 67.3 | 17.6 | 15.1 | 0.43 | 0.02 |
| 88-481 / TRD 1-4 | 25.7 | 39.0 | 35.3 | 1.28 | 0.00 |
| 88-482 / TRD 2-2 | 0.9 | 17.7 | 81.4 | 5.31 | 0.00 |
| 88-483 / TRD 3-2 | 4.3 | 21.3 | 74.4 | 4.60 | 0.02 |
| 88-484 / TRD 4-3 | 1.2 | 33.6 | 65.2 | 4.13 | 0.00 |
| 88-485 / TRD 5-1 | 7.8 | 53.1 | 39.1 | 0.95 | 0.01 |
| 88-486 / TRD 6-1 | 37.2 | 50.7 | 12.1 | 0.34 | 0.00 |
| 88-487 / TRD 6-2 | 4.6 | 54.7 | 40.7 | 1.77 | 0.00 |
| 88-488 / TRD 7-2 | 20.3 | 26.3 | 53.4 | 2.48 | 0.00 |
| 88-489 / CRD 1-2 | 4.6 | 26.3 | 69.1 | 4.28 | 0.17 |
| 88-490 / CRD 1-3 | 1.4 | 18.1 | 80.5 | 4.90 | 0.00 |
| 88-491 / CRD 2-4 | 76.5 | 7.4 | 16.1 | 0.77 | 0.00 |
| 88-492 / CRD 2-9 | 88.9 | 5.6 | 5.5 | 0.12 | 0.36 |
| 88-493 / CRD 3-1 | 4.8 | 52.7 | 42.5 | 1.06 | 1.50 |
| 88-494 / CRD 3-2 | 16.0 | 23.7 | 60.3 | 2.39 | 0.73 |
| 88-495 / CRD 3-3 | 3.6 | 30.5 | 65.9 | 3.20 | 0.47 |

Note: The sand/silt/clay percentages are relative only to solid fraction of the sample and not the entire sample.

again : what does note mean

< less than indicated value
nd - not determined
* reported value near detection limit
ins - insufficient sample

# ANALYSIS REPORT

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**Table 2**

White/Calnan Gross Sample Data
(grams)

| MSL ID#/ SPL ID# | GROSS ORG. | GROSS WATER | GROSS SOLIDS | GROSS SAND | GROSS SILT | GROSS CLAY |
|---|---|---|---|---|---|---|
| 88-480 / TRD 1-3 | 3.1 | 296.4 | 914.4 | 615.4 | 160.9 | 138.1 |
| 88-481 / TRD 1-4 | 31.0 | 413.8 | 545.5 | 139.9 | 212.7 | 192.9 |
| 88-482 / TRD 2-2 | 29.5 | 374.0 | 152.6 | 1.4 | 27.0 | 124.2 |
| 88-483 / TRD 3-2 | 49.1 | 222.0 | 208.9 | 9.0 | 44.5 | 155.4 |
| 88-484 / TRD 4-3 | 18.4 | 566.3 | 293.5 | 3.7 | 98.6 | 191.2 |
| 88-485 / TRD 5-1 | 7.9 | 327.7 | 620.5 | 48.4 | 329.5 | 242.6 |
| 88-486 / TRD 6-1 | 2.0 | 280.8 | 825.2 | 306.8 | 418.6 | 99.8 |
| 88-487 / TRD 6-2 | 17.2 | 304.1 | 520.0 | 23.7 | 284.6 | 211.7 |
| 88-488 / TRD 7-2 | 17.5 | 518.5 | 296.1 | 60.2 | 77.8 | 158.1 |
| 88-489 / CRD 1-2 | 11.0 | 450.1 | 273.2 | 12.6 | 71.8 | 188.8 |
| 88-890 / CRD 1-3 | 19.4 | 476.9 | 245.5 | 3.5 | 44.4 | 197.6 |
| 88-491 / CRD 2-4 | 36.4 | 399.1 | 737.6 | 564.0 | 54.7 | 118.9 |
| 88-492 / CRD 2-9 | 2.0 | 260.6 | 1004.4 | 892.9 | 55.8 | 55.7 |
| 88-493 / CRD 3-1 | 2.3 | 183.3 | 556.3 | 26.8 | 293.2 | 236.3 |
| 88-494 / CRD 3-2 | 6.3 | 408.2 | 316.0 | 50.6 | 74.8 | 190.6 |
| 88-495 / CRD 3-3 | 6.3 | 584.0 | 265.3 | 9.5 | 81.0 | 174.8 |

Note: Gross Sand + Silt + Clay = Gross Solids.
Note: Gross Organics are reported on a air-dried basis. This part of the sample consisted of plant matter except for sample 88-492/CRD 2-9 which consisted of marine shells primarily.

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nd - not determined
ins - insufficient sample

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DAVID W. KOPPENAAL, Ph.D
CHIEF CHEMIST

**Table 3**

Replicate and Reference Material Data
(percentage)

| MSL ID# / SPL ID# | CLAY | ORG. CARBON | INORG. CARBON |
|---|---|---|---|
| 88-485-1/ TRD 5-1 | 39.4 | 0.95 | 0.01 |
| 88-485-2 | 38.7 | 0.96 | 0.01 |
| Average Value | 39.1 | 0.96 | 0.01 |
| Std. Dev. | 0.5 | 0.007 | 0.0 |
| % RSD | 1.3 | 0.7 | 0.0 |
| 88-489-1/ CRD 1-2 | 69.1 | 4.24 | 0.17 |
| 88-489-2 | 69.1 | 4.29 | 0.17 |
| 88-489-3 | | 4.32 | 0.17 |
| Average Value | 69.1 | 4.28 | 0.17 |
| Std. Dev. | 0.0 | 0.04 | 0.0 |
| % RSD | 0.0 | 0.9 | 0.0 |
| MRG-1 / Gabbro | | 0.01 | 0.27 |
| | | 0.02 | 0.27 |
| | | 0.03 | 0.27 |
| Average Value | | 0.02 | 0.27 |
| Accepted Value | | (see note below) | 0.27 |
| Bias | | | 0.00 |
| % Bias | | | 0.00 |

Note: There is no accepted value for organic carbon in this reference material, data is provided only to illustrate the precision of the data.

What does Note mean?

< less than indicated value
* reported value near detection limit
nd - not determined
ins - insufficient sample

# APPENDIX 3

Texas Parks and Wildlife Department Project -- Trinity River Delta and Colorado River Delta
Marsh Transects (end is at row 247)

MARSH TRANSECTS -- TRINITY RIVER DELTA AREA

MARSH TRANSECT 1 (mouth of Long Island Bayou)
(Lat: 29 46 54; Long: 94 44 10) 12-8-87, 1:54 pm (when water level measu

| Sta.# | Description | Distance from 1A (feet) | Rod level H. Inst. (feet) | Rel. Elev. comp. to 1A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 1A | post(82cm)/alidade | 0 | 4.34 | 0 | .82 | (Alidade sta) | Height Instr. | | Panicum dichotomiflorum (fall panic) , Bacopa, scattered cyperus, Aster, Pluchea? |
| 1 | post (79cm high) | 175 | 4.61 | -.27 | .55 | S31W from 1A | | | bare muddy sand |
| 2 | edge of water | 58.17 | 5.16 | -.82 | 0 | S85E from 1A | | | |
| 3 | marker bed, ctr. | 40.71 | 4.22 | .12 | .94 | S50W from 1A | | | fall panic appx. 4.2' hi |
| 1B | post/alidade | 175 | 4.3 | -.27 | .86 | S31W from 1A | Loc.=sta. 1 | | |
| 4 | marker bed, ctr. | 282.5 | 4.57 | -.23 | .59 | S32W from 1B | 107.5' from 1B | | Brass rod, 29.5 cm high in NW corner of marker bed |
| 5 | sed. pan | 39.17 | 4.61 | -.27 | .55 | S61E from 1A | 34' from water | | |
| | | | | | | | 10' to edge veg | | |

MARSH TRANSECT 2 (southeast of channel marker 16 on Trinity R.)
(Lat: 29 45' 54"; Long: 94 41' 33") 12-8-87, 4:05 pm

| Sta.# | Description | Distance from 2A (feet) | Rod level H. Inst. (feet) | Rel. Elev. comp to 2A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | thick mats of alligator weed between levee and marker, |
| 2A | post/alidade | 0 | 4.43 | 0 | 1.72 | N50E-Ch Mkr 16 | post 90cm high | | scattered Phragmites on levee, some trees (willows), |
| | waters edge | 43 | 6.15 | -1.72 | 0 | | | | dead vines over Phragmites, some Bacopa near marker, |
| | cut bank | 21 | 4.8 | -.37 | 1.35 | | | | other green leafy plant, probably swamp lilly (no flowers) |
| 1 | top of levee | 19.33 | 3.9 | .53 | 2.25 | | sal. near (1.5m | | |
| 2 | marker bed | 200 | 4.74 | -.31 | 1.41 | N81W from 2A | from) marker = | 19/5/72x100 | sparse at mkr |
| | post(80.2cm high) | | | | | N79W post-marke | 13.25' to mkr c | | alligator weed |

MARSH TRANSECT 3 (Northern shore of Old River near Round Lake)
(Lat: 29 48' 41"; Long: 94 46' 07") 12-9-87, 10:34 am

| Sta.# | Description | Distance from 3A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 3A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Old River TSC= | 17/0.5/10x100 | on levees--fluvial woodlands of chinese tallow, Phragmites, |
| | | | | | | | nearby pond = | 15/3/40x100 | scattered swamp lilly near pond |
| 3A | post/alidade | 0 | 4.58 | 0 | .52 | | post 75cm high | | |
| 1 | post(75cm also) | 53.8 | 4.23 | .35 | .87 | S13E from 3A | S5W to pile across channel | | post 9.92' from water's edge |
| 1a | waters edge | 63.75 | 5.1 | -.52 | 0 | | | | |
| 2 | marker bed | 19.25 | 4.6 | -.02 | .5 | S66W from 3A | under chinese tallow | | in cluster of chinese tallow; understory--swamp lilly, 32 plants in sq. m lilly < 30 cm h |
| 3 | post(103 cm high) | 156 | 4.43 | .15 | .67 | N14W from 3A | | | |
| 4 | marker bed | 136.75 | 4.45 | .13 | .65 | S2W from st 3 ( 19.25' from 3) | | | alligator weed low < 10 cm; corner of marker Echinochloa crusgalli? up to 70 cm, lowest 25 cm |

MARSH TRANSECT 4 (northern shore of channel that connects Lost River with Trinity River)
(Lat: 29 48' 12"; Long: 93 43' 55") 12-9-87, 2:29 pm

| Sta.# | Description | Distance from 4A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 4A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 4A | post/allidade | 0 | 4.86 | 0 | 1.22 | | | 17.5/0.0/25x10 | Area of alligator weed possibly in transition to open water; |
| 1 | top of berm/levee | 15 | 4.3 | .56 | 1.78 | | | | Thick growths of Phragmites on levee, also spiney aster, Paspalum; Sesbania across channel; |
| 2 | waters edge | 17.92 | 6.08 | -1.22 | 0 | | | | Location of post due W of USACOE Wallisville structure near locks, 50' toward Tri. R. from old metal post on bnk |
| 3 | marker bed | 52.5 | 5.75 | -.89 | .33 | N15E from 4A | | | marker site mostly barren mud flat; 1-2" water on east half of m.b.; subaerial on west half |

MARSH TRANSECT 5 (East bank of Trinity River approx. 7 km upstream from confuence of Old River and Trinity R.)

(Lat: 29 48' 44"; Long: 94 43' 45") 12-9-87; about 3:30pm

| Sta.# | Description | Distance from 5A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 5A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 5A | post/alidade | 0 | 4.62 | 0 | 1.46 | | nat. levee | | fluvial woodlands, willows, bald cypress, oaks, tallow, near cypress swamp; |
| | waters edge | 32.42 | 6.08 | -1.46 | 0 | | post 98cm high | 17/0.0/20x10 | Currents strong; local fisherman said river on rise; |
| | marker bed (ctr) | 21 | 5.22 | -.6 | .86 | S10W from 5A | | | recent deposit of mud at marker site (mud cracks)--few leaves |

MARSH TRANSECT 6 (near mouth of east distributary of Old River Pass--edge of delta)
(Lat: 29 46' 54"; Long: 94 42' 18") 12-10-87, 10:30 am

| Sta.# | Description | Distance from 6A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 6A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 6A | post/alidade | 0 | 4.54 | 0 | .76 | | post 66cm high | | |
| 1 | marker bed | | 4.92 | -.38 | .38 | S37W | | | sparse, stubby, dead, Scirpus maritimus or olneyi |
| 2 | marker bed | 25.67 | 4.61 | -.07 | .69 | S72W from 6A | N32E from 6B | | predominately alligator weed in this area |
| 3 | erosional scarp | 31.17 | 5.6 | -1.06 | -.3 | | 3.83' to mkr 2( | | water .3' deep |
| 6B | post | | | | | | 15' to mkr 1(ed | | |
| | water level | | 5.3 | -.76 | 0 | | | | |

MARSH TRANSECT 7 (near Smith Point)
(Lat: 29 32' 08"; Long: 94 46' 25") 12-10-87, 3:40 pm

| Sta.# | Description | Distance from 7A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 7A (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 7A | stake/alidade | 0 | 4.93 | 0 | 1.22 | | | | Spartina patens, scattered Iva frutescens on shell berm |
| 1 | post | ? | 5.58 | -.65 | .57 | S35W from sta 7 | | | base of berm and beginning of Juncus roemerianus |
| | edge of water | | 6.15 | -1.22 | 0 | S35W to post (1 | 25' frm st 1 | 20.5/15.5/230x1 | |
| | hi edge of S.altern. | | 5.65 | -.72 | .5 | | 15' from st 1 | | |
| | edge S.al trwd markb | 8.83 | 5.26 | -.33 | .89 | | | | contact S. patens and S. alterniflora, S. alt. continues to marker |
| | marker bed (ctr) | 37.33 | 5.89 | -.96 | .26 | S12E from 7A | 33.67 frm st 1 | | S. alterniflora |
| | edge water frm mb | 43.5 | | | | S22W wtr to mar | | | S. alterniflora |
| | edge water from mb | 34.25 | | | | N86W wtr to mar | | | S. alterniflora |

MARSH TRANSECTS -- COLORADO RIVER DELTA AREA

MARSH TRANSECT 1 (Near mouth of Culver Cut)
(Lat: 28 00' 30"; Long: 96 00' 32") 6/25/87, 4:00 - 6:00 pm

| Sta.# | Description | Distance from BM (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to BM (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| BM | COE bench mark | 0 | 4.12 | 0 | .94 | | BM .94'abve grn | 32/1/25 | Temp, sal, cond, taken in open bay about 0.5 mi from transect |
| 4 | berm | 27 | 3.5 | .62 | 1.56 | S83W | | | S. patens dominant, others Salicornia, Borrichia, Iva frutescens |
| 1 | | 100 | 4.78 | -.66 | .28 | N23W | | | Scirpus maritimus, 100% |
| 2 | marker bed | 200 | 4.84 | -.72 | .22 | | | | Distichlis spicata (85%), Scirpus maritimus (10%), Borrichia frutescens |
| 3 | marker bed | 300 | 4.75 | -.63 | .31 | | | | Spartina alterniflora (95%), Scirpus maritimus |
| | water (apprx) | | 5.06 | | 0 | | | | |

MARSH TRANSECT 1 WEST EXTENSION (toward Culver Cut from sta 3 above) (2/9/88, 10:00am-12:30pm)
(Lat.-Long. approx. same as above; tides were lower than during 6/25/87)

Larger circular Distichlis patch, height of Dist. 1.8-2'; scattered stunted S. a

| Sta.# | Description | Distance from 1B (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 1B (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 1B | post/alidade | 0 | 4.2 | 0 | 1.07 | N50E to sta. 3 | post Hght=3.0' | 10.5/18.5/220x10 | @ taken in Culver Cut |
| 5 | | 28 | 4.16 | .04 | 1.11 | | | This site approx | . on levee, indistinct here, not much elevation change |
| 6 | | 50 | 4.25 | -.05 | 1.02 | | | | From 1B to sta 5 - mixed Distichlis, Borrichia, Batis, sta 5 begins Distichlis dominance |
| 7 | | 72 | 4.25 | -.05 | 1.02 | | | | Circular patch of Distichlis (1.8-2'tall); scattered stunted S. alterniflora |
| 8 | | 75 | 4.25 | -.05 | 1.02 | | | | Distichlis (1.8-2' tall), edge of S. alter. appearance |
| 3 | Same as 3 above | 108.6 | 4.33 | -.13 | .94 | | | | Edge of S. alter. (dead 3.2' tall, live 2') dominance to sta 3 |
| 9 | | 19 | 4.25 | -.05 | 1.02 | | .25 square meter marker of red g | | litter added to northwest corner of marker bed site set on 6/25/87 (above) |
| 10 | | 35 | 4.67 | -.47 | .6 | S50W from 1B | toward Culver C | | Contact between S. alter. (1'tall); Scirpus maritimus (3-3.5') |
| 11 | water level | 40.8 | 5.27 | -1.07 | 0 | | | | Pure S. alterniflora (dead 4' tall, live 2') |
| 12 | edge S. alterniflora | 43.6 | 5.67 | -1.47 | -.4 | | 12:20 pm, 2-9-88 | | edge of water in S. alter. (approx same height, a few stems up to 5.5') |
| 13 | marker bed | 12.3 | 4.05 | .15 | 1.22 | N8E from 1B | .25 sq. m of red glitter | | edge of S. alter. along Culver Cut (dead 2.5', live 1.5') |
| 14 | marker bed | 23 | 4.49 | -.29 | | | | | Batis (appr. 1.8' tall)-Aster subulatus? (2') codominant, D. spicata and S. patens on edge |

MARSH TRANSECT 2 (Matagorda Peninsula near Zipprian Bayou)
(Lat: 28 36' 18"; Long: 95 59' 33") 6/26/87, 10:30 am - 2:30 pm
1st leg of transect

Iva, Phragmites, S. patens on higher levee along Culver Cut toward Intracoastal Waterway

| Sta.# | Description | Distance from 1MA (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 1MA (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing from 1MA | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 1MA | post/alidade | 0 | 4.2 | 0 | 1.42 | | | | |
| 1 | | 15.52 | 5.2 | -1 | .42 | N220W | | | Borrichia frutescens and Spartina patens, codominant |
| 2 | | 47.456 | 5.14 | -.94 | .48 | | | | Edge of Borrichia frutescens and Spartina patens, beginn. of Batis maritima |
| 3 | | 64.544 | 5.28 | -1.08 | .34 | | | | Distichlis spicata dom., scat. B. frutescens and S. alterniflora |
| 4 | marker bed | 91.648 | 5.62 | -1.42 | 0 | | | | Edge of S. alternilfora dom.; scat. D. spicata, Salicornia, and Batis |
| 5 | edge of marsh | 119.584 | 6.42 | -2.22 | -.8 | | | | S. alterniflora, approx. 60% |
| 6 | | 16.512 | 4.9 | -.7 | .72 | S27E | | | Edge of marsh; S. alterniflora, about 20% cover (water 0.80ft deep) |
| 7 | | 29.824 | 4.54 | -.34 | 1.08 | | | | Batis maritima dominant; scat. S. patens, Salicornia, & B. frutescens |
| 8 | | 40.416 | 4.65 | -.45 | .97 | | | | S. patens dominant (75%), B. frutescens (25%) |
| 9 | marker bed | 96.96 | 4.72 | -.52 | .9 | | | | Edge of S. patens, begin. of Batis dom.; scat. B. frutescens & Avicennia germinans |
| 10 | | 150.56 | 4.64 | -.44 | .98 | | | | Monanthochloe dominant (80%), Batis (20%), scat. Salicornia |
| 11 | | 227.872 | 4.72 | -.52 | .9 | | | | B. maritima (80%), scat. Salicornia, Distichlis, and S. alterniflora |
| | water level | | 5.62 | | 0 | | | | D. spicata and Batis codominant; edge of patch of Scirpus maritimus |

2nd Leg of Transect

| Sta.# | Description | Distance from 2MA (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 2MA (feet) | Rel. Elev. comp. to water (feet) | Compass Bearing from 2MA | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 12 | | 205.728 | 5.54 | -1.28 | -.34 | S55W | N55E frm sta 11 | | |
| 13 | | 146.208 | 5.57 | -1.31 | -.37 | | | | Distichlis dominant, Batis abundant, Salicornia scattered; 90% cover |
| 14 | | 94.208 | 5.57 | -1.31 | -.37 | | | | Batis dom.; some Salicornia and S. alterniflora; 60 % cover |
| 15 | | 52.16 | 5.55 | -1.29 | -.35 | | | | Edge of S. alterniflora, Batis codominant |
| 16 | | 11.52 | 5.34 | -1.08 | -.14 | | | | S. alterniflora (100%); 80 % cover, wet substrate, mud veneer ovr sand |
| 2MA | post/alidade | 0 | 4.26 | 0 | .94 | | | | Batis begins; Distichlis mixed with S. alterniflora twrd sta. 15 |
| 17 | | 16.992 | 5.22 | -.96 | -.02 | N63E | | | Berm near shore; S. patens dominant; scat. Borrichia, clump of Iva frutescens |
| 18 | | 44.96 | 6.4 | -2.14 | -1.2 | | | | S. alterniflora (100%); 90 % cover |
| | water level | | 5.2 | | 0 | | water 1.2' deep | | Edge of S. alterniflora in water |

MARSH TRANSECT 3 (Col. Riv. Delta at Parker's Cut)
(Lat: 28 37' 15";Long: 95 58' 54") 6/26/87, approx. 4:30 pm

| Sta.# | Description | Distance from 3A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 3A (inches) | Rel. Elev. comp. to water (feet) | Compass Bearing from 3A | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 3A | post (.9m high) | 0 | 0 | 0 | 1.44 | | profiling rods used to measure e | | levations |
| | water level | 23.68 | -1.44 | -17.28 | 0 | | dist. to bank | | |
| 1 | | 20 | -.17 | -2 | 1.27 | elev. correct? | frm top of bnk | | Distichlis, Batis codominant; Borrichia and Lycium scat., height appx. 1.25' |
| 2 | | 40 | -.33 | -4 | 1.11 | N65W | | | Batis and Borrichia codominant; height appx. 1' 2" |
| 3 | | 60 | -.42 | -5 | 1.02 | | | | Batis (1'2"), Lycium (1'8"), Borrichia (1'10") |
| 4 | | 80 | -.58 | -7 | .86 | | | | Batis (1'9") dominant, scat. Borrichia (1'10"), Lycium (2'to2'5"), Distichlis (2'), S. alt. (1'8") |
| 5 | | 100 | -.63 | -7.5 | .81 | | | | Batis (1'7"), Distichlis (2'4"), scat. S. alt. (1'7"), Borrichia (1'5"), (100% cvr) |
| 6 | | 120 | -.67 | -8 | .77 | | | | Batis (1'6"), Distichlis (2'2") codominant; increase in S. alt. (2'4"), sparse Salicornia (1'7") |
| 7 | | 140 | -.69 | -8.25 | .75 | N70W | | | Batis (1'8"), Distichlis (1'8") codominant, S. alt. (2'3"), 100% cvr |
| 8 | | 160 | -.71 | -8.5 | .73 | | | | Batis (1'8"), Distichlis (1'9"), codomin., scat. Salicornia (2'1"), S. alt. (2' 5") |
| 9 | | 180 | -.73 | -8.75 | .71 | | | | Batis (1'7") dominant, Distichlis (1'8"), S. alt. (2'6") |
| 10 | | 200 | -.69 | -8.25 | .75 | | | | Batis (2') dominant, Distichlis (2'), S. alt. (2'2") |
| 11 | | 220 | | | | | | | Distichlis dominant with scat. S. alt. and patches of Scirpus maritimus and Borrichia |
| 13 | | 400 | | | | | btwn 10 and 13 | | S. alterniflora (1'9") dominant from this point to edge of marsh |

Establishment of marker beds (white feldspar clay) on Transect 3, 12/17/87, 9:00 am, extremely low tides from "norther"
Temp. = 14 C, Sal. = 22 ppt., Cond. = 280 uMhos

| | | | | |
|---|---|---|---|---|
| 1st | post (3' high) | sta. 3A ( see above) | | |
| 1st | marker bed | 11'to post | | |
| 2nd | post(3'5.5 in) | 372' from 1st post | N14E frm post 1 mb 28.5 to bnk . | Distichlis dominant (48%), Batis (35%), Borrichia (20%), vegetation height > 2' up to 2'3" |
| 2nd | marker bed | 13'10" from 2nd post | | |
| 3rd | post | 650' from 2nd post | N63E pst to mb | S. alterniflora (2' to 2'3") 55%, Distichlis (1'4" to 1'7") 45% |
| 3rd | marker bed | 17' from 3rd post | | |
| 4th | post (3'5in) | 712'from 3rd post | S32W pst to mb | 100% S. alterniflora (leaf tip up to 2'5"; stem and spikelet 3') |
| | | | | Edge of S. alterniflora, beginning of mud flats/bay |

Establishment of elevations along transect 3 using planetable; 7/20/88, 1;23 pm, high tides

| Sta # | Description | Distance frm 3A (ft) | Rod level/ H. Inst. (ft) | Rel. Elev. comp to 3A (ft) | Rel. Elev. comp to wtr (ft) |
|---|---|---|---|---|---|
| water | Parkers Cut; 1:23 pm | -21.25 | 6.24 | -1.35 | 0 |
| 3A | 1st post and Marker | 0 | 4.89 | 0 | 1.35 |
| 1 | red flag | 200 | 5.53 | -.64 | .71 |
| 2 | 2nd post and Marker | 372 | 5.65 | -.76 | .59 |
| 2.2 | red flag | 572 | | -.88 | .47 |
| 2.3 | water level; 2:30 pm | 637 | | -.93 | .42 |
| 2.4 | red flag | 772 | | -.93 | .42 |
| 3 | 3rd post and marker | 1022 | | -.82 | .53 |

MARSH TRANSECT 4 (Matagorda Peninsula about 1.25 mi east of Phillips Bayou)
(Lat: 28 32' 10"; Long. 96 07' 20") 12/16/87, 11:45 am

| Sta.# | Description | Distance from 4A (feet) | Rod level/ H. Inst. (feet) | Rel. Elev. comp to 4A (feet) | Rel. Elev. comp to water (feet) | Compass Bearing from 4A | Comments | Tem/Sal/Con C/ppt/Mmhos | Vegetation/ other comments |
|---|---|---|---|---|---|---|---|---|---|
| 4A | post/alidade | 0 | 4.7 | 0 | 2.82 | | | 10.5/24.5/260x10 | 0 |
| 1 | edge of water | 72.75 | 7.52 | -2.82 | 0 | N35E | post 2.29' | | |
| 2 | top of sand berm | 56 | 7.1 | -2.4 | .42 | | | | |
| 3 | seawrd edge of S. al | 44 | 7.3 | -2.6 | .22 | | behind oysters | | S. alterniflora up to 4' high |
| 4 | lndwrd edge of S. al | 29 | 6.51 | -1.81 | 1.01 | | | | S. alterniflora up to 2' high |
| 5 | edge of S. patens | 23.5 | 5.87 | -1.17 | 1.65 | | | | S. patens (1.4-2.3' high, incrs. toward berm), mixed with scat. Fimbristylis |
| 6 | edge of patens | 47.5 | 5.55 | -.85 | 1.97 | | | | S. patens mixed with Batis, Distichlis, Borrichia toward flats |
| 7 | edge of Monan. | 47.25 | 5.81 | -1.11 | 1.71 | S35W | | | Monanthochloe bome prodominant |
| 8 | New bearing | 116.92 | 5.85 | -1.15 | 1.67 | | | | Edge of Monanthochloe (short 6-7") and sand flat |
| 9 | edge of S. alt. | 150.25 | 5.98 | -1.28 | 1.54 | S56W from 4A | | | patches of annual Salicornia in area, scat. Batis |
| 10 | Marker bed | 207.25 | 6.24 | -1.54 | 1.28 | | | | marker bed in dense S. alterniflora (1.7-1.9'), |
| 11 | edge of S. alt | 293.58 | 6.52 | -1.82 | 1 | | | | |