OBSERVATIONS ON THE DISTRIBUTION AND ECOLOGY
OF SALT MARSH AND MARINE PLANTS,
LIGHTHOUSE AREA, HARBOR ISLAND
TEXAS GULF COAST

by

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INTRODUCTION

The purpose of this study is to describe in detail the distribution of salt marsh and marine plants in a small area on the Texas Gulf Coast and to relate the distribution to observable physical and biological habitat factors. The study spans only the months of June and July 1966, and the results of observations and mapping during other seasons and years would be somewhat different, especially with the small scale (1 inch equals 100 feet) chosen for mapping. With this limitation in mind, I have attempted to establish hypotheses governing the distribution of plants in the area.

A study is still in progress in which soil salinity (pore water salinity), water content, and sand to mud ratios of 80 sediment samples from this area are being measured. The samples were collected on eight short traverses across ecotones; plant abundances and average heights were recorded on the traverses. A graphic representation of this material is presented in figures 10-17, showing the data exclusive of sand to mud ratios. A statistical treatment of the values obtained on these traverses may suggest more consistent ecologic relations of plant abundances and average height to the measured habitat factors.

I wish to thank John Thompson and Reese Brown of the University of Texas Institute of Marine Science at Port Aransas, Texas for their cooperation in providing transportation. I would also like to acknowledge the invaluable aid of Sandra B. Hoover—my wife, and Eddie Royce Killian—a friend, who served as field assistants and critics during the two month period of field observations.
LOCATION AND PHYSIOGRAPHIC SETTING

Harbor Island (Fig. 1), located near the town of Port Aransas, Texas, is a tidal delta. It consists of sediment deposited on the landward side of Mustang and St. Joseph islands by tidal currents through Aransas Pass and earlier tidal inlets nearby. Of the channels distributing tidal currents that now form boundaries of the island or transect it, Lydia Ann Channel and Corpus Christi Bayou are the only ones which have not been significantly modified by dredging. Corpus Christi Channel is located near the site of a natural channel shown on early navigation charts (Chart No. 210, Aransas Pass, 1900 Ed.).

The position of the tidal inlet, now Aransas Pass, changed considerably before stabilization by jetties. At various times Middle Pass and North Pass were open, and the active tidal inlet for any period of time migrated seasonally, reflecting changes in predominant northward or southward longshore drift (Price, 1952). The tidal inlet in this area has migrated up and down St. Joseph Island over a distance of two miles, its present position being approximately its most southerly.

Harbor Island in the area of this study consists predominantly of shallow submerged grass flats on the western side of the island; these extend east from Corpus Christi Channel and South Bay approximately one mile to a narrow band of subaerial salt marsh dissected by tidal creeks. The salt marsh extends as a long narrow strip 1000 to 2000 feet wide, from an abandoned lighthouse on Lydia Ann Channel north to the southern
Figure 1. Index Map.
end of Quarantine Shore, where the strip of salt marsh is modified by high (one to six feet) shell storm ridges. Behind the storm ridges of Quarantine Shore lie extensive algal flats. There is only patchy, discontinuous salt marsh vegetation in this area. Many remnants of salt marsh physiography, such as tidal creeks blocked by shell ridges, are present, suggesting a sequence of development from salt marsh as the earliest subaerial type of physiography on the tidal delta to its modification by the development of shell storm ridges. In this area shell is derived primarily from Aransas Bay; it accumulates along the northeastern shoreline of Harbor Island as a result of northerns and is redistributed by currents and waves generated by other types of storms.

The mean tide range near Harbor Island is one-half foot, except in the vicinity of Aransas Pass. Although astronomical tides are minor in importance, wind tides have a considerable effect. Under conditions of flood tide and southeast winds in Lydia Ann Channel, water level may be raised as much as a foot above the normal astronomical tide level in Aransas, Redfish, and South bays. The effect of wind on tidal currents in Aransas Pass has been well documented (Shepard and Moore, 1960), and maximum tidal currents of 1.2 knots have been measured with wind reinforcing the astronomical tidal current. Flood tide currents, somewhat diminished as water is distributed among Corpus Christi, Aransas, and Lydia Ann channels, are still detectable in these channels and have a marked effect on the distribution of plants in both the submerged and exposed areas near them. Tidal currents in small tidal creeks in the area of this study maintain clear channels with hard sand and shell bottoms.
LIGHTHOUSE AREA PHYSIOGRAPHY

The area discussed in this report is located one-half mile north of the abandoned lighthouse on Lydia Ann Channel (Fig. 1). It was chosen for study because it is representative of the marsh physiography and vegetation along Lydia Ann Channel, it has a wide variety of physiographic units, it has striking zonations of plant types, and it is relatively unmodified by man's activities.

The Lighthouse Area consists of four basic physiographic divisions: marsh islands, tidal creeks, channel grass flat, and bay grass flat. Within each of these (except the bay grass flat, which is remarkably uniform), there are several subdivisions.

MARSH ISLANDS

Marsh islands are land bodies that are irregular in plan and saucer-shaped in profile, surrounded by tidal creeks, oyster ponds, and larger water bodies (Lydia Ann Channel and shallow bay waters). Highest elevations occur around their edges where there are low natural levees and shelly-sand mounds (probably swash bars). The centers of the marsh islands are slightly lower than the natural levees and consist of extensive, fairly uniform, vegetated flats interspersed with algal flats, low sand mounds, and oyster ponds. Marsh islands range in elevation from approximately mean sea level (Plate 1) to 0.8 feet above mean sea level. Their average elevation is approximately 0.5 feet above mean sea level. From mid-June through early July the marsh islands were partially inundated at high tide, leaving only natural levees and low sand mounds exposed. On at least one
occasion, the inundation was unrelated to astronomical tides; flooding occurred as a result of strong easterly winds accompanying thundershowers. Water level rose approximately one-half foot after strong winds blew across Lydia Ann Channel for approximately two hours. It subsided almost as quickly when the winds assumed a more southerly direction and diminished in velocity. Complete inundation of the marsh islands is relatively rare; it has been observed only once during the field season when heavy rains occurred in late April and early May of 1966. Water in the bays rose to approximately two feet above mean sea level, the highest point on the islands being covered by 1.5 feet of water. Although an infrequent occurrence, the inundation of the area by bay water reduced in salinity may have a profound influence on the vegetation, although no immediate effects were observed. Flooding by Gulf water occurs as a result of hurricanes in late Summer and early Fall and the abnormally high tides accompanying them. (This occurred once in 1966 when hurricane Inez neared its landfall in northern Mexico and tides were two to three feet above normal at Corpus Christi.)

TIDAL CREEKS

Two major tidal creeks transect the area. They are complex creek systems with tributaries, shoals, and small islands. The tributaries of the major creek system spread out to form shallow oyster ponds. One of the creeks, the one farther to the north (Plate 2), is no longer connected to shallow bay water to the west. It has been blocked at least since 1934, as shown by 1934 aerial photographs. In contrast to the stability of the inactive creek, examination of several sets of photographs taken between
1934 and 1961 shows that the major active creek system has been simplified considerably in recent years by filling of tributaries, loops, distributary channels, and other complexities, resulting in the confinement of water to a single major channel, the present active channel.

The active channel and its tributaries form the major avenues of water exchange between Lydia Ann Channel and shallow water of South and Redfish bays. The nearest open channel to the south is artificial Aransas Channel (1.6 miles); the nearest one to the north is a tidal creek 0.6 miles away.

The active channel is approximately 5.5 feet deep near its entrance to Lydia Ann Channel (Plate 1). From this maximum depth the channel shoals in both directions. Toward Lydia Ann Channel, the depth of the creek becomes slightly shallower over a low-relief channel mouth bar. Water depth over the bar is between three and four feet.

West of the deepest point the channel depth gradually becomes shallower to the point of entry of the westernmost major tributary. Here the overall channel depth becomes much shallower and a narrow thalweg meanders between grass-covered shoals and oyster shoals. Halfway between the tributary and the bay mouth of the channel, the channel system breaks down into a series of disconnected, scoured pockets separated by interconnected grass-covered shoals. At the bay mouth, the channel bifurcates to form a simple distributary system around a partially submerged delta. The two distributaries have grass bottoms, and are partially blocked by oyster bars.
Only in the deeper part of the channel, from the westernmost tributary to the mouth at Lydia Ann Channel, is the flow of water relatively unimpeded by shoals and grass. In this reach, there is a hard sand and shell bottom flanked on both sides by mud shoals or banks rising steeply from the relatively flat bottom.

The inactive channel is somewhat simpler, its deepest point being slightly west of a channel mouth bar at Lydia Ann Channel. Westward from the deepest point, the channel gradually becomes shallower and meanders between submerged grass-covered shoals. At its western end, the channel is filled with mud that supports clumps of oysters (Fig. 2). Beyond this point, the previous course of the channel is marked by a line of Spartina bordered by two hedgerows of Avicennia.

**CHANNEL GRASS FLAT**

The grass flat in Lydia Ann Channel extends from the edge of vegetation on the marsh islands into channel water approximately four feet deep. The grass flat is a gently sloping surface unbroken in its grass coverage except for small bare pockets and larger areas near the mouths of tidal creeks and small unvegetated sand bars near the marsh islands.

**BAY GRASS FLAT**

In contrast to the channel grass flat, the bay grass flat begins approximately 300 feet bayward from the west side of the marsh islands. It extends westward to Corpus Christi Bayou in water between one and two feet deep.
Fig. 2. Western end of inactive tidal creek, showing mud fill with oyster clumps. *Avicennia* in foreground delineates natural levee. Extensive algal flat appears in background, *Batis-Salicornia* community to left.
PLANT DISTRIBUTION

The distributions of species of plants were mapped by plane table at a scale of 1 inch equals 100 feet; these are illustrated in Plate 2. With the exception of the Batis-Salicornia community-type, the plants were not grouped into communities. If one were to convert this distribution map to a map of community-types, the following would be included: Monanthochloë, Batis-Salicornia, Spartina-Avicennia, Ruppia, and Diplanthera. For the purposes of this study, however, the grouping of plants into communities obscured three important relationships: the association of Avicennia with natural levees (and the more significant divergence from that association), the relationship of the distribution of Salicornia perennis to elevation, and the mixing of Diplanthera and Ruppia.

MARSH ISLAND PLANTS

The following plants are found on the marsh islands:

- Spartina alterniflora
  - Smooth cordgrass
- Avicennia nitida
  - Black mangrove
- Batis maritima
  - Maritime saltwort
- Salicornia perennis
  - Woody glasswort
- Salicornia bigelovii
  - Bigelow glasswort
- Monanthochloë littoralis
  - Shoregrass
**Spartina alterniflora**

*Spartina alterniflora*, a tall, thick-leaved marsh grass, is found throughout the area in a narrow zone outlining the marsh islands. The zone extends in elevation from approximately mean low water (0.6 feet below mean sea level) to mean sea level. It varies in width from one foot or less to 100 feet. It is generally narrow along Lydia Ann Channel and along tidal creeks with natural levees; it reaches its widest extent on the bay side of the marsh islands. The grass is usually very dense and the boundaries of the zone are sharp (Fig. 3), although there is some mixing of plants —*Batis, Salicornia perennis*, and *Avicennia*—on the landward side of the zone. Average height of the grass near Lydia Ann Channel is between three and four feet; average height on the bay side of the marsh islands is between 3.5 and 4 feet, with some luxuriant stands averaging four feet in height.

*Spartina* grows in muddy sand along Lydia Ann Channel and sandy mud along tidal creeks and around oyster ponds. The sediment is usually very soft because of large populations of burrowing *Uca* crabs and worms.

*Spartina* occurs at the lowest elevation of any of the marsh plants. On Lydia Ann Channel it is mixed over a narrow band with *Diplanthera*, a submerged marine grass. Its substrate and roots are nearly always submerged in sea water with salinity of about 32 o/oo in the Summer. The ability of this grass to derive its nutrients from sea-water saturated substrates and its long flowering period from early August through September make it one of the hardiest and most persistently recurring plants in the area. High tides and waves accompanying storms do not easily disturb its thickly
Fig. 3. Inactive tidal creek outlined by *Spartina alterniflora*. *Avicennia* delineates natural levees. *Batis-Salicornia* community occurs in left foreground and background.
matted root system or thick, flexible leaves. The conditions under which it cannot grow are created by its sediment trapping ability and the resulting higher land surface. Apparently the plant cannot survive where the substrate goes through frequent cycles of drying and wetting, but must have a saturated or nearly saturated substrate all the time.

An unusual event during the Summer of 1966 caused retreat of the outer edge of the Spartina zone on Lydia Ann Channel as much as 15 feet behind its position in late Spring. Large quantities of Sargassum accumulated along the western bank of Lydia Ann Channel and formed a thick mat of decaying vegetation mixed with sediment that created unfavorable conditions for the growth of Spartina.

Under normal conditions, and assuming uniform rates of accumulation of sediment throughout the Spartina zone, its width measured perpendicular to shorelines should remain relatively constant. As deposition occurs at the outer edge of the zone, Spartina will be able grow farther out from the original shoreline. At the same time, sediment is accumulating on the landward side of the gently sloping surface of the zone. As more and more sediment accumulates, the substrate will eventually be elevated above the zone of saturation by sea water and conditions on the landward side will become less favorable for the plants' growth. Thus, the entire zone migrates, maintaining a fairly constant width, if sediment accumulation is uniform over the width of the zone. Appreciable widening of the zone suggests more rapid accumulation of sediment on the outer edge over a period of years; this appears to be the case on the bay sides of marsh islands.
**Avicennia nitida**

The black mangrove occurs in this area as a low shrub with an average height of two feet (Fig. 4). Each plant has lines of pneumatophores extending out radially from the area of the central stem. Pneumatophores near the central stem are usually about one foot tall; their height decreases outward.

*Avicennia* occurs in a narrow zone that slightly overlaps the upper edge of the *Spartina* zone and extends down the landward flanks of natural levees (Fig. 5). *Avicennia* occurs on all natural levees, but its distribution is by no means limited to this occurrence. Scattered seedlings and mature plants may be found anywhere on the marsh islands.

The dense lines of *Avicennia* growing along natural levees suggests either preferentially favorable growth conditions or early establishment in these areas, or both. In some places, dense growths of the mangrove can be found in abandoned tidal creek channels that have been filled. Thus, higher elevations do not seem to be necessary for its survival. Moreover, the nonsystematic distribution of seedlings in most of the area suggests that the plant could grow nearly anywhere, and will eventually increase in density throughout the area.

* Batis maritima and Salicornia perennis

These succulent halophytes form the most extensive continuously vegetated expanses in the area. Except for a few pure stands of *Salicornia* near the bay sides of the marsh islands, *Batis* predominates over *Salicornia*. Ground coverage is dense (Fig. 6) and many areas are covered with a tangle of stems and exposed rhizomes.
Fig. 1. *Avicennia nitida*, the black mangrove, with lines of pneumatophores extending out radially from base of plant; *Batis-Salicornia* community in background.
Figure 5. Generalized profile showing typical distribution of plants in & near tidal creek.
Fig. 6. *Batis maritima*, showing typical dense coverage and predominance over *Salicornia perennis*. 
Where *Salicornia perennis* is most abundant or where it occurs in pure stands, it is usually near a shoreline of the bay or a tidal creek, and is usually slightly lower in elevation than areas covered by *Batis*. Although there are many exceptions to this relationship, it suggests a possible seral relation between *Batis* and *Salicornia*, with the latter plant first occupying areas slightly higher in elevation than the upper edge of the *Spartina*. Thus, *Batis* and *Salicornia* may be differentiated with respect to elevation at some early stage of development of the vegetated land surface. If this seral relation exists, then the sporadic occurrence and smaller numbers of *Salicornia* attest to the competitive superiority of *Batis*.

*Salicornia bigelovii*

The annual *Salicornia* is similar to *Salicornia perennis* in stem morphology, but differs in branching and root system. *S. bigelovii* has a central stem rising above a single taproot, whereas *S. perennis* has rhizomes and many nonbranching stalks rising vertically from the rhizome. At maturity the individuals of *S. bigelovii* range in height from 6 to 14 inches.

*Salicornia bigelovii* occurs as scattered individuals in the *Batis-Salicornia perennis* community, but is found in greatest abundance on algal flats. Small seedlings appear in early April (Fig. 7); the plants reach maturity by early June. In mid-July they began turning brown near the base and, by the beginning of September, had turned brown over their entire length. This change probably occurs as a result of *distribution of this plant was not mapped.*
Fig. 7. Seedlings of *Salicornia bigelovii* at edge of algal flat. Note remains of mature individuals from previous year. Dense clumps (left and background) are *Salicornia perennis*.
periodic evaporation of shallow, hypersaline, high temperature ponds
during late Summer.

**Monanthochloë littoralis**

The stems of this grass range in height from one to eight inches
and densely cover the ground with closely spaced clumps four to eight
inches in diameter (Fig. 8). Patches occur on high, sandy mounds that
have been thoroughly burrowed by *Uca* crabs. Elevation of the mounds
ranges from 0.5 to 0.8 feet above mean level.

Firm, sandy mounds near the bay sides of the marsh islands are
sometimes ringed by discontinuous patches of *Monanthochloë*. The unvege-
tated central portions of the mounds contain root fragments of *Monan-
 throchloë*, however, and one may infer that the plant covered the mounds
at one time. This consistent association of *Monanthochloë* with higher,
loose-sand mounds indicates that it only populates well drained, sandy
areas above the level of saturation.

**Blue-green Algal Mats**

Thin, leathery mats of blue-green algae form on flat areas that
are otherwise barren except for scattered clumps of *Batis*, *Salicornia*
perennis, and *Monanthochloë* (Fig. 9). The flats are sparsely populated
in the Spring by *Salicornia bigelovii*.

High salinity and high water temperatures seem to be favorable for
growth of algae in shallow, flat depressions. These conditions are probably
unfavorable for the growth of other plants that are found around the edges
of the algal flat; these conditions may be prohibitive for reproduction of
*Batis* and *Salicornia perennis*. During the Summer of 1966, the flowering
Fig. 8. Clump of Monanthochloa littoralis (in flower April 9, 1966) on high sand mound burrowed by fiddler crabs.
Fig. 9. Algal flat sparsely populated by Batis, Salicornia perennis, and Monanthochloa.
of these two plants corresponded with a month-long period of high tides and the maximum growth of algae on the submerged algal flats. If seeds were dispersed over the algal flats during this period of time, they may have been destroyed by dessication in the hypersaline water.

**MARINE GRASSES**

*Diplanthera wrightii*

*Diplanthera* occurs on grass flats in Lydia Ann Channel and shallow bay water west of the marsh islands; it is also found in the active tidal creek and its tributaries.

In Lydia Ann Channel, *Diplanthera* extends from the outer edge of the *Spartina* marsh into water approximately 4 feet deep. In deeper water (2.5 to 4 feet), it is found with rare individuals of *Halophila engelmanii*. Elsewhere along Lydia Ann Channel to the north, the *Diplanthera* grass flat is confined to shallower water, and grass flats of *Thalassia testudinum* extend from its edge into water approximately 5 feet deep. Where *Diplanthera* is exposed at low tide, the average stem length is two inches or less, and the grass has an ephemeral population, subject to leaf kill by repeated exposure at low tide during certain periods of the year (e.g., late July, early August 1966).

*Diplanthera* is found on muddy shoals in the active tidal creek. Here it is usually separated from the *Spartina* marsh by a few inches of unvegetated muddy sand. The grass covered shoals extend into water approximately 1.5 feet deep. The bottom of the active creek from the junction of its major tributary westward is covered by *Diplanthera*. Coverage in this reach is discontinuous between bare shoals, bare, scoured depressions,
and segments of channels. In some parts of the channel and tributary, it occurs mixed with *Ruppia maritima*.

An extensive grass flat on the bay sides of the marsh islands extends from the boundary of *Diplanthera* shown on Plate 2 westward to Corpus Christi Bayou. The grass is longer (avg. 4-6 inches) than that found in Lydia Ann Channel, and bottom coverage is much more dense. Water depth in this shallow bay grass flat is between one and two feet.

*Diplanthera* in the bay and tidal creeks is covered with algae that seems to be very sensitive to changes in tide level, tide range, and circulation conditions. It was observed in greatest abundance and extent in mid-July, near the end of a period of somewhat lower than normal tides.

*Ruppia maritima*

*Ruppia* is indiscriminately mixed with *Diplanthera* in the active channel and its major tributary. It occurs alone on mud shoals in the inactive tidal channel, where bottom coverage is dense and the plant attains its maximum length (about 12 inches).

Factors Affecting Distribution of Marine Grasses

Factors affecting the distribution of *Diplanthera* and *Ruppia* include water depth, temperature, salinity, and turbidity, and nutrient supply by currents. Of these, water depth and currents seem to be most critical in determining the distribution and relative dominance of the two plants in this area, inasmuch as the other factors seem relatively uniform over the area. Salinity in the active creek at high tide measured 32.1 o/oo (the same as Lydia Ann Channel at that time), and the inactive
creek at the same time had a salinity of 31.5 o/oo. Many more salinity measurements are needed along the lengths of the tidal creeks, at different stages of the tide cycle, and during different seasons, but it seems that salinity is not greatly different in the two tidal creeks where the distribution of the two submerged grasses is so markedly different. It is possible, however, that the salinity range in the two creeks encompasses the lower salinity tolerance limit of *Diplanthera* and the upper limit of *Ruppia*, in which case very small differences in salinity may produce very large differences in distribution.

The other factor that is quite different in the two creeks is circulation and, by inference, the nutrient and CO₂ supply. Currents flush the active tidal creek two or more times a day and there is free interchange of water from Lydia Ann Channel, probably the major nutrient source. Water in the inactive creek is never completely replaced during normal tide cycles; the creek is partially filled and partially drained from the Lydia Ann Channel side. It would seem, then, that the nutrient requirements of *Ruppia* are not as rigid as those of *Diplanthera*.

**ECOTONE TRAVERSSES**

To illustrate the sharpness of plant zone boundaries and the relationship of two habitat factors, soil salinity and water content, to plant distribution, the results of eight traverses are presented in graphic form in figures 10 through 18.

Plant abundances and average heights were measured in ten, six by ten inch rectangles laid end to end in a rope-ladder type grid. The grid was placed across visible plant zone boundaries in all cases, but location
along the boundary was determined randomly (by tossing a stick). Plants were counted in each of the ten rectangles and average height was estimated. Abundances are plotted on the graphs as the number of plants in each 60 square inch rectangle shown at a point on the graph representing the center of the rectangle. For plants with rhizomes, such as *Batis* and *Salicornia perennis*, individual erect stems were counted. The abundance of pneumatophores of *Avicennia* was taken as a rough measure of plant abundance and proximity to individual shrubs, except where small seedlings were enclosed by one of the rectangles. Basal sheaths of grasses enclosing several individual leaves were counted.

A sediment sample was taken from the center of each rectangle in the grid, using a plastic vial 2.5 inches long inserted into the substrate. Sample weights ranged from 40 to 100 grams. The sample was capped and taped to minimize water loss by evaporation. In the laboratory, the sample was weighed, oven dried for 24 hours, and weighed again to determine the weight loss by evaporation of water. From this, the weight percentage of water in the sample was calculated.

A normalized "salinity" of the sample was then determined by adding 50 ml of distilled water, mixing thoroughly, and measuring the salinity of the resulting solution with an optical salinometer. Assuming the error introduced by not including the volume of dissolved salts in the total solution volume (50 ml plus volume dissolved salts) is small, the total weight of dissolved salts can be calculated. Using this figure and the weight of water originally contained in the sample, the salinity of the pore water solution was calculated. Assuming all the salts in the substrate were dissolved, this figure represents the environmental factor the plants
would "detect" or respond to.

As mentioned earlier, this portion of the study will be expanded by statistical treatment and will eventually include the sand to mud ratio of the sediment as a third habitat factor.

VARIABILITY OF HABITAT FACTORS

Weight percent water ranges from 20 to 35%, the highest values occurring in loosely compacted mud sediments at the edges of tidal creeks (see traverse 1, fig. 10.). The possible range of water content of the sediments is from near zero to saturation. The value at which saturation occurs depends on porosity, which in turn depends on grain size, sorting, and compaction.

Pore water salinity ranges from 8 to 200 o/oo. The lowest figure occurs in traverse 5 near the edge of the Spartina zone on Lydia Ann Channel. The highest figure occurs in traverse 3 near a clump of Monanthochloa. The salinity of the water in the pore system depends on (1) the amount of water in the sample at the time it was collected, (2) the saturation history of the sample, i.e., whether it is subjected to constant saturation or repeated saturation and draining, and (3) leaching of salts from the sediment by rain water and fresh ground water draining from the islands through the sediment. Exceptionally high values are found in areas subjected to frequent wetting and drying by tide-changes. Exceptionally low values may be the result of leaching in an area of fresh ground water drainage or (a factor not evaluated in this study) of bacterial activity in stored samples. Testing of the former hypothesis could be performed by determining whether a minimum pore water salinity value exists at some relatively constant elevation around the marsh islands. The second could be tested by determining
salinity periodically on sets of duplicate stored samples.

Traverse 1 (Fig. 10)

This traverse begins at the crest of a natural levee on the inactive tidal creek (1-1), and extends toward the creek to the landward edge of the Spartina zone (1-10). The difference in elevation between the two end points is approximately one-half foot.

Pore water salinity is highest and water saturation lowest at the crest of the natural levees. The decrease in salinity and gradual increase in water saturation are accompanied by the appearance of Salicornia perennis, Avicennia, and Spartina, and a decrease in the abundance of Batis.

Traverse 2 (Fig. 11)

This traverse extends from an area populated by Batis (2-1) to the edge of an algal flat (2-10) with sparse Salicornia perennis. Elevation is approximately the same over the length of the traverse.

The general increase in pore water salinity represents an actual increase in the proportion of dissolved salts in this traverse, inasmuch as the weight percent pore water remains constant (about 23%). Pore water salinity remains at a high level in the algal flat and Salicornia areas. The high salinity values are probably due to evaporation of sea water in shallow ponds, and to the inefficiency of leaching in sediments with firmly bound, thin algal laminae at the surface.

Traverse 3 (Fig. 12)

This traverse begins in a slightly elevated clump of Monanthochloa and Batis (3-1 through 3-5), extends across an unvegetated flat (3-6 through 3-8), and ends in Batis (3-9, 3-10).
TRaverse 1

Figure 10

Plant Abundance vs. Average Height (in)

Salicornia perennis

Pneumatophores of Avicennia nitida

Spartina alterniflora

Sample Numbers & Position in Traverse

Weight Percent H2O vs. Pore Water Salinity (%)

Batis maritima
Values of pore water salinity are higher in this traverse than in any other (100-196 o/oo); as in the previously discussed traverse, the differences are actual differences in amounts of dissolved salts. The highest values (130-196 o/oo) correspond with a lack of vegetation in 3-5 through 3-7, but Batis occurs in the last two rectangles (3-9, 3-10) with salinity values of 138 and 196 o/oo.

Traverse 4 (Fig. 13)

This traverse begins on the Lydia Ann Channel grass flat and extends to the crest of a small sand bar, to within a few feet of the outer edge of the Spartina zone.

The decrease in water depth correlates with a decrease in the abundance of Diplanthera. Pore water salinity decreases at the end of the traverse (12 o/oo), and in the next traverse shoreward (traverse 5), the minimum of 8 o/oo occurs in rectangle 5-1. The two traverses are not contiguous; they are separated by a distance of 10 feet, with traverse 5 beginning in the small, shallow lagoon behind the bar.

Traverse 5 (Fig. 14)

This traverse extends into the Spartina zone. Diplanthera begins in moderately great abundance in the shallow lagoon and decreases in abundance landward as Spartina increases slightly. These changes are accompanied by a gradual increase in pore water salinity from a minimum for all traverses of 8 o/oo to 25-30 o/oo.

Traverse 6 (Fig. 15)

Traverse 6 is contiguous with traverse 5, extending farther shoreward into the Spartina zone. In rectangles 6-5, 6-6, 6-9, and 6-10, no living
TRAVERSE 5

FIGURE 14

PLANT ABUNDANCE

Diatomatae

Weight percent H₂O

Pore water salinity (per.)

Sample number & position in traverse

Spartina alterniflora
vegetation was found, due to the occurrence of a thick mat of decaying *Sargassum*. Except for changes in the abundance of *Diplanthera*, all the other changes observed can be attributed to the occurrence of this mat.

**Traverse 7 (Fig. 16)**

This traverse is contiguous with Traverse 6; it extends across the *Spartina* zone and up onto a slightly elevated swash bar with *Batis* and *Salicornia*.

A decrease in the abundance of *Spartina* and the appearance of *Batis* and *Salicornia* are accompanied by a sharp increase in pore water salinity and a gradual decrease in amount of water.

**Traverse 8 (Fig. 17)**

This traverse was chosen in the area populated by *Batis* and *Salicornia* to determine if any of the measured habitat factors could be related to their apparently nonsystematic mixing. The results are inconclusive.

**General Summary**

Although good correlation of habitat factors and plant abundances are shown in traverses 1 and 7, the results are not comparable between the two traverses. For example, the appearance of *Batis* and *Salicornia* is accompanied by an increase in pore water salinity in traverse 7, and by a decrease in traverse 1. In both instances the higher values of salinity correspond with higher elevations (natural levee in traverse 1, swash bar in traverse 7). Many other inconsistencies may be found by comparisons among the traverses.
TRAVERSE 7

FIGURE 16

PLANT ABUNDANCE
AVERAGE HEIGHT (IN)

Salicornia perennis

Batis maritima

Spartina alterniflora

SAMPLE NUMBERS & POSITION IN TRAVERSE

WEIGHT PERCENT H₂O
POROUS WATER SALINITY (%)
More meaningful results in studies of this sort may be obtained by
(1) evaluating the effect on the salinity of bacterial activity during
storage of samples; (2) information collected day by day over a period of
several months on frequency of inundation and levels of inundation;
(3) meticulous attention to sediment sampling so that samples are collected
without compaction and attendant loss of pore water; (4) repeated sampling
at different levels of tides, after rains, after long dry spells; (5) sea-
sonal sediment sampling and plant counts; and (6) repopulation studies on
sampled traverses.

SEDIMENTOLOGIC SIGNIFICANCE
OF PLANT DISTRIBUTION

The effectiveness of plants, especially submerged marine grasses,
in the entrapment of sediment particles was brought to the attention of
geologists by Ginsburg and Lowenstam (1958). Since publication of their
work, vegetation has been the object of more detailed studies in Recent
environmental complexes. The present study was undertaken on the premise
that the plants in this area constitute primary facies determinants, that
they greatly affect the present distribution of sediment types, and have
been largely responsible for the course of physiographic development of the
tidal delta.

On a large scale, the effects of vegetation on the island can be
inferred from the stability of the area over a period of 32 years.
Examination of aerial photos of the area since 1934, one set of which was
taken within 10 days after hurricane Carla in 1961, shows no detectable
effects of storms over the major portion of the area. The changes that
do take place seem to be confined to tidal creeks; their courses do not
change appreciably, but they may be scoured to somewhat greater depths, shapes of the channel mouth bars are probably changed, and the creeks carry a large suspended sediment load for several days after storms.

Vegetation protects marsh islands from erosion by tidal currents, waves, and surge tides associated with storms. Vegetation serves as a sediment trap for suspended sediment in receding tide waters both under normal tide conditions and during storm tides that carry large amounts of sediment in suspension.

Drainage across the present salt marsh area is confined to relatively few, small channels because of vegetation. If the area were unvegetated, drainage would be more efficient and would probably be accomplished by large, interconnected channel systems that would change position with every tide cycle.

Dense vegetation along tidal creeks has the effect of providing bank cohesiveness. This confines the tidal waters to steep-sided, comparatively deep channels that tend to meander. Migration of meanders does not occur by the usual processes, however, if it occurs at all. There is evidence in this area that both inside and outside bends of meander loops receive sediment, possibly as a result of better nutrient supply and more luxuriant growth of epiphytes on submerged plants at the outside bends, and the normal process of deposition due to reduced current velocity on inside bends. Whatever the specific causes and processes involved, the courses of tidal creeks in the area appear to be controlled entirely by vegetation.

The effect of submerged grasses on sedimentation has been emphasized.
by Ginsburg and Lowenstam (1958). *Diplanthera* serves as a sediment binding agent with its rhizomes and dense mat of rootlets. Its leaves serve as current baffles that reduce current velocity near the sediment interface and allow suspended sediment to settle out. In addition to these functions, the grass leaves also serve as favorable substrates for the growth of filamentous algae that are capable of trapping particles as large as fine sand size.

Small scale effects are equally as important to the geologist interpreting cores of Recent sediments and ancient sedimentary rocks as are large scale effects. These include the destruction of primary sedimentary structures by root growth and the production of complex root mottles. The growth of plants in the Lighthouse area precludes the possibility of interpreting cores in vegetated or once vegetated areas on the basis of primary sedimentary structures. On the other hand, root mottles of *Avicennia* are preserved as important secondary bioturbation structures in cores. Mottles produced by the present plants extend down as far as a foot below the surface. In addition to this, root fragments of some of the grasses (*Diplanthera, Spartina, and Monanthochloa*) can be found in cores and used as interpretive tools if principles governing their present distribution are well known. The coarse, woody roots, rhizomes, and stems of *Batis* and *Salicornia* are also distinctive in Recent cores. Algal mats in this area are infrequently preserved below the sediment surface because of burrowing by *Uca*. Algal mats can be preserved, however, and constitute an important and easily recognizable depositional facies in many areas of the Gulf Coast.

The present processes of growth of the tidal delta are intimately related to vegetation. The filling of tidal creeks occurs primarily as a
result of stabilization of the bottom by Diplanthera and the banks by Spartina. This is well illustrated by the shallow, western portion of the active tidal creek in the Lighthouse area. Bottom currents are greatly impeded by the grass leaves, and by interconnected grass clumps between disconnected channel segments.

A tentative hypothesis has been formulated regarding the method of growth of the island, although its verification will require more study. It appears that the present method of growth is by slow accretion on the bay sides of marsh islands, with stabilization by Spartina. Tidal currents carry suspended sediment to the bay side of the marsh islands where it is deposited in the shallow, unvegetated area behind the marsh islands, in the bay grass flat, and in the Spartina zone. The sediment deposited in the unvegetated flat (if any is actually deposited there) is the only sediment that is free to move again when ebb tide currents begin draining the bay. The sediment deposited in the Spartina zone is trapped and, as mentioned earlier, allows the Spartina to extend farther out into the bay. This process is not important on the Lydia Ann Channel sides of marsh islands because of continuous sweeping of the banks by fairly swift tidal currents.

CONCLUSIONS

1. Zonations of plants observed and mapped in the Lighthouse area, Harbor Island, can be correlated with elevation and the attendant factors of frequency of inundation by tides, sediment pore water salinity, and water saturation.

2. The physiographic subdivisions of the area—marsh islands, tidal creeks, channel and bay grass flats—are, in essence, vegetation subdivisions,
and the present physiography is closely related to the development of patterns of plant distribution.

3. The sedimentologic significance of plant distribution in this area is far-reaching and determines to a large extent the distribution of facies types in the area.
REFERENCES


Shepard, F.P., and David G. Moore, 1960, Bays of Central Texas Coast, in Recent Sediments, Northwest Gulf of Mexico, Shepard, et al. (ed.), p. 117-152.