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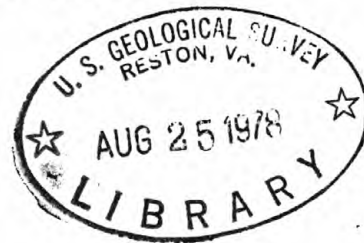
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LONGITUDINAL TURBIDITY STRUCTURES IN  
A BAR-BUILT COASTAL PLAIN ESTUARY:  
CORPUS CHRISTI BAY, TEXAS

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Abstract.--Corpus Christi Bay is a shallow, bar-built variety of estuary that is characteristic of the South Texas Coastal Plain. On the basis of synoptic in situ measurements of light transmissivity and suspended-sediment concentrations at six monitoring stations, a time sequence of six turbidity structures was established along the longitudinal trend of the bay and its tidal inlet over a 16-month observation period. The bay turbidity structures were observed to be highly variable in time and space. Structures ranged from a vertically homogeneous water column, to a well-stratified column exhibiting an increasing turbidity gradient with depth. Wind appeared to be the dominant forcing agent influencing turbidity toward the bayhead sector, where it both generates waves for bottom-sediment resuspension and regulates fluvial sediment influx from the Nueces River. Turbidity toward the baymouth sector appeared to be dominantly regulated by tidal forcing effects from Aransas Pass inlet. Both the discharge characteristics of the Nueces River and the mean density of the bay's water column had no discernible influence on the observed bay turbidity structures.

#### INTRODUCTION

The south Texas coast along the northwest Gulf of Mexico is characterized by a well-developed barrier island chain, and an extensive backbarrier lagoonal-estuarine system. These coastal features were developed during the latter stages of the Holocene

rise in sea level, which commenced approximately 18,000 years ago. The drowning of Pleistocene fluvial channels, in conjunction with subsequent barrier construction during the last few thousand years, resulted in the development of the shallow "bar-built" type of estuary (Schubel, 1971a) along the Texas coast, of which Corpus Christi Bay is a representative example (fig.1).

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Extensive discussions of the estuarine environment have been presented in various works (e.g. Lauff, 1967; Schubel, 1971b; Nelson, 1972). In general, an estuary is a highly dynamic and complex sedimentary environment characterized by continuously changing physical, chemical, and biological conditions. The sediment fill in estuaries can be attributed to a combination of sources that can be either external (fluvial, coastal, or shelf influx), marginal (shoreline erosion), or internal (biogenic and substrate erosion). After introduction into the estuarine system, sediments may undergo numerous cycles of deposition and resuspension, in response to a highly variable hydraulic regime that includes both tidal and nontidal components. Estuaries can exhibit varying circulation patterns ranging from a highly stratified salt-wedge variety to a well-mixed vertically homogeneous variety (Pritchard and Carter, 1971). An estuary's circulation pattern is highly influenced by its physical configuration, and by external driving forces consisting of river flow, tidal flow, and wind stress. As noted by Stommel (1951),

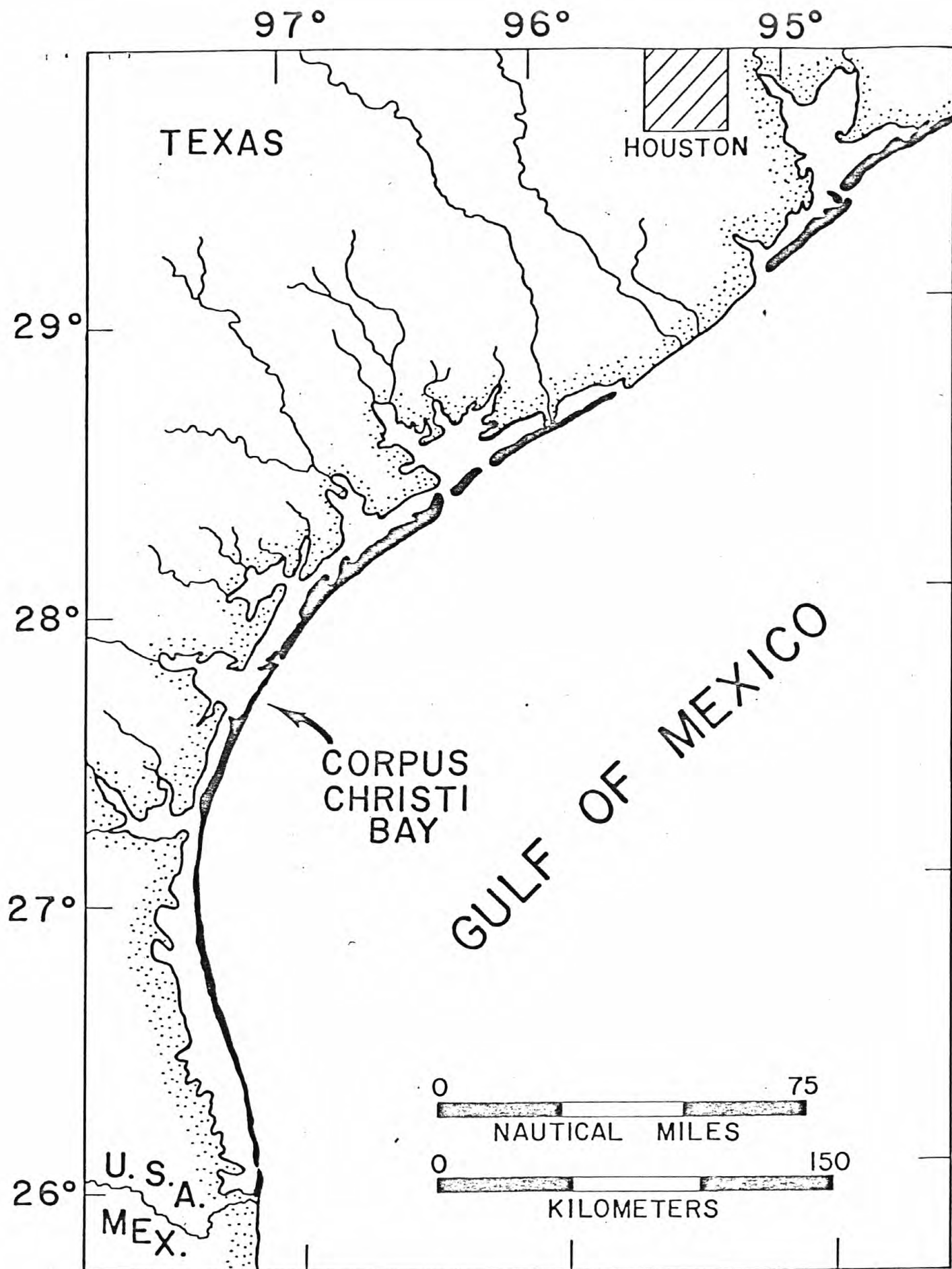


Figure 1. Barrier island chain along the south Texas coast, and associated backbarrier lagoonal-estuarine system.

any of these external forces can dominate the circulation of a particular estuary; consequently, they have a major role in regulating estuarine sedimentation.

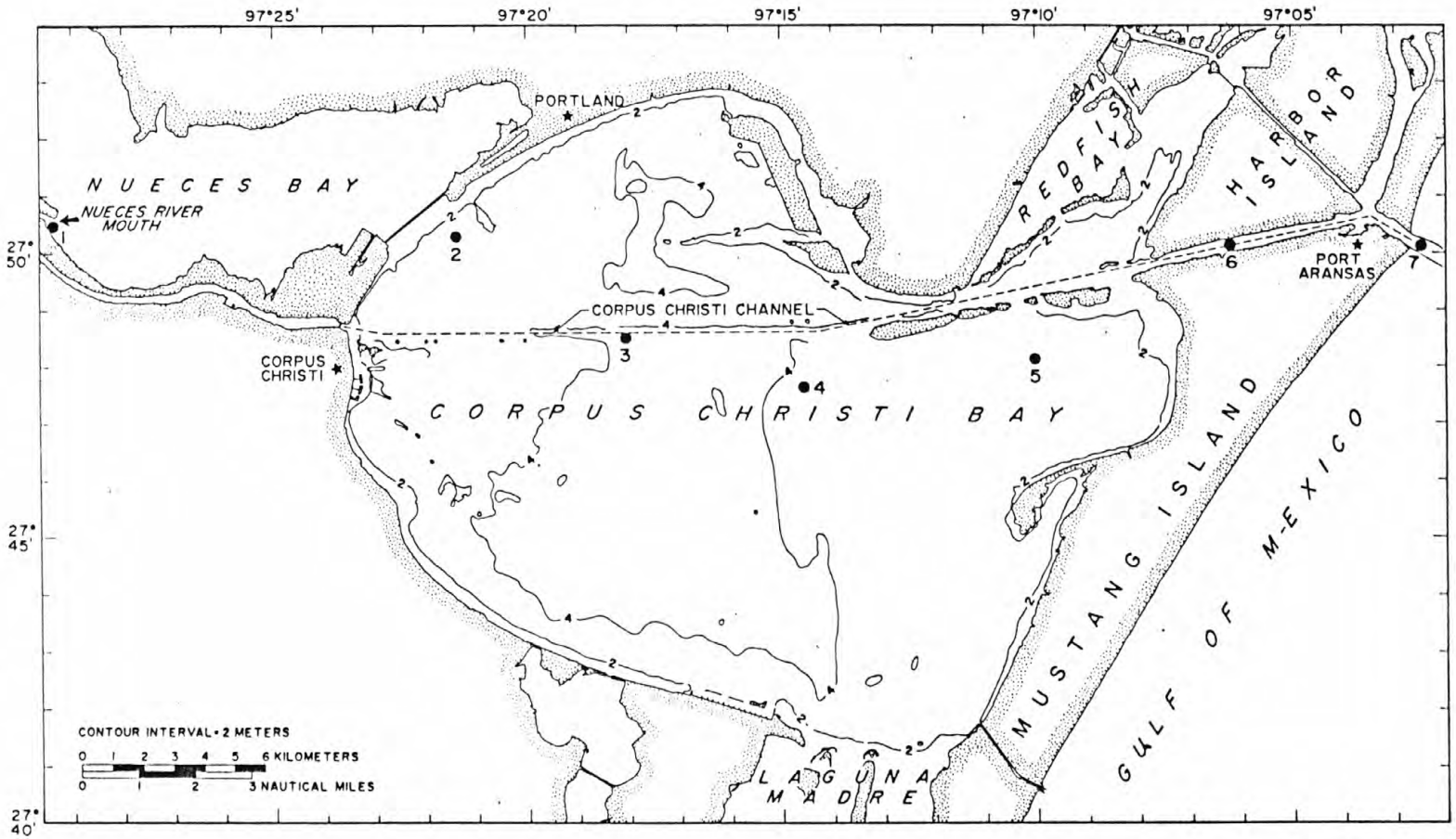
The purpose of the present study was to establish a comparative time sequence of estuarine turbidity structures along the longitudinal trend of Corpus Christi Bay, and to attempt to relate these structures to ambient environmental conditions. This was done in an effort to gain some insight into sedimentary processes indigeneous to the shallow bar-built variety of coastal plain estuary that is characteristic of the south Texas Gulf coast.

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#### ENVIRONMENTAL SETTING

Corpus Christi Bay is a relatively shallow estuary, being generally less than 5 meters deep (fig. 2); an exception is the Corpus Christi ship channel that is maintained for navigation by dredging to a depth of approximately 15 meters. The bay has a slight NW/SE elongation, and is separated from the Gulf of Mexico by the Mustang Island barrier; the main tidal inlet (Aransas Pass) is located near the city of Port Aransas. The main fluvial flow into the estuarine system is from the Nueces River which discharges

Figure 2. Map of Corpus Christi Bay showing sites of monitoring stations and bay bathymetry.



directly into Nueces Bay. In turn, the very shallow Nueces Bay (<1 meter) has water exchange with adjacent Corpus Christi Bay via a causeway-connected inlet. Present in the bay are several dredge spoil banks that are concentrated largely in the northern sector, as well as numerous oil and gas production platforms.

Bottom sediment within Corpus Christi Bay is predominantly mud within the central sector, whereas shelly sand and gravel-size detritus tends to be concentrated toward the marginal areas. The local bedrock that serves as the primary source of bay sediment is the Pleistocene Beaumont Formation; this unit is composed of a heterogeneous mixture of gravel, sand, silt, and clay fluvial and paralic lithosomes (Univ. of Texas, 1975). The composition of the bay's suspended sediment is predominantly inorganic silt and clay detritus, with a subordinate organic fraction dominated by diatoms.

The average annual rainfall in the Corpus Christi area over a 40-year period is about 65 cm, with rainfall maxima in May and September (Hayes, 1965). Local prevailing winds are onshore from the southeast, being most consistent during the summer. During the winter months, relatively high velocity northerly winds frequently occur in association with the passing of polar cold fronts southward into the Gulf of Mexico. Visual observations indicate that the response of the bay's circulation system and associated turbidity patterns to changing wind conditions is rapid (less than a few hours), largely because of the bay's shallowness. The bay is susceptible to both "norther"

storms during the winter, as well as to tropical storms and hurricanes during the summer and fall seasons.

Both meteorological forces and astronomical tides have a substantial influence on bay circulation. Astronomic tides are of both diurnal and semi-diurnal varieties; the tidal range in the adjacent open Gulf during fair weather is generally less than 0.3 m (Marmer, 1954), and decreases bayward. Studies of water-level variations within the bay (Smith, 1974, 1977) suggest that water exchanges between the bay and the Gulf may be dominated by long-period meteorological forcing effects resulting from variations in surface pressure gradients and windstress. In contrast, tidal exchanges are somewhat subdued because of low tidal amplitudes and a dampening effect from the constraining Corpus Christi ship channel.

Although the bay's circulation system is poorly understood, some tentative generalized circulation patterns have been proposed on the basis of wind and current measurements compiled over the 1970-72 period (Southwest Research Inst., 1977). With both diurnal and semidiurnal tides, these data suggested that prevailing southeasterly winds generate predominantly northwesterly surface and bottom flow along the bay's central axial trend. Near the bayhead sector, the axial flow appears to diverge both northeasterly and southwesterly into two gyre-like patterns, in conformity with shoreline configuration. Regarding water exchange between Corpus Christi Bay and Nueces Bay, southeasterly

winds were associated with a flow direction into Nueces Bay. The flow pattern associated with northeasterly winds is even less clearly defined because sufficient current data are not presently available; however, with semi-diurnal tides, gyre-like circulation does appear to occur within the bayhead sector. In addition, the flow of Nueces Bay waters appears to be directed into Corpus Christi Bay during northeasterly winds.

#### METHODS

Field work consisted of obtaining a sequence of water-column measurements at six monitoring stations (2-7) along the longitudinal trend of Corpus Christi Bay and its associated tidal inlet (fig. 2). This station network was selected for two reasons: 1) it provided the maximum number of stations that could be occupied within a one-day work period, thus providing essentially synoptic coverage; 2) it provided data along the deeper longitudinal trend of the bay, which was judged to be most informative in relating turbidity patterns to physical processes. Field sampling was conducted on six dates during different seasons, encompassing a total time span of 16 months. The sampling dates were: October 20, 1975; January 19, 1976; May 11, 1976; June 7, 1976; August 9, 1976; February 14, 1977.

At each bay monitoring station, vertical in situ transmissivity/temperature profiles were obtained through the water column to determine turbidity and thermostructure, using a light-beam transmissometer with a 25-cm optical path. In addition, surface and near-bottom water samples were collected with a 3-liter Van Dorn bottle

for laboratory analyses. The bay stations were consistently monitored in numerical sequence, with station 2 occupied at the beginning of the sampling period, and station 7 occupied last. In addition to bay samples, a surface sample of Nueces River water (station 1) was obtained near its mouth for approximating the rate of fluvial sediment influx during the sampling date.

Collected surface and near-bottom water samples at each station were analyzed in the laboratory for salinity using an induction salinometer. Water sample densities were then determined as a function of salinity and temperature, and expressed as sigma-T values [ $\sigma_t = (\text{density} - 1) \times 1000$ ]. The samples also were analyzed for suspended-sediment concentrations, in terms of total mass (mg/l). Mass determinations were determined gravimetrically by filtration on pre-washed 0.45 Millipore filters. Mean values of both baywater density and sediment concentrations were then determined on the basis of the 12 measurements. In considering the bay's shallowness, the mean values were considered to be representative of the water column along the monitored transect. The filtered samples also were examined by SEM, and photomicrographs were point counted to approximate the proportions of organic and inorganic constituents comprising the particulate system.

Comparative vertical transmissivity cross sections were constructed to illustrate the turbidity structure along the longitudinal transect of the bay during the six sampling dates. In

addition, statistically significant differences in mean values of turbidity in terms of suspended-sediment concentrations (mg/l) among the six sampling dates were determined with a t-statistic test at the 95 percent confidence level, using a SAS computer program (Barr and others, 1976). The t-statistic tests also were used to determine significant differences in mean baywater density ( $\sigma-t$ ) because of its potential influence on suspended-particle settling velocities and overall turbidity. Differences among the six sets of field measurements were then interpreted in terms of variations in ambient environmental conditions during the sampling periods, in an effort to gain insight into physical processes.

Local wind data were obtained from the U. S. Weather Service at Corpus Christi, and local tidal data at the Aransas Pass inlet were obtained from standard tide tables (U. S. Dept. Commerce, 1975-1977). Stream discharge data from the Nueces River were obtained from U. S. Geological Survey's water-data reports (1975-1977), Austin District. Approximations of the relative rates of river sediment influx (gm/sec) during the sampling dates were based on the measurements of sediment concentration (mg/l) from the collected river water samples, and on the average daily stream discharge rates ( $m^3/sec$ ).

#### TRANSMISSIVITY/SEDIMENT CONCENTRATION RELATIONSHIP

Turbidity of the Corpus Christi Bay water column was determined both optically in terms of light transmissivity (% T/0.25 m), and

gravimetrically in terms of total suspended sediment mass (mg/l). Although light transmissivity and total mass both can be used as indices of turbidity, they are actually measures of different water-column properties. As noted by various workers (e.g. Jerlov, 1968; Gibbs, 1974), light-beam transmittance is a complex function of several variables that can influence the optical absorption properties of the water column. Regarding variables within the suspensate system itself, certainly concentration or total sediment mass (mg/l) is a major factor. However, other important factors include particle size distribution, particle mineralogy and shape, and the amount of dissolved organic matter. In view of the complex nature of the transmissivity parameter, it was desirable to empirically establish a functional relationship between the transmissivity and total sediment mass values observed during the study.

Corresponding values of water-column transmissivity and total sediment mass from the six bay stations during the six sampling periods were collectively plotted on a scatter diagram to determine any empirical relationship between the two parameters (fig. 3).

Transmissivity values range from zero to a maximum of 74 percent, whereas total sediment mass values range from a minimum of 0.4 mg/l to a maximum of 164 mg/l. These data were subjected to regression analyses to determine the optimum form of the least-squares function that best characterizes the observed relationship. Using standard curve-fitting programs (Hewlett Packard, 1974), functions tested

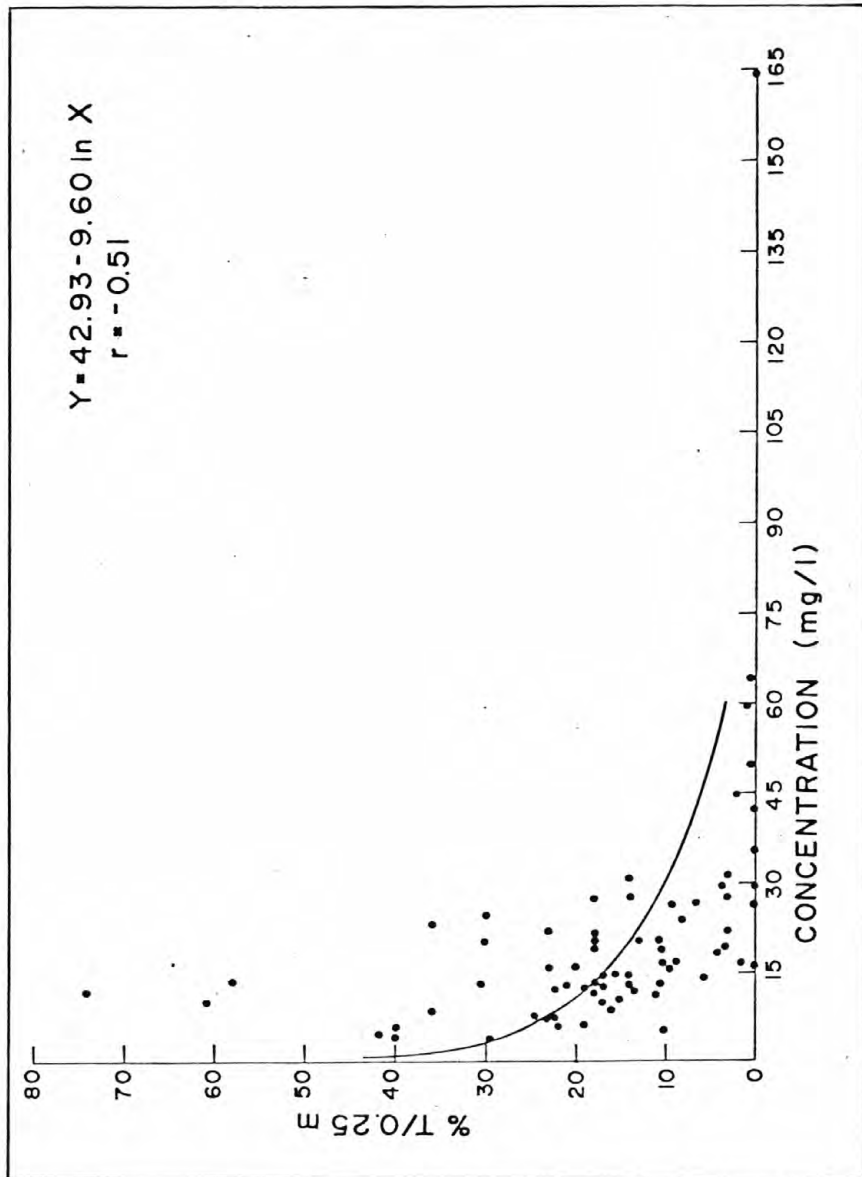


Figure 3. Scatter diagram of bay water transmissivity (%T@0.25 m) and corresponding observed values of total suspended-sediment mass (mg/l). Also illustrated are the optimum least-square function and associated correlation coefficient.

consisted of linear ( $Y = a+bX$ ), exponential ( $Y = ae^{bX}$ ), power ( $Y = aX^b$ ), and logarithmic ( $Y = a+b \log X$ ) forms. Among the tested curves, the logarithmic equation  $Y = 42.93-9.60 \log X$  appears to provide the optimum least-squares fit to the observed data; this is suggested by both the highest correlation coefficient ( $r = -0.51$ ) and by visual inspection.

Although a general reduction in transmissivity can be related to a logarithmic increase in sediment concentration, the functional relationship itself is rather poor and does not appear to be effective in prediction applications. The great amount of scatter is attributed largely to the previously mentioned variables within the suspensate system. Within Corpus Christi Bay, the particulate matter generally consists mainly of a predominant inorganic silt and clay fraction, and a subordinate organic fraction dominated by diatoms. However, the percentage of organic components varies both spatially and temporally; mean organic percentages based on the six bay stations ranged from a minimum of 7.5 percent during the June observations, to a maximum of 57.8 percent in February. This variation in the organic/nonorganic ratio, with concomittant variations in the shape and size distribution of the total particulate system, is probably a major source of variance in transmissivity values for a given sediment concentration.

Variations in the amount of dissolved organic matter may also be a contributing factor. In essence, transmissivity values along the bay transect are inversely related to sediment concentrations. However,

transmissivity does not appear to be accurately predictable from total mass determinations because of a relatively high variance resulting from substantial compositional variability within the particulate system itself.

#### DISCUSSION OF TURBIDITY STRUCTURES

The observed longitudinal turbidity structures based on light transmissivity are the composite responses to several environmental variables that are complexly interrelated. Differences among the observed structures could potentially reflect variations in any one or more of the following parameters: 1) tidal conditions (tidal phase and current velocities), 2) wind direction and velocity, 3) wave conditions, 4) Nueces River discharge (water volume and suspended-sediment load), 5) bay water density (function of temperature and salinity), and 6) organic productivity. Under natural uncontrolled field conditions, one or more environmental parameters may vary simultaneously; therefore, the individual influence of each parameter on the turbidity structure may not be totally resolvable. In addition, the actual response time of bay turbidity structure to changing environmental conditions is unknown; consequently, it was frequently impossible to distinguish residual effects generated prior to the monitoring periods. Although recognizing these limitations, some insight can be acquired regarding the dominant forcing parameters by comparing the observed sequence of bay turbidity structures developed under different ambient field conditions.

October 20, 1975/May 11, 1976/February 14, 1977 Structures

An informative comparison can be made of the October/May/February sequence of turbidity structures because they occurred under the most uniform set of ambient field conditions obtained during the study (fig. 4). All three patterns occurred during a similar tidal phase (waning ebb tide and accelerating flood tide), with a similar onshore wind direction (southeasterly), and under similar very calm sea state conditions (SS1). The absence of significant waves during these sampling periods is especially noteworthy because visual observations indicate that waves within the shallow bay are highly influential in establishing turbidity patterns through the resuspension of bottom sediments. Consequently, a distinguishing aspect of the three structures composing the sequence is that they appear to have been generated largely through processes not associated with ambient wave activity.

The three turbidity structures within the bay interior (stations 2-5) are basically similar in the respect that each exhibits some degree of turbidity stratification, with an increasing turbidity gradient with depth; this suggests an absence of significant vertical homogenization of the water column by wave activity. An absence of significant homogenization during these three dates is also supported by the presence of slightly negative temperature gradients within the bay's interior, rather than isothermal conditions. In terms of mean overall transect turbidity based on sediment

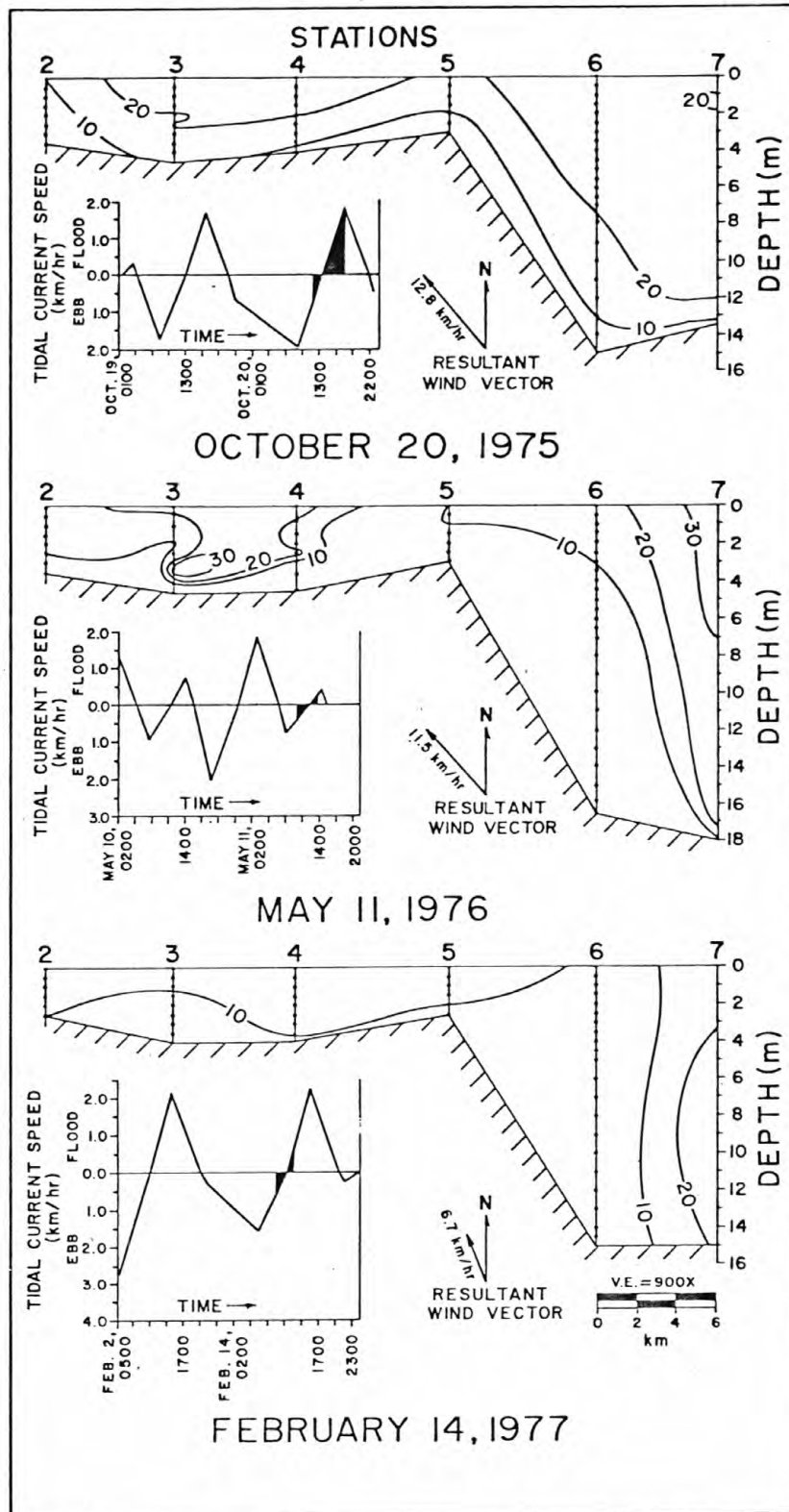


Figure 4. Comparative sequence of transmissivity profiles illustrating bay turbidity structure for the following observation dates: Oct. 20, 1975; May 11, 1976; Feb. 14, 1977. Contour interval is  $10\%T/0.25$  meter. Also illustrated are ambient tidal current variations (shaded interval is sampling period) and daily resultant wind vectors.

concentration (mg/l) measurements at all six stations, t-statistic tests indicate that the only significant difference among the three sampling dates is that February was significantly more turbid than October (tables 1, 2). The contrast in the October/February mean turbidity is not associated with a corresponding significant difference in mean density ( $\sigma_t$ ) of the water column, indicating the absence of a cause-and-effect relationship (tables 1, 2). The relatively noninfluential nature of water-column density on turbidity in this transect sequence is further supported by a significantly higher density during May relative to both October and February, which is not associated with significant differences in overall turbidity.

In attempting to relate these three turbidity structures to external forces, the most prominent environmental variable during the acquisition of this sequence of cross sections was the discharge of the Nueces River, in terms of both water volume and suspended-sediment load (table 3). Maximum fluvial sediment influx occurred in May during a high-water stage, at an approximate rate of 7,504 gm/sec. Minimum influx occurred in October (80 gm/sec); whereas, the influx during February was at an intermediate level (301 gm/sec). A comparison of the May/October turbidity structure is informative. Although the river sediment influx was nearly two orders of magnitude greater in May than in October, this was not manifested in a corresponding contrast at bay station 2, which is closest to the Nueces River mouth. The combined average concentration of both surface and bottom waters at station 2 was 9.5 mg/l in October, compared with only 13.0 mg/l in

May. In fact, in terms of transmissivity, higher overall station 2 turbidity actually occurred in October when river influx was minimal. In addition, t-statistic tests indicate that overall mean transect turbidity based on sediment concentration measurements (mg/l) at all six bay stations was not significantly higher in May than in October (tables 1, 2). These relationships suggest that river influx, even during a high-water stage, was not highly influential in contributing to the variations observed among the turbidity structures from the three sampling dates.

It is hypothesized that the apparent absence of river influence on bay turbidity during these periods may be attributed to the entrapment of fluvial sediments within the adjacent shallow Nueces Bay which could have functioned as an effective settling basin. Entrapment within Nueces Bay would have been facilitated by the absence of significant wave action to maintain sediments in suspension, and by set-up effects and wind-drift currents toward the northwest generated by the ambient southeasterly onshore winds; this would have inhibited the dispersal and mixing of relatively turbid Nueces Bay water with the less turbid waters of Corpus Christi Bay. The generally higher turbidity of Nueces Bay relative to Corpus Christi Bay during the February 14 date is documented by LANDSAT imagery (fig. 5). In contrast, an example of the effective dispersal of the more turbid Nueces Bay waters into Corpus Christi Bay during a time of relatively



Figure 5. LANDSAT image (multispectral scanner) of Corpus Christi Bay and surrounding area on February 14, 1977. Lighter coloration indicates greater turbidity. Note relatively high turbidity of Nueces Bay and conspicuous ebb-tide sediment plume at Aransas Pass inlet. (This is an enlargement of part of image no. 8275416052500 (band 5). Copies of this image can be ordered from: User Services Unit, EROS Data Center, Sioux Falls, SD 57198)

strong (22 km/hr) offshore westerly winds also has been documented by aerial photography (fig. 6). Consequently, it appears that Nueces Bay may function as a release valve for fluvial sediment influx into Corpus Christi Bay, a valve that is regulated mainly by wind direction. The dominant influence of the wind regime in generating currents and producing set-up effects within Nueces Bay itself also has been noted by McGowen (1971), who observed their regulatory influence on the development of a fan delta along the northern shore of Nueces Bay.

The most apparent differences among the three turbidity structures occur in the vicinity of the tidal inlet (stations 6, 7), ranging from a highly stratified water column in October to vertically homogeneous conditions in February. These differences can be reasonably interpreted as the result of tidal forcing effects. As the inlet stations in all three cross sections were occupied during the same basic tidal phase (accelerating flood tide), inlet variations could conceivably reflect differences in any combination of the following: 1) tidal current velocities, 2) duration of prior flooding, and 3) residual effects from previous tidal phases. Turbidity stratification at the inlet was best developed in October, a period characterized by the relatively highest tidal current velocities, the longest duration of prior flooding, and the longest previous ebb phase. These conditions might also account for the significantly lower mean transect turbidity in October relative to February. The lower October turbidity could reflect the more efficient prior seaward flushing of relatively turbid ebb waters, and greater subsequent exchange by relatively clean

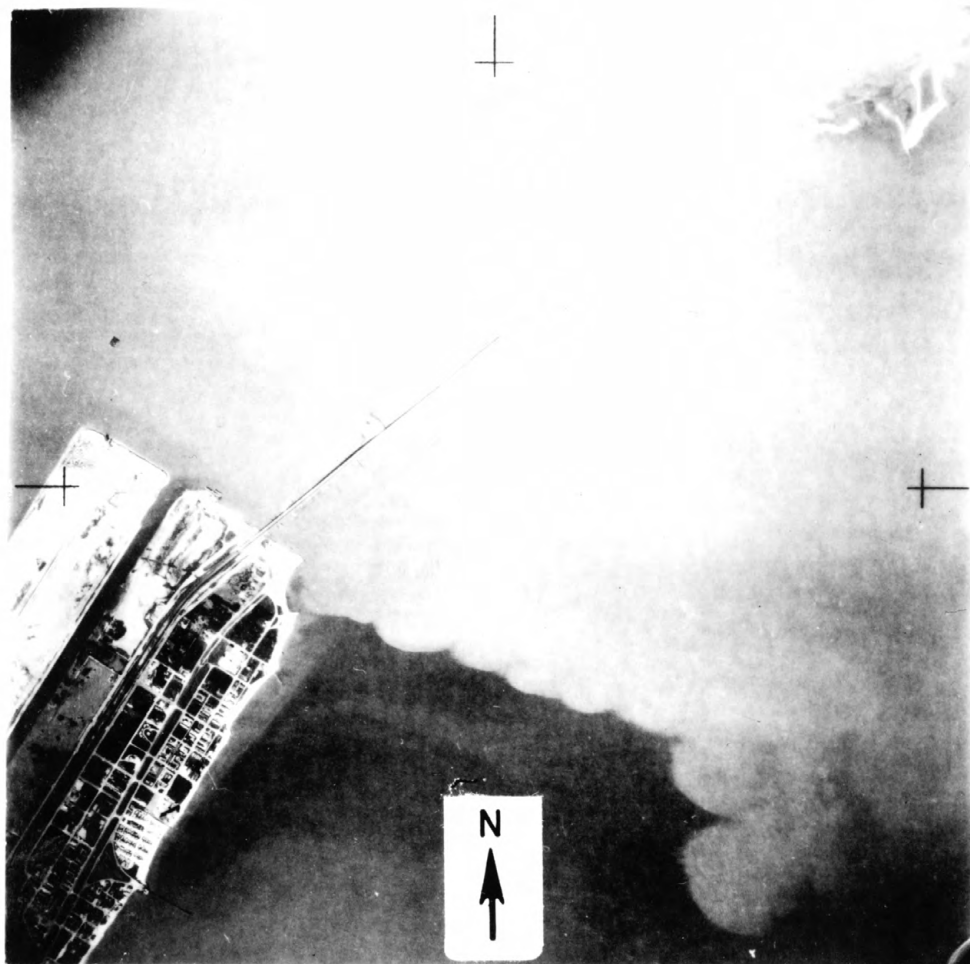


Figure 6. Aerial photograph of Nueces Bay-Corpus Christi Bay inlet taken at 12,500 ft. on Jan. 21, 1973. Turbid Nueces Bay waters moving into Corpus Christi Bay under conditions of strong offshore winds; daily resultant wind vector was from the northwest ( $290^{\circ}$ ) at a speed of 22 knots.

oceanic flood waters. The effectiveness of the tidal flushing mechanism during the February observation data is documented on LANDSAT imagery by the development of a prominent ebb-tide plume at the Aransas Pass inlet (fig. 5). More effective flooding during October may have been enhanced by a more prominent onshore wind-drift current component resulting from relatively stronger onshore winds (12.8 km/hr), as compared to the weaker February winds (6.7 km/hr). The stronger onshore winds in October also would have more effectively inhibited the dispersal of relatively turbid Nueces Bay waters into Corpus Christi Bay, thus further contributing to the lower overall transect turbidity during October in relation to February.

#### January 19, 1976 Structure

The turbidity structure for January occurred entirely during a waning ebb tide, with a relatively strong (30.1 km/hr) southeasterly onshore wind, and very choppy seas (fig. 7). The discharge from the Nueces River was the lowest among the six sampling dates, in terms of both water volume and suspended-sediment load. The approximate sediment influx rate was only 24 gm/sec. As a result of this low rate, in conjunction with strong onshore southeasterly winds, the influence of fluvial influx on the January pattern was probably minimal. The pattern consists of a homogeneously turbid inner-bay sector (stations 2-4), becoming somewhat stratified toward the tidal inlet. Compared to the October/May/February sequence, the main

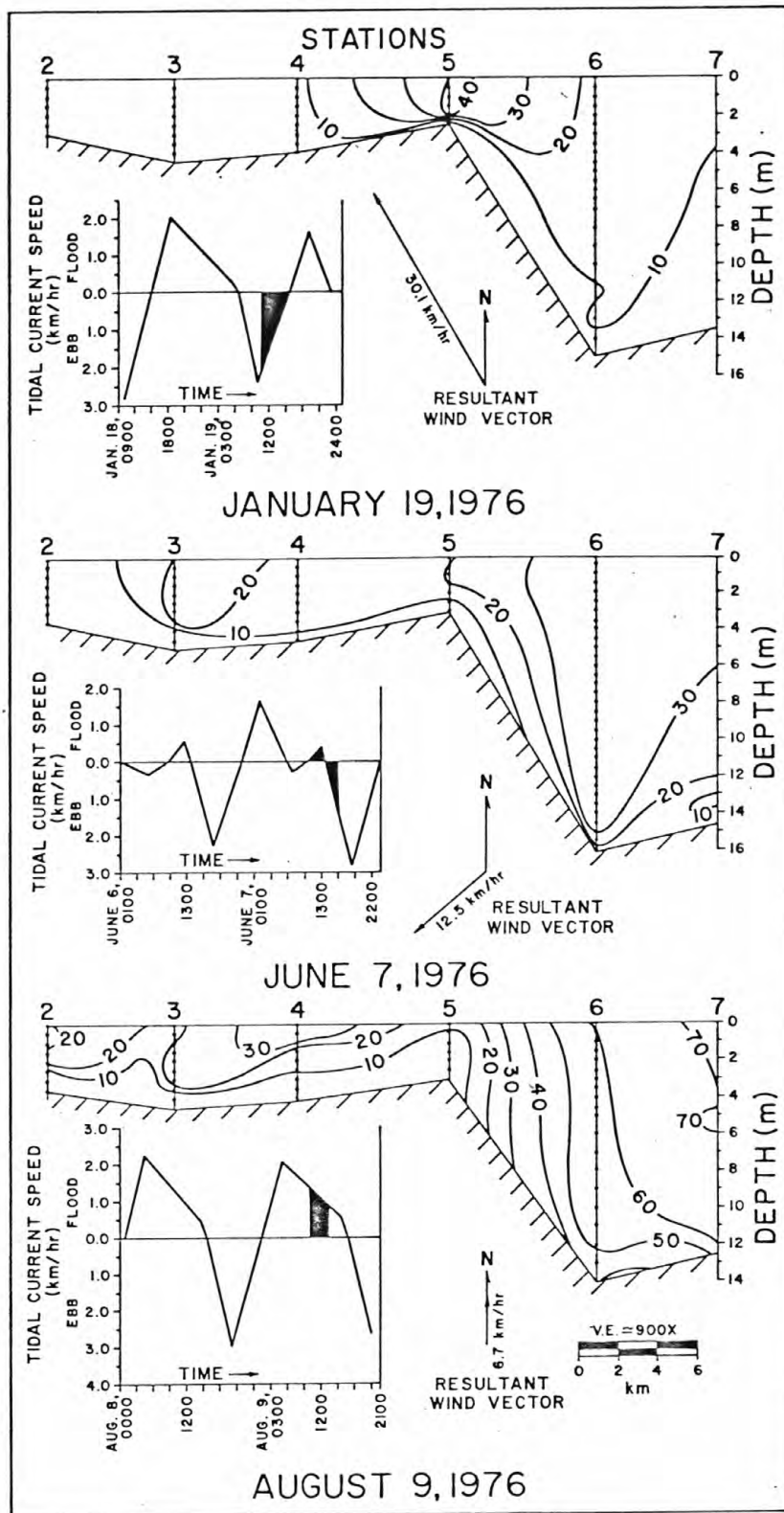


Figure 7. Comparative transmissivity profiles illustrating bay turbidity structure for the following dates: Jan. 19, 1976; June 7, 1976; Aug. 9, 1976. Contour interval is 10%T/0.25 meter. Also illustrated are ambient tidal current variations (shaded interval is sampling period) and daily resultant wind vectors.

differences in ambient conditions during January were much stronger southeasterly onshore winds, substantial wave activity, and the absence of prior contiguous flood-tide effects. In addition, the mean water-column density ( $\sigma_t = 22.0$ ) along the transect during January was significantly higher than during all other five sampling periods (tables 1, 2). Except in the inlet sector (stations 6, 7), the bay's water column was vertically isothermal, indicating substantial homogenization. Since the strong onshore winds would tend to inhibit the dispersal of turbid Nueces Bay waters into Corpus Christi Bay, the greater inner-bay turbidity in January is attributed to a higher degree of bottom-sediment resuspension and vertical mixing by waves toward the head of the bay; this bay sector is especially susceptible to intense wave action generated by strong southeasterly onshore winds because of maximum fetch for the bay-length component. In terms of mean transect turbidity based on sediment concentrations (mg/l), the t-statistic tests indicate that January turbidity was significantly greater than in October; this difference is attributed both to the greater degree of bottom-sediment resuspension by waves resulting from the stronger southeasterly winds, and to the absence of contiguous prior replacement by less turbid flood-tide Gulf waters. The significantly higher water column density during January had no determinable effect on turbidity. The January turbidity structure appears to have been wind dominated.

## June 7, 1976 Structure

The turbidity structure for June occurred during a complete flood-tide phase and an accelerating ebb-tide phase (fig. 7). Winds were from the northeast at 12.5 km/hr, and the seas were slightly choppy. Fluvial sediment influx from the Nueces River was at a moderate rate (352 gm/sec). Mean water-column density ( $\sigma_t = 18.4$ ) along the transect was significantly lower than during both May and January. The June structure is characterized by a homogeneously turbid bayhead sector (station 2), with the remainder of the bay exhibiting varying degrees of turbidity stratification; the degree of stratification increases toward the tidal inlet. In terms of thermostructure, the bay's water column was isothermal at all transect stations, indicating substantial homogenization. Relative to the previously discussed observation dates, the most distinguishing variable in ambient environmental conditions during June was a change in wind direction, with alongshore northeasterly winds oriented essentially normal to the bay's longitudinal trend. In addition, the tidal conditions during sampling were different.

Of significance are the more turbid conditions (41 mg/l) at the bayhead (station 2), relative to May turbidity (13 mg/l) when the rate of river influx was over an order of magnitude greater. This is interpreted as being largely the combined result of both a higher degree of sediment resuspension by waves, and the more effective dispersal of turbid Nueces Bay waters into Corpus Christi Bay by

set-up effects and wind-drift currents generated by the northeasterly winds. In addition to offshore winds, alongshore winds parallel to the Gulf coast which have strong northerly components also appear to be effective agents for flushing out the Nueces Bay settling basin. In terms of mean sediment concentration (mg/l), overall transect turbidity was significantly higher in June than in October (tables 1, 2). This is attributed to the more effective dispersal of turbid Nueces Bay water, greater wave activity, and possibly to somewhat less replacement by cleaner Gulf waters because the June flood-tide phase was characterized by relatively lower current velocities and shorter duration.

#### August 9, 1976 Structure

The August turbidity structure occurred during a waning flood tide, with relatively weak (6.7 km/hr) southerly winds, and very calm sea state conditions (fig. 7). The sediment influx from the Nueces River was relatively high, with an approximate rate of 2,774 gm/sec, being second only to the high-water stage influx during May. The water density along the transect during August was significantly lower than during January. Regarding thermostructure, the water column at some stations was isothermal (stations 2, 4, 6), whereas the remaining stations had a slight negative gradient. The distinguishing environmental variables during August are the southerly winds, high fluvial sediment influx, and flood-tide conditions during the entire sampling period. The August structure is characterized by a high

degree of turbidity stratification, apparently reflecting an absence of significant wave homogenization. Similar to the May/June comparison, the high fluvial influx during August is associated with a lower concentration at station 2 (20.4 m/1) compared to the lower fluvial influx but higher station 2 concentration (41 mg/1) during June. Once again, this is attributed to the confinement of fluvial sediments within Nueces Bay with set-up and currents generated by the onshore southerly winds during June. In terms of mean sediment concentrations, the transect turbidity during August was not significantly different than that of any of the other five sampling periods. However, the tidal-inlet sector (stations 6, 7) had relatively cleaner waters than during any other period, with transmissivity values (%T/0.25m) reaching a maximum of 76 percent at station 7. These were the most transparent conditions observed during the study, probably reflecting the relatively long period of exchange by flooding Gulf waters prior to sampling. The extensive flood tide also may have partially contributed to the relatively high degree of turbidity stratification.

#### SUMMARY AND CONCLUSIONS

Turbidity along the longitudinal trend of Corpus Christi Bay is highly variable in time and space. Transmissivity values (%T/0.25 m) of the water column along the monitored transect ranged from zero to a maximum of 74 percent, but were generally less than about 40 percent. Mean sediment concentrations ranged from a minimum of 11.8 mg/1 in

October, to a maximum of 25.6 mg/l in January. Transmissivity values are inversely related to sediment concentrations, but exhibit a high degree of variance for a given concentration.

Longitudinal turbidity structures ranged from a vertically homogeneous water column, to a well-stratified column with an increasing turbidity gradient with depth; the structure changed with varying ambient conditions. Turbidity toward the bayhead sector appeared to be largely dominated by wind rather than by stream discharge; the discharge characteristics of the Nueces River had no discernible effect on observed bay turbidity patterns. It is postulated that fluvial sediment influx from the Nueces River enters adjacent Nueces Bay, which functions as a shallow storage basin that entraps sediment at times when winds have southeasterly onshore components. However, during periods of westerly and northerly offshore or alongshore winds, set-up effects and wind-drift currents appear to flush and disperse relatively turbid Nueces Bay waters into the head of Corpus Christi Bay. In essence, the influx of fluvial sediments into the estuarine system may ultimately be regulated by the wind direction. Winds further influenced the turbidity structures by generating waves that resuspend bottom sediments, resulting in a vertically-mixed uniformly turbid water column; this process appears to be most influential within the bayhead and marginal sectors. Turbidity structure toward the baymouth sector appears to be dominated largely by tidal forcing effects associated with Aransas Pass Inlet.

Variations in mean density of the bay's water column during the observed periods ranged from a maximum value ( $\sigma_t = 22.0$ ) in January 1976, to a minimum value ( $\sigma_t = 17.1$ ) in February 1977; these density variations had no discernible effect on bay turbidity. Winds and tides appeared to be the dominant forcing agents regulating the observed bay turbidity structures.

The foregoing observations were of a reconnaissance nature, and the resulting tentative inferences are applicable only to the monitored transect. The establishment of more definitive relationships between baywide turbidity structures and estuarine forcing agents would require additional future monitoring studies based on a more detailed synoptic sampling network. Some general aspects requiring further investigation are the accurate establishment of the bay's circulation patterns under varying meteorological conditions, the isolation of turbidity response effects associated with individual forcing agents, and the differentiation of instantaneous and residual response effects.

TABLE 1.--Summary of suspended-sediment concentrations and water-column characteristics along the monitored transect

Observation date	Mean sediment concentrations (mg/l)	Temperature range (C°)	Salinity range (‰)	Mean water density ( $\sigma_t$ )
October 20, 1975	11.8	23.3-25.3	24.7-29.0	17.9
January 19, 1976	25.6	13.0-13.5	29.2-29.9	22.0
May 11, 1976	18.5	23.0-25.0	28.4-32.4	19.9
June 7, 1976	25.0	27.0-28.0	27.4-30.2	18.4
August 9, 1976	14.7	25.0-29.0	21.2-36.5	18.2
February 14, 1977	17.6	10.5-13.5	14.3-30.2	17.1

TABLE 2.--Results of t-statistic tests for comparisons of the monitored transect's water column in terms of mean sediment concentration and mean density during the six observation dates

Compared observations	Mean sediment concentration (mg/l)	Mean water density ( $\sigma_t$ )
Oct. vs Jan.	2.81*	16.45*
Oct. vs May	1.35	5.47*
Oct. vs June	3.40*	1.37
Oct. vs Aug.	0.68	0.17
Oct. vs Feb.	2.44*	0.93
Jan. vs May	0.98	7.08*
Jan. vs June	0.09	15.81*
Jan. vs Aug.	1.61	2.77*
Jan. vs Feb.	1.39	5.85*
May vs June	1.14	4.39*
May vs. Aug.	0.64	1.27
May vs. Feb.	0.18	3.24*
June vs. Aug.	2.04	0.14
June vs Feb.	2.04	1.46
Aug. vs Feb.	0.73	0.65

\*Significant difference at the 0.05 level of confidence (d.f. = 11,  $t_{0.05} = 2.20$ )

TABLE 3.--Discharge characteristics of the Nueces River during the field observation dates

Observation date	Water volume (m <sup>3</sup> /sec)	Sediment Concentration (m <sub>g</sub> /l)	Sediment influx rate (gm/sec)
Oct. 20, 1975	2.9	27.7	80
Jan. 19, 1976	1.3	18.4	24
May 11, 1976	73.0	102.8	7,504
June 7, 1976	5.0	70.4	352
Aug. 9, 1976	36.5	76.0	2,774
Feb. 14, 1977	9.3	32.4	301

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