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Final

"The use of *Juncus* and *Spartina* Marshes by Fishery Species in Lavaca Bay, Texas, with Reference to Effects of Floods"

By

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ABSTRACT

Coastal _Spartina_ marshes, deltaic _Juncus_ marshes, and subtidal substrate without vegetation were compared in Lavaca Bay for usage by aquatic fauna. Samples were at the coast and the delta during spring, summer and fall seasons, under salinities ranging between 13 to 30 ppt. In general, the delta and coast were used similarly. Abundant species at each location, particularly fishery species, were present or abundant at the other location. Only a few rarer species did not use both areas. Accordingly, the densities of penaeid shrimps, blue crabs and economically important fishes were usually not significantly different between the coast and the delta. But within locations abundances were usually significantly higher in marsh as compared to subtidal microhabitat. Variations in distributions and abundances were attributed more to seasonal differences in marsh inundation and animal recruitment patterns than to coastal or deltaic locations.

In a related study, the effect of freshwater flooding on utilization of delta marshes was examined. Animal densities before and after floods in the fall of 1986 and the spring of 1987 were compared. After the first two floods (October 1986 and May 1987), salinities returned to background levels within a week. After the third flood, in late May and early June 1987, background salinities of 5 to 18 ppt declined to 0 ppt for at least 2 weeks. In most instances, the floods did not cause densities of decapod

crustaceans and fishes in marsh and subtidal microhabitats to change. Where significant changes did occur, the effect was usually negative for decapod crustaceans and positive for fishes. The mere presence of estuarine crustaceans and fishes after Flood 3, where salinities decreased to near zero, suggested a high degree of physiological tolerance to freshwater flooding. These results suggest that short term lowering of salinity does not deter estuarine animals from using deltaic marshes, but rather it may be longer term habitat changes that cause such responses.

INTRODUCTION

Purpose.

The purpose of this paper is to characterize usage of saline coastal and brackish deltaic habitats by estuarine aquatic species. Estuarine marshes are the focus of the study. Two objectives have been addressed in two separate studies. The first objective was to compare densities of fishes and decapod crustaceans from *Spartina* salt marshes and adjacent nonvegetated bottom with *Juncus* delta marshes and adjacent nonvegetated bottom. This was done by comparing locations in Lavaca Bay, Texas, near the coast with those at the delta in the upper bay. The hypothesis was that coastal and deltaic locations, under mesohaline salinity conditions, would be utilized similarly by estuarine aquatic fauna, and particularly by fishery species. The second objective was to characterize the impact of freshwater flooding on utilization of brackish deltaic habitat. This study was conducted on the lower Lavaca River. The hypothesis was that densities of estuarine species after flooding, and temporary lowering of salinity, would be similar to those before flooding.

Marsh Utilization.

Salt marshes have long been deemed important to estuarine aquatic animals (see general reviews by Teal 1962; Daiber 1977 and 1982; Thayer et al. 1978; Montague et al. 1981). The pervasive view has been that salt marshes are valuable for export of organic matter to fuel estuarine and near shore food chains (Odum 1980). Salt marshes have not been considered particularly important as habitat directly utilized by estuarine aquatic species. This is largely because it is an intertidal habitat with limited aquatic accessibility. But some evidence has supported direct utilization. Aquatic grass shrimps, such as, Palaemonetes pugio, and killifishes, such as, Fundulus heteroclitus are well known associates of salt marshes (Welsh 1975; Morgan 1980; Kneib and Stiven 1982). Moreover, Bell and Coull (1977) and Bell (1980) inferred significant predation by estuarine macrofauna on salt marsh meiofauna; Parker (1967) and Weinstein (1979) showed that shallow waters next to intertidal marshes have large numbers of juveniles of estuarine species; and, Turner (1977) demonstrated a relationship between production in offshore shrimp fisheries and area of intertidal marsh inshore.

Until recently the degree of direct utilization of salt marsh surfaces had not been known. A Texas salt marsh was the first in which direct utilization by estuarine macrofauna was quantified (Zimmerman et al. 1984; Zimmerman and Minello 1984). The inundated marsh surface was extensively used by decapod crustaceans and fishes and that were transient juveniles of economically important species. Juveniles of brown shrimp (Penaeus aztecus), blue crab (Callinectes sapidus), red drum (Sciaenops ocellatus) and spotted seatrout (Cynoscion nebulosus) had greater densities on the marsh surface than in nonvegetated open water at the marsh edge. In addition, juveniles of white shrimp (Penaeus setiferus), southern flounder (Paralichthys lethostigma), and Atlantic croaker (Micropogonias undulatus) were as abundant in the marsh as in open water. The only economically important species that were more abundant in subtidal open water were spot (Leiostomus xanthurus), Bay anchovy (Anchoa mitchilli), Gulf menhaden (Brevoortia patronus) and striped mullet (Mugil cephalus).

Use of oligohaline marsh areas by estuarine species has received very little attention. In North Carolina, Rozas and Hackney (1983 and 1984) found many decapod crustaceans and fishes common to salt marshes in creeks associated with oligohaline marshes. In Virginia, McIvor and Odum (1986) confirmed that high numbers of estuarine grass shrimp (P. pugio), mummichog (F. heteroclitus) and blue crab used a freshwater tidal marsh surface. These occurred together with a freshwater community including banded killifish (F. diaphanus), bluegill (Lepomis macrochirus), pumpkinseed (L. gibbosus), mosquitofish (Gambusia affinis), tessellated darter (Etheostoma olmstedi) and spottail shiner (Notropis hudsonius) as prominent members. Among 24 nektonic species in the community, 7 had estuarine affinities. Degree of exploitation of the marsh surface appeared to depend at least partially on the location and quality of nearby subtidal habitats (Rozas and Odum 1987; McIvor and Odum 1988).

Differences in utilization between riverine and saline types of marshes has not been examined previously. One question of economic importance is whether utilization by fishery species differs depending upon marsh type and/or salinity regime. Our study has addressed this question by comparing salt marshes and delta marshes within a bay system.

Influences of Freshwater on Marsh Utilization.

Salinity has been identified as a primary factor in determining distributions of estuarine organisms (Remane and Schlieper 1958; Gunter 1961 and 1967). Most of the observed patterns are cited as a response to low salinity limitations. This is because of physiological requirements for accommodating low salinities. Hence, low salinity areas in the upper reaches of estuaries are not considered to be of much direct value for estuarine species. But, it is also known that most estuarine animals tolerate broad ranges of salinity. In addition, distributions observed in nature often conflict with lower tolerance limits reported in the laboratory. This leads to relationships of faunal abundance to salinity that are footnoted with numerous exceptions. It has also led to much confusion in interpreting the value of various salinity conditions for estuarine species.

Freshwater floods, for example, are often considered to have negative effects by displacing estuarine animals or causing their mortalities. However, an examination of recent evidence suggests that flooding does not always have such adverse effects. The studies noted earlier (Rozas and Hackney 1983 and 1984; McLvor and Odum 1986 and 1988; Rozas and Odum 1987) show that prominent estuarine animals such as grass shrimp, blue crab and killifishes can exist side-by-side with freshwater species. Moreover, Rogers et al. (1984) reported that abundances of fishes, such as Atlantic croaker, southern flounder, silver perch, spot and Atlantic menhaden, either increased or were unaffected in a Georgia estuary during high river discharges. Furthermore, fishery harvests of estuarine dependent species in the Gulf of Mexico are positively related to river discharges (Deegan et al. 1986). These investigations indicate an acceptance of low salinity situations by many, if not most, estuarine species. One way of testing acceptance or ability to accommodate low salinities is to compare faunal abundances before and after floods. We have taken this approach in our study that examines utilization of delta marshes.

METHODS

Study Sites.

In 1985 and 1986, densities of aquatic fauna from shallow water microhabitats were compared between sites at coast and delta locations in Lavaca Bay (Fig. 1). The coast sites were located in *Spartina* marshes of three secondary bays, Chocolate Bay, Keller Bay and Powderhorn Lake, each of which opened into the middle part of Lavaca Bay. Three comparable delta sites were located in *Juncus* marshes in the upper bay near the mouth of the Lavaca River. The delta sites influenced by modified riverflow due to an impoundment about 10 km upstream at Lake Texana. The sites near the coast were influenced by seawater flowing through Caballo Pass from the Gulf of Mexico . At both locations, intertidal marsh and the adjacent subtidal bottom were sampled as microhabitats. The subtidal bottom, adjacent to the marsh edge, was always barren of vegetation. These microhabitats were designated coast marsh, coast subtidal bottom, delta marsh and delta subtidal bottom.

During 1986 and 1987, two locations on the Lavaca River delta were studied for the effects of freshwater flooding on microhabitat utilization (Fig. 2). One was near the river mouth (designated lower delta) and the other was about 6 km upriver at Redfish Lake (designated upper delta). Animal densities were compared at these locations before and after floods. Samples were taken in the marsh and adjacent subtidal bare bottom as before. The microhabitats were designated lower delta marsh, lower delta subtidal bottom, upper delta marsh and upper delta subtidal bottom.

Field Procedures.

Drop sampling, described by Zimmerman et al. (1984), was used as the method of quantifying animal abundances on marsh surfaces and in adjacent subtidal habitats. This method employs a large cylindrical sampler (1.8 m dia.) dropped from a boom affixed to a small boat to entrap organisms in a prescribed 2.6 m^2 area. Once in place, the mobile fauna were collected using dip nets as water was pumped from the sampler into a 1 mm sq. mesh plankton net. When the sampler was drained, animals remaining on the bottom were picked up by hand. This method is highly effective in sampling decapod crustaceans and small fishes and is especially useful where trawls and seines cannot be used. Moreover, the technique improves on conventional methods because it quantifies densities (numbers/unit area) rather than giving relative abundances of organisms. It has been used in water depths of 1 meter or less in marshes, seagrass beds, mangroves, oyster reefs, and bare mud and bare sand bottoms.

In both studies reported here, four samples (covering 2.6 m^2 apiece) of each microhabitat were taken at each sampling site during each sampling period. Densities of decapod crustaceans and fishes were the basis for our analyses. The faunal samples were preserved in the field using 10% Formalin made up with seawater and Rose Bengal stain.

To compare the coast and delta, a balanced set of 4 samples from each microhabitat at each site was analyzed for the fall (Oct. 1985) and the spring (May 1986) seasons (total of 96 samples). The delta marsh was not inundated during the summer (Aug. 1986), creating an unbalanced data set without delta marsh samples. This summer set was analyzed separately, only using subtidal microhabitat to compare coast and delta locations. In addition to comparing marsh types between locations, small stands of delta Spartina and coast Juncus were compared within locations with the opposite (dominant) marsh type. These subsets consisted of 4 Spartina and 4 Juncus samples taken at a coastal site (Chocolate Bay) and a delta site (the Lavaca River mouth). The subsets were acquired during the fall and spring.

The second study was conducted at the Lavaca River delta to evaluate the effect of floods on utilization. An upper and lower delta site were sampled, consisting of 8 marsh and 8 subtidal samples per site, before and after each flood event. Data sets (64 samples) were taken regularly until a flood event caused salinities to be significantly lowered in delta marshes. Accordingly, five sets were divided among three high rainfall events, one in the fall of 1986 and two consecutive events in the spring of 1987 (320 samples overall). These floods, each with a "before" and "after" data set, were delineated Flood 1, Flood 2 and Flood 3. The fourth data set (late May 1987) served simultaneously as an "after" set for Flood 2 and the "before" set for Flood 3. Only during Flood 3, in late May and early June 1987, did salinities change over an extended period.

Other observations from samples included vegetation density and biomass, maximum and minimum water depth, temperature, salinity, dissolved oxygen and turbidity. Subsamples emergent plants were cut and placed in plastic bags, without preservation, for laboratory processing. Water depth was measured with a meter rule in cm (nearest 0.1). Water temperature (nearest 0.1 °C) and dissolved oxygen (nearest 0.1 ppm) were measured using a YSI Model 51B meter. Field salinity was measured using an American Optical refractometer (ppt). Water samples were collected from each drop sample in 500 cm^2 bottles to measure turbidity (HR Instruments Model DRT 15) and to check salinity with a Hydrolab Data Sonde at the laboratory.

Laboratory Procedures:

In the laboratory, fishes and crustaceans were sorted to species (using identifications based on taxonomic guides listed in Appendix I), then measured and counted. Fish were counted within

10 mm size intervals (1 to 10, 11 to 20, ...etc.) and decapod crustaceans were counted within 5 mm size intervals (1 to 5, 6 to 10, 11 to 15, ...etc). Marsh plants were identified and weighed wet (kg) soon after returning to the laboratory, then air dried for at least two months and weighed again, dry (kg). After drying, the number of culms in each sample were counted to calculate plant stem densities. All the data were hand written first onto standardized preprinted forms and then transcribed to microcomputer files using dBASE III Plus. After processing, faunal samples were stored in 5% Formalin or 70% ETOH. These will be kept in storage for at least 5 years from the date of collection. All field sheets, laboratory forms and data files will be kept at the NMFS Galveston Laboratory for at least 8 years.

Analytical Procedures:

We used factorial ANOVAs to test for differences in means between locations in both studies. The observation was faunal densities. Separate analyses were conducted for each abundant fish and decapod crustacean species and for selected groups of species eg., all fishes, all decapod crustaceans, economically important fishes, economically important decapod crustaceans and certain families. A 3-way ANOVA was used to test spring and fall data sets for differences in densities attributable to microhabitat, location, and season. The test was also extended to physical and vegetational measurements. The raw data were transformed for all tests, using log x + 1, to correct for heterogeniety of variances (see means and standard errors in Appendices). A 0.05 probability level was chosen to denote significant differences. All ANOVAs were executed on a micro-computer using SAS/STAT programs.

The main test of the first study was comparison of delta and coast locations. So, sites were considered replicates (3 at each location) and individual drop samples were considered subsamples (4 drops in each microhabitat at each site). This analysis was used to analyze the spring and fall seasons together. In the summer (August 19860, however, the delta marsh was not available for sampling; therefore, for ANOVAs within the summer season, we used orthogonal contrasts to evaluate differences in means between coast and delta sites using subtidal microhabitats, only.

In the second study, each flood event was treated separately in a 3-way ANOVA. Flood stage was the main factor (2 periods, before and after the flood), location a second factor (2 locations, upper and lower delta), and microhabitat the third factor (2 microhabitats, marsh and subtidal). Individual drop samples were treated as replicates (8 in each microhabitat).

Untransformed means and standard errors of physical measurements and faunal densities were tabulated by season by site and by microhabitat. These are given in the Appendices in tables prepared with Lotus 1-2-3. Graphics were done using ENERGRAPHICS and Sigma Plot. All data and analyses have been stored on standard 5 1/2 inch magnetic floppy disks using an IBM compatabile microcomputer.

RESULTS

Physical Environment.

Salinity Regimes and Floods. During our sampling in the fall of 1985 and the spring and summer of 1986, salinities in Lavaca Bay marshes ranged from mesohaline to polyhaline (Appendix IIA). Within locations, salinities did not differ significantly over seasons, but between locations were significantly lower at the delta than the coast (Table 1; Fig. 3). Nevertheless, salinities at delta *Juncus* marsh were relatively high, ranging between 13 to 25 ppt and overlapped with 15 to 30 ppt salinities of coastal *Spartina* marshes. The impoundment within 10 km of the mouth of the Lavaca River and low rainfall in 1986 may have promoted unexpectedly high salinities. As another factor, our sampling was baised to coincide with periods of higher tides, so this may also have contributed to higher values. Withstanding these biases, the relatively high salinities in delta marshes did coincide with observations of low river flow (from less than normal rainfall) and were supported by other measurements taken from continuous records of data sondes placed in the upper bay.

Rainfall did cause general flooding in the Lavaca River watershed during November of 1986, and May and June of 1987. Our surveys in delta marshes before and after floods showed that one of these events (June 1987) was large enough to change salinities over an extended period. But, during the fall flood (the 1st flood event), 8 inches of rainfall in one day (Oct.23, 1986 at Port Lavaca, Texas) did not effectively lower salinities. Before the event, on October 21 and 22 salinities were 14 to 15 ppt in lower delta marshes and 4 to 5 ppt in upper delta marshes. Following the event, on November 3 and 4, salinities were 12 to 13 ppt at the lower delta and 6 ppt at the upper delta. Similar rains in mid-May of 1986 (the 2nd flood event) also had no effect on lowering of salinities. On May 12 and 13, salinities were 7 to 9 ppt at the lower delta and 1 to 3 ppt at the upper delta. By May 25 and 26, following rains in the area, salinities had actually increased (presumably due the greater effect of high tides over riverflow), so that the lower delta was 14 to 16 ppt and the upper delta was 5 to 10 ppt. However, rainfall continued into June and flooding (the 3rd flood event) finally was effective enough to cause sustained lowering of salinities in delta marshes. During our sampling on June 11 and 12, lower delta salinities were 0.1 to 0.5 ppt and upper delta salinities were 0 to 1.4 ppt. The record of this salinity decline and the associated riverflow is in Figure 4.

<u>Water Depths and Other Parameters</u>. Subtidal water depths differed significantly between seasons (lower during the summer period), but not between coast and delta locations (Table 1; Fig. 3). However, it was apparent that coastal <u>Spartina</u> was lower than

in deltaic Juncus (Fig. 3). This was attributed to a characteristic higher elevation of delta marsh environments. As a result, Juncus was inundated by tides less frequently, for shorter periods and at shallower depths than Spartina. Seasonal periodicity of tidal heights in the northwestern Gulf of Mexico has a large effect on inundation patterns. Seasonal tides are high in the spring and fall and low in the summer and winter (Fig. 4). Under these circumstances, tidal flooding, especially in deltaic Juncus, was more frequent in the spring and fall. Low water in the summer and winter causes delta surfaces to be drained for extended periods. The effect of seasonal tides and elevation differences was apparent during our sampling in the summer of 1986. At this time, coast Spartina was inundated during the high tide but Juncus was not (Fig. 3). Notwithstanding, Juncus marshes were inundated by aperiodic river floods that continued for days or weeks depending upon the amount of rainfall. If river flooding coincided with high seasonal tides, as it did during May and June of 1986, inundation was prolonged.

Using subtidal values for spring, summer and fall, water temperatures differed significantly over seasons and between coast and delta locations (Table 1; Fig. 3). The overall range of mean temperatures (daylight hours only) was 24.2 to 28.6 ° C in the spring, 25.8 to 33.6 ° C in the summer, and 23.4 to 27.9 ° C in the fall (Appendix II).

Utilization of Coast Versus Delta Microhabitats.

All Fishes. During the initial study, 41 species of fishes were collected from *Spartina* and *Juncus* marshes at delta and coastal locations (Appendix III). Of these, 35 species were found at the coast compared to 27 at the delta. It is noteworthy that, although species overlapped extensively between the coast and delta, less than 50% of fish species were found at both locations at any one time (Fig. 6; Appendix III). However, most of those collected in both areas were species with large numbers of individuals, which always included economically important species. In both areas, species numbers were always higher in marsh than in adjacent subtidal microhabitat (Fig. 6).

A total of 1291 individual fishes were taken at the coast compared to 1613 at the delta, from 60 drop samples in each area. Including both microhabitats across seasons, mean densities were 8.3 fish / m^2 on the coast and 10.3 fish / m^2 at the delta. In our 3-way ANOVA using spring and fall densities, overall fish abundances had significant interactions for both season and location, and season and habitat (Table 2). In the spring, overall fish abundances were higher on subtidal bottom and not different between the coast and delta (Fig. 7). During the fall, the reverse occurred, abundances were higher in marsh and higher at the delta. These interaction effects appear to be largely due to gobies (in the fall) and menhaden (in the spring). Overall abundances of important game fishes did not differ between the coast and delta, but were significantly more abundant in marsh microhabitat at both locations (Table 2; Fig. 7). Likewise, abundances of the bay anchovy (a bait fish), were not different between the coast and delta, but, in contrast to game fishes, were significantly greater in subtidal microhabitat (Table 2; Fig. 7). In a similar manner, gobies were significantly more abundant in marsh microhabitat, while Gulf menhaden were more abundant over subtidal microhabitat. But, as noted above, both had strong interactions between microhabitat and season (Table 2; Fig. 7). Our comparison of *Juncus* and *Spartina* microhabitat within locations, showed there was no significant difference in overall fish densities, nor among any of the abundant fish groups, between the marsh types.

Seatrout, Flounder and Drum. In order of abundance, spotted seatrout, southern flounder and red drum each occurred at coast and delta sites (Fig. 8). Spotted seatrout were significantly more abundant during the fall and in marsh microhabitat, and did not differ in abundances between coast and delta sites (Table 2; Fig. 8; Appendix III). However, low numbers during the spring caused an interaction between microhabitat and season, and summer densities were restricted to subtidal bottom (Table 2; Fig. 8). Abundances of spotted seatrout also were not different between *Juncus* and *Spartina* within locations. Southern flounder were significantly more abundant in the spring, and did not differ between coast and delta sites nor marsh and subtidal microhabitats. Red drum numbers were considered to low to test, however, occurrence was in the spring, subtidal and equally divided between coast and delta sites (Fig. 8).

<u>All Decapod Crustaceans</u>. During the first study, 23 species of decapod crustaceans were collected from coastal and delta locations (Appendix III). Of these, 21 were at the coast compared to 17 at the delta. The abundant decapods, including prominent species of grass shrimps, penaeid shrimps, portunid and xanthid crabs, were found in both areas. Numbers of decapod crustacean species were always higher in marsh than in adjacent bare subtidal microhabitat (Fig. 9).

A total of 13,763 decapod crustaceans were caught at the coastal location compared to 6,627 at the delta in 60 drop samples from each area. Across seasons and microhabitats, the means were 88.2 decapods/m^2 on the coast and 42.3 decapods/m^2 at the delta. In our 3-way ANOVA using spring and fall densities, overall decapod crustacean abundances, unlike fishes, did not differ significantly between seasons, but did between microhabitats (higher in marsh). Like fishes, their overall abundances were not different between coast and delta locations (Table 2; Fig. 10; Appendix III). The two most abundant groups, grass shrimps and penaeid shrimps had significantly higher densities in the spring and in marsh microhabitat, and did not differ between coast and delta sites (Table 2; Fig. 10). Species with significant differences between coast and delta locations were the brokenback shrimp *Hippolyte zostericola*, the stick shrimp *Tozeuma carolinense* and the grass shrimp *Palaemonetes vulgaris*, all with significantly higher densities at the coast, and the mud crab *Neopanope texana* with significantly higher densities the delta (Appendix III). In comparing *Juncus* and *Spartina* within locations, densities of most decapod crustaceans were not different between the marsh types. The two exceptions were the blue crab, with significantly higher densities in *Juncus*, and the brokenback shrimp with significantly higher densities in *Spartina* (Appendix III).

Commercial Shrimps and Crabs. In rank order of abundance, brown shrimp, blue crab, white shrimp and pink shrimp were prominent both on the coast and the delta (Fig. 11; Appendix III). However, abundances varied significantly between spring and fall seasons for all, except white shrimp (Table 2). Thus, brown shrimp were more abundant in the spring, and blue crab and pink shrimp were more abundant in the fall (Fig. 11). Also, blue crab, white shrimp and pink shrimp abundances were not significantly different between locations. But, brown shrimp had significant interaction between season and location (Table 2), with more on the coast in the spring and more at the delta in the fall (Fig. 11). All four species were significantly more abundant in the marsh than subtidal microhabitat during the spring and fall (Table 2; Fig. 11). As noted before, marsh was largely unavailable in the summer. Among these important crustaceans, only blue crabs had different abundances between *Juncus* and *Spartina* microhabitats within locations; they were significantly higher in *Juncus*.

Effects of Floods on Delta Utilization.

All Fishes. Overall fish abundances increased significantly in delta microhabitats after floods on the Lavaca River in May and June of 1987, but not in October of 1986 (Table 3). Salinities did not decline after the October 1986 flood (Flood 1) and densities among prominent fishes, except Atlantic croaker, did not change (Table 3). In May of 1987 (Flood 2), salinities likewise did not change, but fish numbers increased significantly among gobies (skilletfish, naked goby), sheephead minnow and bay anchovy after the flood; all others did not change in densities. Salinity decrease was precipitous and relatively long lasting during the June 1987 flood (Flood 3; Fig. 4). Fish numbers afterward increased significantly in the marsh and on subtidal bottom at both the upper and the lower delta sites (Fig. 12). Among prominent species, densities of Gulf menhaden and sliver perch increased significantly, skilletfish and sheephead minnow decreased significantly, and all others remained the same after Flood 3 (Table 3). When changes did occur in fish numbers after floods, abundances were usually increased (Table 3). Differences in overall fish abundances between microhabitats did not occur in Floods 2 and 3, but fishes were significantly more abundant in marsh microhabitat in Flood 1 (Appendix IV).

Bay Anchovies and Gulf MenhadBay. anchovy and Gulf menhaden were the most numerous of delta fishes and were considered important for their value as prey. Both species tended to increase after river floods (Appendix IV; Fig. 13). These increases were significant for bay anchovy after Flood 2 and for Gulf menhaden after Flood 3 (Table 3). The dominance of both species was especially notable at the upper delta location (Fig. 13). Bay anchovy were significantly more numerous in subtidal microhabitat in Floods 1 and 3, while Gulf menhaden did not differ between microhabitats (Appendix IV).

All Decapod Crustaceans. Floods did not significantly change the overall abundances of decapod crustaceans (Table 3; Fig. 12). Among major groups, the abundances of grass shrimps and mud crabs were not significantly different after any of the three floods, and penaeid shrimps and portunid crabs were significantly different only after Flood 3 (Table 3). Moreover, microhabitat appeared to affect crustacean abundances more than floods. Accordingly, the numbers of crustaceans were nearly always significantly greater in the marsh as compared to subtidal bottom (Appendix IV; Table 3A). Where changes did occur after floods, crustacean numbers were usually reduced (Table 3).

Commercial Shrimps and Crabs. Brown shrimp and blue crab were significantly fewer in numbers after Flood 3 and white shrimp were significantly fewer after Flood 1 (Table 3 and 3A). Brown shrimp were significantly more abundant in marsh as compared to subtidal microhabitat in Flood 1 and 2, but not in Flood 3 (Table 3A), while white shrimp did not differ in abundance between microhabitats in any flood. Blue crab were always significantly more abundant in the marsh (Appendix IV).

DISCUSSION

Usage of Salt Marshes and Delta Marshes.

The two study areas in Lavaca Bay contrasted in several ways. The marsh plants were different (smooth cordgrass versus black rush), the locations were separated in distance from the coast (lower coast versus deltaic upper reaches), and the salinity regimes differed (saline versus brackish). Together, the sites represented conditions common in many temperate estuaries from Texas to New Jersey. Salt marshes in the Gulf of Mexico and southeastern U.S. are usually dominated by smooth cordgrass with black rush as a subdominant (Kurz and Wagner 1957; Charbreck 1972; Gallagher, et al. 1980). Or, in some areas, such as coastal Mississippi, black rush is the dominant (Eleuterius 1980). Both species occur under brackish and saline conditions. In Lavaca Bay, the saline marshes nearer the coast were predominately smooth cordgrass with black rush along the landward edges. Black rush became a progressively greater component of marshes in the upper bay. On the brackish lower delta, in the uppermost reaches of the bay, black rush was the dominant marsh plant and smooth cordgrass a subdominant. Thus, Lavaca Bay has tidal marshes from development on a delta, behind a barrier island and along a bay shoreline, each differing (Pethick 1984), but occurring in the same estuary. Estuaries are defined by mixing of freshwater and salt water (Prichard 1967) which creates a salinity gradient. This and geomorphology determines the extent of salinity regimes in the estuary. Most are drowned river valleys, thus narrow in their upper reaches and broadening near the coast. Many are blocked at the coast by bar built barrier islands. At the mouth of Lavaca Bay, Caballo Pass transgresses the barrier island and a channel runs directly up the main bay axis to the Lavaca River. Throughout our study, river flow was characteristically low, creating mesohaline to polyhaline conditions (13 to 30 ppt) throughout most of the bay. Oligohaline conditions (> 6 ppt) usually commenced on the delta about 5 to 10 km upriver. Only once in two years of observation (1985-1987) did these conditions deviate. This occurred as temporary but baywide lowering of salinities after floods in May and June of 1987. It was this largely mesohaline environment that was available for use by estuarine fauna.

Estuarine nekton used Juncus delta marshes and Spartina coastal marshes similarly and extensively, leading to important implications. First, it shows that estuarine fauna are able exploit the range of differing habitats available in a mesohaline system. It also demonstrates that tidal marshes regardless of type may be used more intensively by estuarine fauna than subtidal bottom. The reason appears to be that tidal marshes provide more food (Rader 1984; Fleeger 1985; Zimmerman, Minello and Dent 1989) and protection (Minello and Zimmerman 1983; McIvor and Odum 1988) for at least some fishes and shrimps, compared to subtidal bottom.

The juveniles of fishery species used marsh surfaces of Lavaca Bay as extensively as those in Galveston and Barataria Bays (Zimmerman and Minello 1984; Zimmerman, Minello, Castiglione and Smith 1989a and b; Zimmerman 1989). In these surveys, mesohaline and polyhaline marshes are used by all the major estuarine-dependent fishery species found the NW Gulf of Mexico. Furthermore, compared to other species, juveniles of brown shrimp, blue crab and spotted seatrout were always significantly more numerous on the marsh surface and occurred as a greater percentage of their total numbers in the marsh. These high abundances suggest a relationship between the nursery function of marshes and fishery yields for at least some species. In accordance, some tidally flooded marshes functioned similar to high quality nursery habitat such as submerged seagrass. In Christmas Bay, Thomas et al.(1989) reported that densities of small blue crabs did not differ between salt marshes and seagrasses. Seagrass and salt marsh habitats provided equivalent food and protective qualities that were far superior to bottom without vegetation (Thomas 1989). In West Bay, small brown shrimp grew faster, because of higher densities of food, (Zimmerman, Minello and Dent 1989) and survived better, due to structural protection, (Minello and Zimmerman 1983) in salt marsh compared to nonvegetated bottom. Nonetheless, salt marshes on the east coast of the U. S. did not function like those in Texas. Orth et al. (1984) and Wilson et al.(1989) have found that blue crabs in New Jersey and Virginia use seagrasses but not salt marshes as nurseries. Likewise, young brown shrimp in South

Carolina use subtidal bottoms more extensively than tidal marshes (E. Wenner, personal communication). The difference appears to be one of degree in duration of marsh flooding. Because of subsidence, NW Gulf marshes are flooded more frequently and for longer periods than east coast marshes (Baumann 1987). This allows tidal marshes to develop ecological characteristics that are like subtidal seagrasses. Since the NW Gulf has extensive tidal marshes, but few seagrass beds, the nursery function of these marshes is unusually important.

The salinity regimes of tidal marshes modify their nursery value. For example, faunal usage of marshes in Galveston Bay and San Antonio Bay (Zimmerman, Minello, Castiglione and Smith 1989 a, b and c), varied in relation to long term salinity characteristics. Species numbers at oligohaline and polyhaline ends of the gradient were generally higher than the mesohaline middle, reflecting incursions of freshwater and marine species, respectively. However, abundances were highest in mesohaline areas. This was particularly true of juveniles of estuarine dependent fishery species. Delta marshes became especially depauperate in abundances of estuarine species when exposed to salinities below 2 ppt for periods longer than one month. This occurred in association with high river flows, over extended periods, in Galveston Bay at the Trinity Delta and in upper San Antonio Bay near the Guadelupe Delta (Zimmerman, Minello, Castiglione and Smith 1989c). Changes in usage under oligohaline conditions in Galveston Bay were attributed to reductions in small epibenthic fauna useful as food (Zimmerman, Minello, Castiglione and Smith 1989b).

Thus, accessibility and area surfaces as well as quality of marsh surface may greatly affect the outcome of secondary productivity. An estuary with a large mesohaline area and highly accessible marsh surfaces stimulates faunal production. This appears to have been the case for Lavaca Bay. Relatively low river flow promoted mesohaline to polyhaline conditions. As a result, faunal utilization of marshes was high throughout the bay. These conditions, especially in delta marshes, expanded the estuarine system. Gulf fisheries are highly estuarine dependent (Gunter 1961). Does this estuarine expansion translate to larger offshore yields? The implications of these findings to NW Gulf fisheries are further discussed below.

The Effects of Flooding.

Freshwater floods, both with and without precipitous decline in salinity, had relatively little effect on short term (days to weeks) utilization of marshes. Most estuarine species were similar in abundance levels before and after floods. Accomodation to flooding among estuarine fishes is supported by Rogers et al. (1984). Sciaenids including, Atlantic croaker, silver perch, and spot, as well as menhaden and southern flounder were not deterred by freshwater conditions up to 100 days from flooding of a Gerogia salt marsh (Rogers et al. 1984). In Calcasieu estuary, Louisiana, Felley (1987) reported that juveniles of Gulf menhaden, southern flounder, Atlantic croaker, spot and bay anchovy were attracted to freshwater and oligohaline areas. In our study of Lavaca River delta marshes, Gulf menhaden and bay anchovy increased in abundances after floods. Floods may also generate longer term beneficial effects. Red drum, known to use low salinity waters as early juveniles (Peters and McMichael 1987), had high recruitment success during a year of reduced salinities, caused by flooding following a hurricane, in the Laguna Madre of Texas (Matlock 1987). High rainfall patterns and freshwater inflow have also been associated with increased production of white shrimp (Gunter and Hildebrand 1954; Mueller and Matthews 1987). In Louisiana, white shrimp occurrences are often cited under oligohaline and freshwater circumstances (Felley, 1987). In Lavaca Bay marshes, white shrimp were seasonally abundant and not affected by salinity changes. Other decapod crustaceans responded to floods with lower abundances, but even they demonstrated a high degree of apparent tolerance to freshening conditions. Distribution patterns in estuaries have long been based on salinities (Hedgepeth 1953; Gunter 1961) and changes in community structure have been related to freshwater inflow changes (Hoese 1960; Copeland 1966). But, we still do not understand the cause-effect relationships between salinity and occurrences of estuarine animals. This is clear from observations in Lavaca Bay where fauna were relatively unaffected by short-term extreme changes in salinity due to floods.

Marsh Utliization and Fishery Production

Analyses of NMFS landing records for the Gulf indicate that fishery landings and recruitment have increased even though marsh habitat is being severely lost in both Texas and Louisiana (Zimmerman, Klima and Minello 1989). Since 1960, it is estimated that brown shrimp and white shrimp recruitment have increased by 50 % and menhaden recruitment is up by 100 %. In response, the fishing effort and dockside landing have increased without diminishing catch per unit effort.

The answer to the paradox is in understanding what is happening to tidal marshes of the NW Gulf. In NW Gulf tidal marshes, high and low, fresh and salt, inundation is occurring for unusually long periods because of accelerating subsidence and sea-level rise. One result is that low marshes (mostly salt marshes) are drowning and breaking up into ever smaller but increasingly numerous islands in ever expanding areas of open water. In the process of deterioration, the marshes offer an ideal environment for food organisms foraged by shrimp, blue crabs and small commercial and sports fishes such as flounder, spotted seatrout and red drum. The multitudes of small marsh islands have more edge than large unbroken expanses of marsh and are more readily accessible from surrounding the open water. As both high and low marshes become progressively lower relative to sea level, the duration of intertidal flooding and saltiness increases, which makes most NW Gulf marshes more favorable to exploitation by estuarine fauna. These conditions appear to have stimulated fishery production over the last few decades and have engendered the paradox; but, this is occurring at the expense of marsh area loss.

Impounding our rivers and reducing freshwater inflow, as in the case of Lavaca Bay, may be one of the factors increasing our fishery productivity. This is possible because deltas are normally low salinity environments, that without optimal freshwater input function as highly exploitable mesohaline environments. The effect expands usable nursery area especially for fishery species. But, deltas are built by river borne sedimentation that comes from freshwater inflow. Active delta building is our major source of wetland creation, and, at present, the only means to offset other causes of wetland losses. Thus, if we do not maintain delta building processes, high quality nursery areas needed in future systems will not exist. And, the eventual effects of ongoing wetland losses will assure future declines in fishery production.

LITERATURE CITED

Armstrong, N. E. 1987. The ecology of open-bay bottoms of Texas: a community profile. U.S. Fish. Wildl. Serv. Biol. Rep. 85(7.12) 104 pages.

Baldauf, R. J. 1970. A study of selected chemical and biological conditions of the lower Trinity River and the upper Trinity Bay. Tech. Rep. No. 26, Water Resources Institute, Texas A&M Univ., College Station, Texas. 168 pp.

Baumann, R. H. 1987. Chapter 2. Physical Variables. pp. 8-17. In: W. H. Conner and J. W. Day, Jr. (eds.) The Ecology of Barataria Basin, Louisiana: An Estuarine Profile. U. S. Fish. Wildl. Serv. Biol. Rep. 85 (7.13).

Bell, S. S. and B. C. Coull 1978. Field evidence that shrimp predation regulates meiofauna. Oecologia 35:141-148.

Bell, S. S. 1980. Meiofauna-macrofauna interactions in a high salt marsh habitat. Ecol. Monogr. 50:487-505.

Benson, N. G. 1981. The freshwater-inflow-to estuaries issue. Fisheries 6 (5):8-10.

Borey, R. B., P. A. Harcombe and F. M. Fisher 1983. Water and organic fluxes from an irregularly flooded brackish marsh on the upper Texas coast, U.S.A. Estuar. Coast Shelf Sci. 16:379-402.

Charbreck, R. H. 1972. Vegetation, water, soil characteristics of the Louisiana coastal region. Bull. Louisiana State Univ. Agri. Exp. Sta. 664. Baton Rouge. 72 pp.

Copeland, B. J. 1966. Effects of decreased river flow on estuarine ecology. J. Water Pollut. Control Fed. 38:1831-1839.

Daiber, F. C. 1977. Salt-marsh animals: distributions related to tidal flooding, salinity and vegetation. pp. 79-108. In: V. J. Chapman (ed.) Ecosystems of the World: I, Wet Coastal Ecosystems. Elsevier Scientific Publ. Co., Amsterdam, Netherlands.

Daiber, F. C. 1982. Animals of the Tidal Marsh. Van Nostrand Reinhold Co., New York. 422 p.

Deegan, L. A., J. W. Day, Jr., J. G. Gosselink, A. Yanez-Arancibia, G. Soberon Chavez and P. Sanchez-Gil 1986. Relationships among physical characteristics, vegetation distribution and fisheries yield in the Gulf of Mexico estuaries. pp. 83-100. In: D. A. Wolfe (ed.) Estuarine Variability. Acad. Press, Inc. New York, N. Y.

Eleuterius, L. N. 1980. Tidal marsh plants of Mississippi and adjacent states. Mississippi-Alabama Sea Grant Consortium, Pub.

No. MASGP-77-039, Gulf Coast Res. Lab., Ocean Springs, Mississippi 39564

Felley, J. D. 1987. Nekton assemblages of three tributaries to the Calcasieu estuary, Louisiana. Estuaries 10:321-329.

Fleeger, J. W. 1985. Meiofaunal densities and copepod species composition in a Louisiana, U.S.A., estuary. Trans. Am. Microsc. Soc. 104:321-332.

Flint, R. W. 1985. Long-term estuarine variability and associated biological response. Estuaries 8:158-169.

Gallagher, J. L., R. J. Reimold, R. A. Linthurst and W. J. Pfeiffer 1980. Aerial production, mortality, and mineral accumulation-export dynamics in *Spartina alterniflora* and *Juncus roemerianus* plant stands in a Georgia salt marsh. Ecology 61:303-312.

Gunter, G. 1961. Some relations of estuarine organisms to salinity. Limnol. Oceanogr. 6:182-190.

Gunter, G. 1967. Some relationships of estuaries to fisheries of the Gulf of Mexico. pp. 621-637. In: G.H. Lauff (ed). Estuaries. Amer. Assoc. Adv. Sci. Publ. No. 83.

Gunter, G. and H. H. Hildebrand 1954. The relationship of rainfall of the state and catch of the marine shrimp (Penaeus setiferus) in Texas waters. Bull. Mar. Sci. Gulf Carib. 4:95-103.

Hedgpeth, J. W. 1953. An Introduction to the zoogeography of the northwestern Gulf of Mexico with reference to invertebrate fauna. Publ. Inst. Mar. Sci. Texas 3:107-224.

Hicks, S. D. , H. A. Debaugh Jr. and L. E. Hickman 1983. Sea level variations for the United States 1855-1980. NOAA/NOS Rpt., National Ocean Survey, Tides and Water Levels Branch, Rockville, MD. 170 pp.

Hoese, H. D. 1960. Biotic changes in a bay associated with the end of a drought. Limnol. Oceanogr. 5:326-336.

Holt, J., R. Godbout and C. R. Arnold 1981. Effects of temperature and salinity on egg hatching and larval survival of red drum, Sciaenops ocellata. Fish. Bull. 79:569-573.

Kneib, R. T. and A. E. Stiven 1982. Benthic invertebrate responses to size and density manipulations of the common mummichog, Fundulus heteroclitus, in an intertidal salt marsh. Ecology 63:1518-1532.

Kurz, H. and K. Wagner 1957. Tidal marshes of the Gulf and Atlantic coasts of northern Florida and Charleston, South Carolina. Fla. St. Univ. Stud. 24:1-168. Tallahassee, Florida.

Matlock, G. C. 1987. The role of hurricanes in determining year-class strength of red drum. Contrib. Mar. Sci. 30:39-47.

McIvor, C. C. and W. E. Odum 1986. The flume net: a quantative method for sampling fishes and macrocrustaceans on tidal marsh surfaces. Estuaries 9:219-224.

McIvor, C. C. and W. E. Odum 1988. Food, predation risk, and microhabitat selection in a marsh fish assemblage. Ecology 69: 1341-1351.

Morgan, M. D. 1980. Grazing and predation of the grass shrimp *Palaemonetes pugio*. Limnol. Oceanogr. 25:896-902.

Montague, c. L., S. M. Bunker, E. B. Haines, M. L. Pace and R. L. Wetzel 1981. Aquatic macro-consumers. pp. 69-85. In: L. R. Pomeroy and R. G. Wiegert (eds.), The Ecology of a Salt Marsh. Springer-Verlag, New York, N. Y.

Minello, T. J., and R. J. Zimmerman 1983. Fish predation on juvenile brown shrimp, *Penaeus aztecus* Ives: the effect of simulated *Spartina* structure on predation rates. J. Exp. Mar. Biol. Ecol. 72:211-231.

Mueller, A. J. and G. A. Matthews 1987. Freshwater inflow needs of the Matagorda Bay system with focus on penaeid shrimp. NOAA Tech. Memo. NMFS-SEFC-189, 97 pp.

Odum, E. P. 1980. The status of three ecosystem-level hypotheses regarding salt marsh estuaries: tidal subsidy, outwelling, and detritus-based food chains. pp. 485-495. In: V. S. Kennedy (ed.), Estuarine Perspectives. Academic Press, New York,N.Y.

Orth, R. J. and J. van Monfrans 1989. Factors affecting settlement, survival and utilization in marsh and seagrass systems by post-larval and early juvenile stages of Callinectes sapidus along latitudinal gradients. Bull. Mar. Sci. (in press).

Parker, J. C. 1970. Distribution of juvenile brown shrimp (Penaeus aztecus Ives) in Galveston Bay, Texas, as related to certain hydrographic features and salinity. Contrib. Mar. Sci. 15:1-12.

Pethick, J. 1984. An Introduction to Coastal Geomorphology. Edward Arnold, Ltd., London. 260 pp.

Peters, K. M. and R. H. McMichael, Jr. 1987. Early life history of the red drum, Sciaenops ocellatus (Pices: Sciaenidae), in Tampa Bay, Florida. Estuaries 10:92-107.

Pritchard, D. W. 1967. What is an estuary: physical viewpoint. pp.3-8. In: G. H. Lauff (ed.) Estuaries. Pub. No. 83, Am. Assoc.

Adv. Sci., Wash., D. C.

Rader, D. N. 1984. Salt-marsh benthic invertrbrates: small-scale patterns of distribution and abundance. Estuaries 7:413-420.

Remane, A. and C. Schlieper 1958 (translated 1971). The biology of brackish water. Wiley-Interscience, New York, N.Y. 372 pp.

Rogers, G. S., T. E. Targett and S. B. Van Sant 1984. Fish-nursery use in Georgia salt-marsh estuaries: the influence of springtime freshwater conditions. Trans. Am. Fish. Soc. 113:595-606.

Rozas, L. P. and C. T. Hachney 1983. The importance of oligohaline estuarine wetland habitats to fisheries resources. Wetlands 3:77-89.

Rozas, L. P. and C. T. Hackney 1984. Use of oligohaline marshes by fishes and macrofaunal crustaceans in North Carolina. Estuaries 7:213-224.

Rozas, L. P. and W. E. Odum 1987. Use of tidal freshwater marshes by fishes and macrofaunal crustaceans along a marsh stream-order gradient. Estuaries 10:36-43.

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of

Georgia. Ecology 43:614-624.

Thayer, G. W., H. H. Stuart, W. J. Kenworthy, J. F. Ustach and A. B. Hall 1978. Habitat values of sal;t marshes, mangroves, and seagrasses for aquatic organisms. pp. 235-247. In: Greeson, P. E., J. R. Clark and J. E. Clark (eds.), Wetland functions and values: the state of our understanding. Proc. National Sym. Wetlands, Am. Water Res. Assoc., Minneapolis.

Thomas, J. 1989. A comparative evaluation of Halodule wrightii, Spartina alterniflora and bare sand as nursery habitats for juvenile Callinectes sapidus. M.S. Thesis. Biology Department, Texas A&M University, College Station, Texas.

Thomas, J., R. J. Zimmerman, and T. J. Minello 1989. Abundance patterns of juvenile blue crabs (Callinectes sapidus) in nursery habitats of two Texas bays. Bull. Mar. Sci. (in press).

Turner, R. E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Trans. Am. Fish. Soc. 106: 411-416.

Welsh, B. L. 1975. The role of grass shrimp, Palaemonetes pugio, in a tidal marsh system. Ecology 56:513-530.

Wilson, K. A., K. W. Able and K. L. Heck, Jr. 1989. Habitat use by juvenile blue crabs: a comparison among habitats in southern New

Jersey. Bull. Mar. Sci. (in press).

Zimmerman, R. J. and T. J. Minello 1984. Densities of *Penaeus aztecus*, *Penaeus setiferus*, and other natant macrofauna in a Texas salt marsh. Estuaries 7:421-433.

Zimmerman, R. J., T. J. Minello, and G. Zamora 1984. Selection of vegetated habitat by *Penaeus aztecus* in a Galveston Bay salt marsh. Fish. Bull. 82:325-336.

Zimmerman, R. J. 1989. An assessment of salt marsh usage by estuarine aquatic fauna at Grande Isle, Louisiana. NMFS/SEC Rep. to EPA Region IV (Dallas). NMFS Galveston Lab., Galveston, Tex., 27 pp.

Zimmerman, R. J., E. F. Klima and T. J. Minello 1989. Problems Associated with Determining Effects of Nursery Habitat Loss on Offshore Fishery Production. Annual Meeting Am. Fish. Soc., Anchorage, Alaska., 1 p.(Abst.).

Zimmerman, R. J., T.J. Minello, M. Castiglione and D. Smith 1989a. Marsh Usage by Fishery Organisms Along a Salinity Gradient in Galveston Bay. NMFS/SEC Rep.to Tex. Parks Wildl. Dept. & Tex. Water Development Bd., NMFS Galveston Lab., Galveston Tex., 160 pp.

Zimmerman, R. J., Minello, T. J., Castiglione, M. and Smith, D. 1989b. Implications of Riverflow to Utilization of Estuarine Marshes by Fishery Species. International Meeting Assoc. State Wetland Managers, Charleston, S. C., July 6-9, 1989. 1 p.(Abst.).

Zimmerman, R. J., T. J. Minello, M. Castiglione, and D. Smith 1989c. Freshwater inflow effects on marsh utilization in San Antonio Bay. NMFS/SEC Rep. to Tex. Parks Wildl. Dept. and Tex. Water Develpoment Bd., NMFS Galveston Lab., Galveston Tex.

Zimmerman, R. J., T. J. Minello and S. Dent 1989. Habitat-related growth and resource partitioning of penaeid shrimp in a salt marsh. Mar. Ecol. Prog. Ser. (conditionally accepted).

TABLE 1. An analysis of temperature, salinity and water depth means in subtidal microhabitat, adjacent to marsh, in Lavaca Bay between delta and coastal locations, during spring, summer and fall seasons. P values from ANOVA, with significant differences denoted by asterisks and significant interactions in bold print.

	Temperature	Salinity	Minimum Water Depth
Season	< 0.001**	0.31	0.003*
Location	0.022*	0.002*	0.07
Season x Location	**0.011**	0.14	0.66

TABLE 2. An analysis of differences in faunal abundances in Lavaca Bay between marsh and subtidal microhabitats, delta and coastal locations, during spring and fall seasons. P values from ANOVA, with significant differences denoted by asterisks and significant interactions in bold print.

	All Fishes	Game Fishes	Bait Fishes	Naked Goby	Bay Anchovy	Menhaden	Spotted Seatrout	Southern Flounder
Season	0.01*	0.70	0.48	0.002**	0.054*	0.009**	<0.001**	0.007**
Location	0.31	0.74	0.82	0.003**	0.70	0.59	0.20	0.68
Season x Loc.	**0.005**	0.46	**0.049**	**0.029**	0.075	0.59	0.52	0.68
Microhabitat	0.089	0.03*	0.051*	<0.001**	0.005**	0.009**	<0.001**	0.50
Sea. x Mh.	**0.028**	0.10	0.12	**<0.001**	0.54	**0.009**	**0.003**	0.50
Loc. x Mh.	0.42	0.10	0.94	0.22	0.61	0.59	0.06	0.32
S x L x M	0.62	0.98	0.69	0.51	0.48	0.59	0.20	0.32

	Decapod Crustacea	Penaeid Shrimps	Brown Shrimp	All Grass Shrimps	Pugio Grass Shr.	Blue Crab	White Shrimp	Pink Shrimp
Season	0.12	0.001*	<0.001**	0.06	0.029*	<0.001**	0.81	<0.001*
Location	0.12	0.69	0.23	0.25	0.35	0.56	0.69	0.28
Season x Loc.	0.58	0.55	**0.039**	0.16	0.091	0.26	0.79	0.28
Microhabitat	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	0.014*	<0.001**
Sea. x Mh.	0.23	0.055*	0.87	0.49	0.45	**<0.001**	0.47	<0.001**
Loc. x Mh.	0.36	0.25	0.85	0.71	0.72	0.44	0.84	0.48
S x L x M	0.30	0.9	0.37	0.21	0.18	0.37	0.76	0.48

TABLE 3. Differences in faunal abundances between samples taken before and after floods in marshes of the Lavaca River delta, Texas. P values from ANOVAs, with + or - indicating direction of significant change (in bold print) after the freshening event.

Taxonomic Group	Flood 1 (Oct. 1986)	Flood 2 (May 1987)	Flood 3 (June 1987)
All Fishes	0.45	**0.001 (+)**	**0.017 (+)**
Cyprindodontidae	0.14	0.19	0.21
Gobiidae	0.91	**<0.001 (+)**	0.67
Sciaenidae	**0.034 (+)**	0.37	0.64
Bait Fishes	0.07	0.09	**0.006 (+)**
Commercial/Sport Fishes	0.42	1.0	0.74
Anchoa mitchilli	0.06	**0.003 (+)**	0.11
Bairdiella chrysoura	np	id	**0.035 (+)**
Brevoortia patronus	np	0.31	**0.002 (+)**
Cyprinodon variegatus	0.23	**0.036 (+)**	**0.020 (-)**
Fundulus grandis	0.47	0.31	0.74
Gobiesox strumosus	np	**0.027 (+)**	**0.044 (-)**
Gobiosoma bosci	0.94	**<0.001 (+)**	0.59
Lagodon rhomboides	id	0.93	0.25
Leiostomus xanthurus	id	0.73	0.57
Micropogonias undulatus	**0.014 (+)**	0.77	0.48
Menidia berylina	id	0.12	0.63
Mugil cephalus	id	0.30	0.72
Myrophis punctatus	id	0.82	0.09
All Decapod Crustaceans	0.46	0.18	0.12
Grass Shrimps	0.67	0.51	0.40
Penaeid Shrimps	0.17	0.06	**<0.001 (-)**
Xanthid Crabs	0.75	0.49	0.53
Callinectes sapidus	0.59	0.18	**0.017 (-)**
Neopanope texana	**0.028 (-)**	0.95	id
Palaemonetes intermedius	0.56	id	0.67
Palaemonetes pugio	0.78	0.62	0.36
Penaeus aztecus	0.99	0.07	**<0.001 (-)**
Penaeus duorarum	0.61	np	np
Penaeus setiferus	**0.044 (-)**	0.1	0.47
Rhithropanopeus harrissi	**0.006 (+)**	0.42	0.98

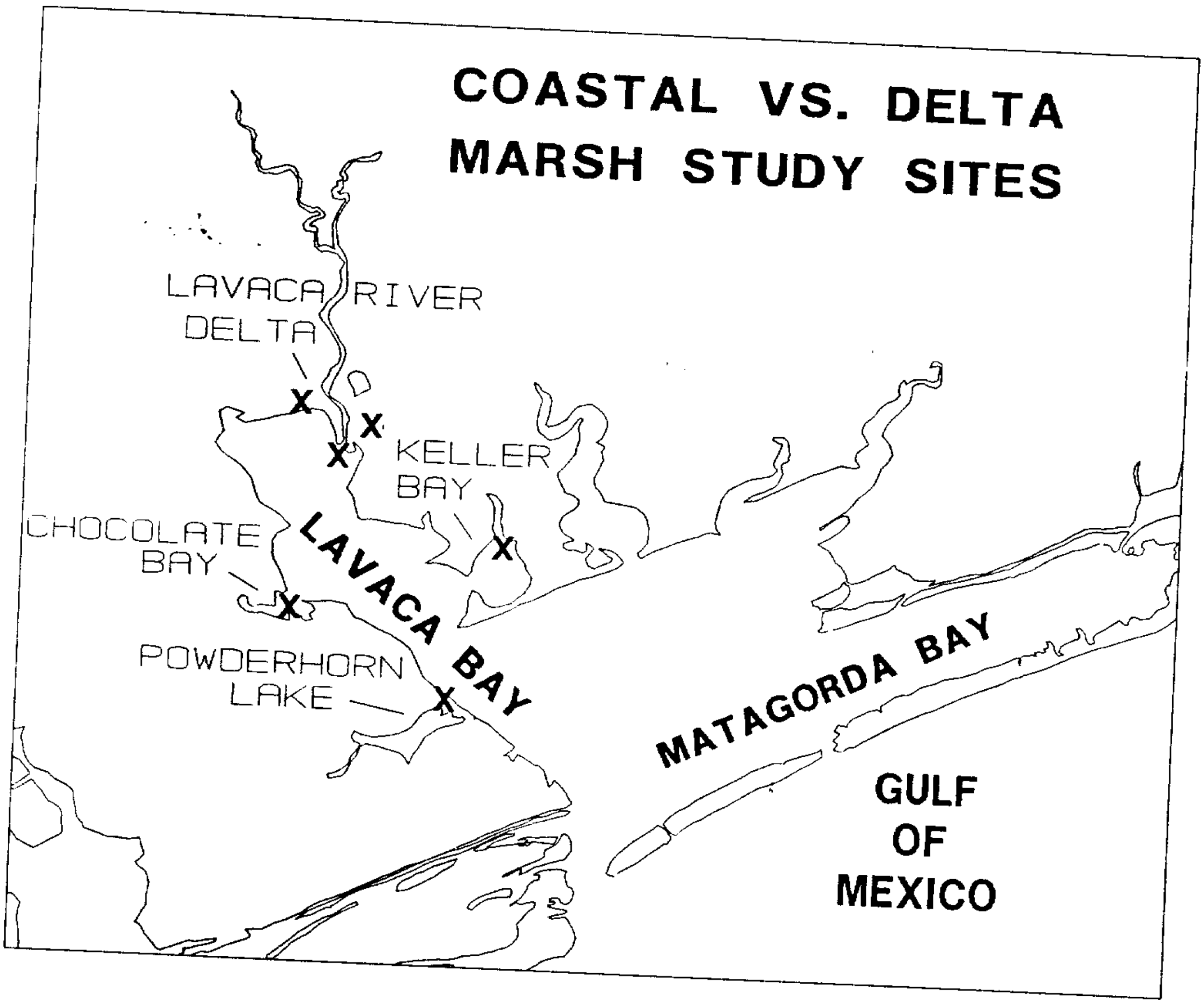
Notations: np = not present; id = insufficient data for ANOVA.

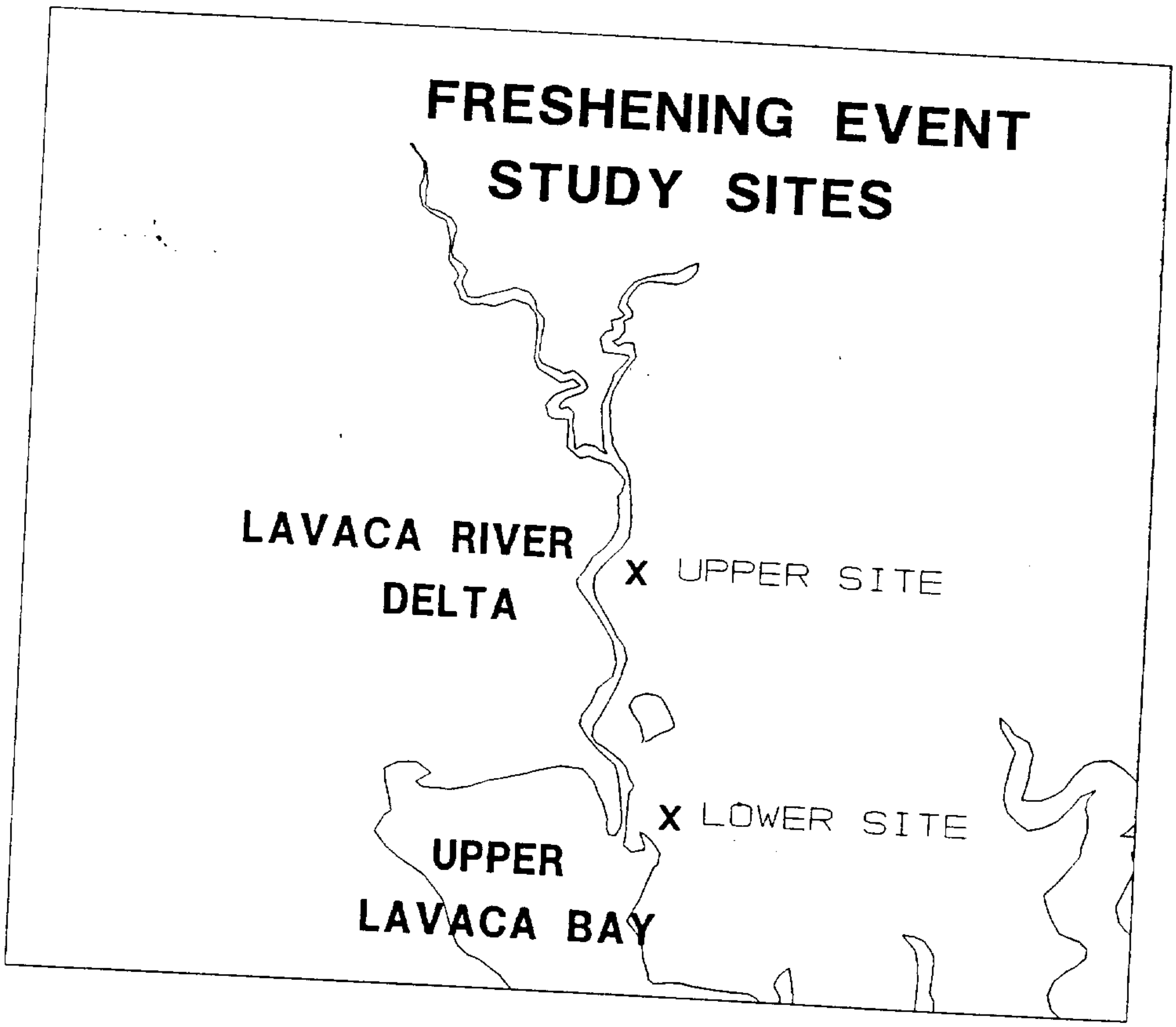
TABLE 3A. Changes in faunal abundances during flood #3 at the Lavaca River delta, Texas, in marsh and subtidal microhabitats, and upper and lower delta locations, comparing samples before and after freshening. P values from ANOVA, with significant differences denoted by asterisks and significant interactions in bold print.

	All Fishes	Game Fishes	Bait Fishes	Sciaenids	Gobiids	Menhaden	Bay Anchovy
Flood	0.017*	0.74	0.006**	0.64	0.67	0.002**	0.11
Location	<0.001**	0.32	<0.001**	0.83	0.014*	0.004**	<0.001**
Fld. x Loc.	0.25	0.17	0.18	0.56	0.67	0.16	0.39
Microhabitat	0.43	0.74	0.035	0.31	0.20	0.73	<0.001**
Fld. x Mh.	0.67	**0.046**	0.59	0.96	0.98	0.71	0.93
Loc. x Mh.	0.44	0.17	0.37	**0.004**	0.74	0.47	0.48
F x L x M	0.60	0.32	0.53	0.68	0.17	0.86	0.49

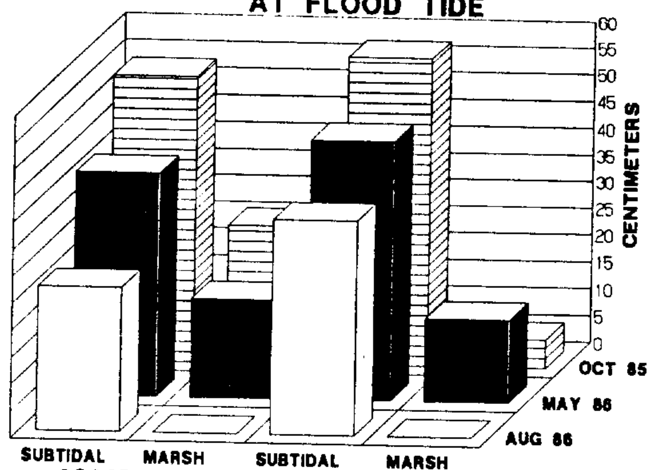
	Decapod Crustacea	Grass Shrimps	Brown Shrimp	White Shrimp	Blue Crab	Mud Crab
Flood	0.12	0.40	<0.001**	0.47	0.017*	0.98
Location	0.82	0.99	0.24	0.26	0.008**	0.15
Fld. x Loc.	0.57	0.20	0.94	0.47	0.84	0.93
Microhabitat	<0.001**	<0.001**	0.17	0.77	0.002**	0.59
Fld. x Mh.	0.80	0.15	0.47	0.33	0.45	0.59
Loc. x Mh.	0.52	0.48	0.42	0.77	0.77	0.66
F x L x M	**0.018**	0.071	0.28	0.33	0.14	0.66

LIST OF FIGURES

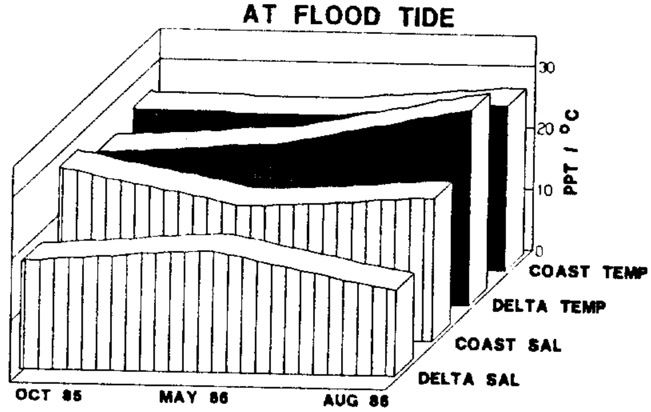

COASTAL VS. DELTA
MARSH STUDY SITES
LAVACA RIVER
DELTA
KELLER
BAY
CHOCOLATE
BAY
LAVACA BAY
POWDERHORN
LAKE
MATAGORDA BAY
GULF
OF
MEXICO


FRESHENING EVENT
STUDY SITES
LAVACA RIVER
DELTA
X UPPER SITE
X LOWER SITE
UPPER
LAVACA BAY

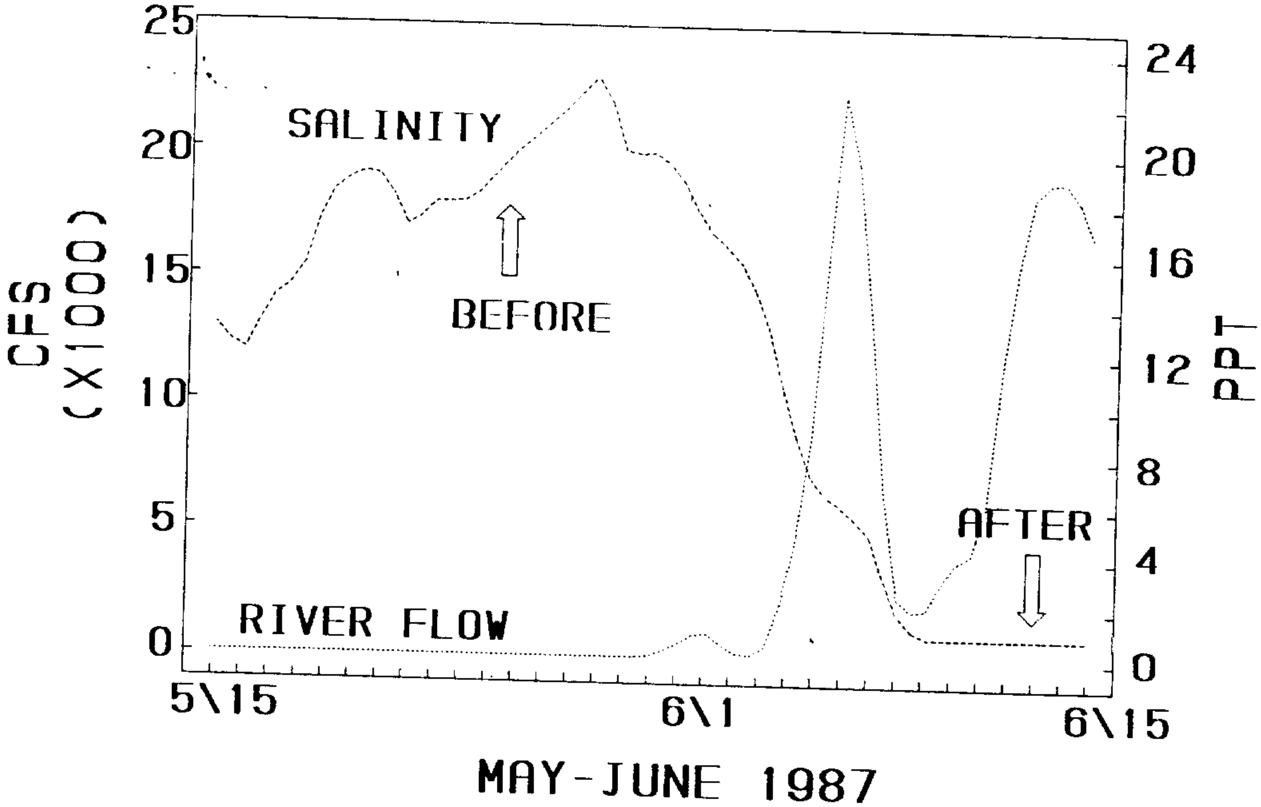
MINIMUM WATER DEPTH
AT FLOOD TIDE

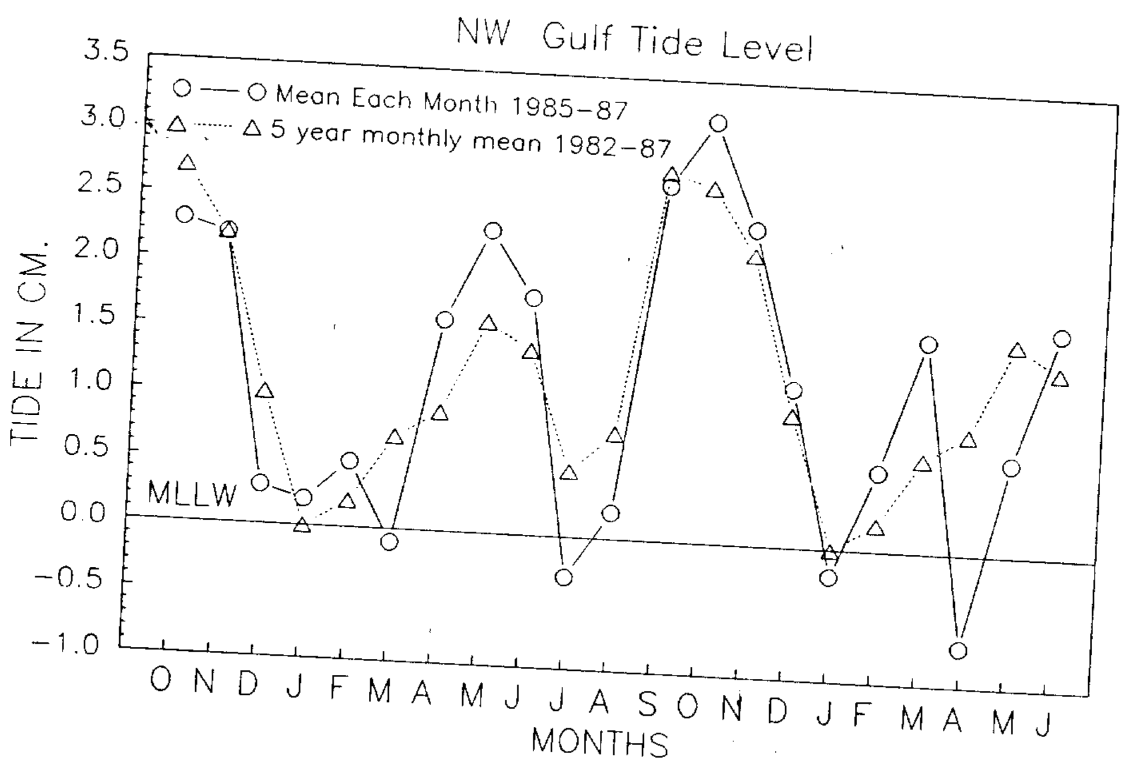


TEMPERATURE AND SALINITY
AT FLOOD TIDE

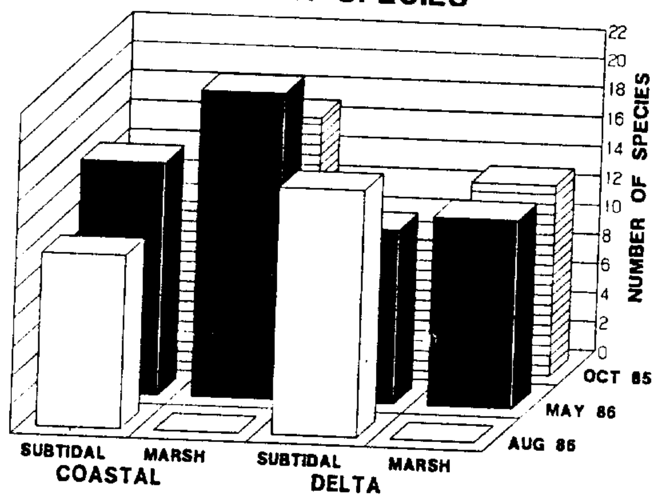


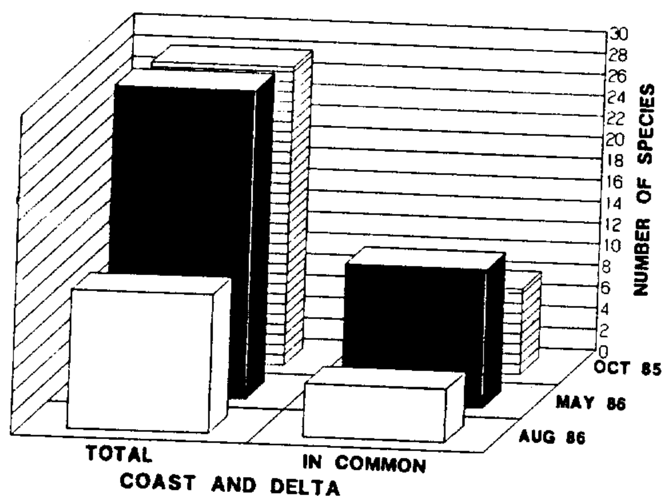
FLOOD EFFECTS: SALINITY CHANGE



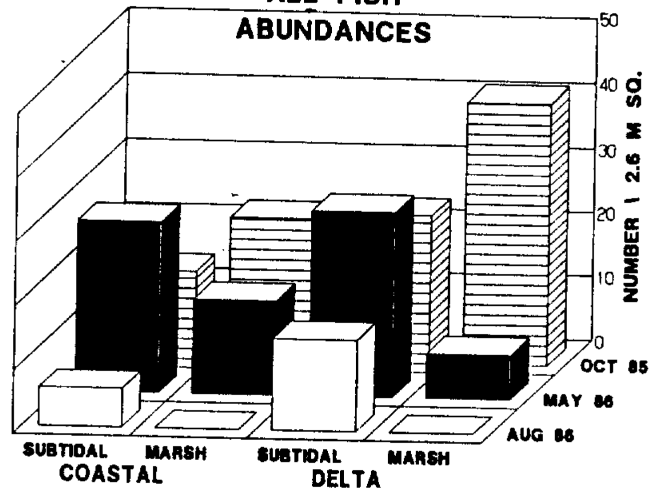

NW Gulf Tide Level
Mean Each Month 1985–87
5 year monthly mean 1982–87
TIDE IN CM.
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
MLLW
O N D J F M A M J J A S O N D J F M A M J
MONTHS

FISH SPECIES

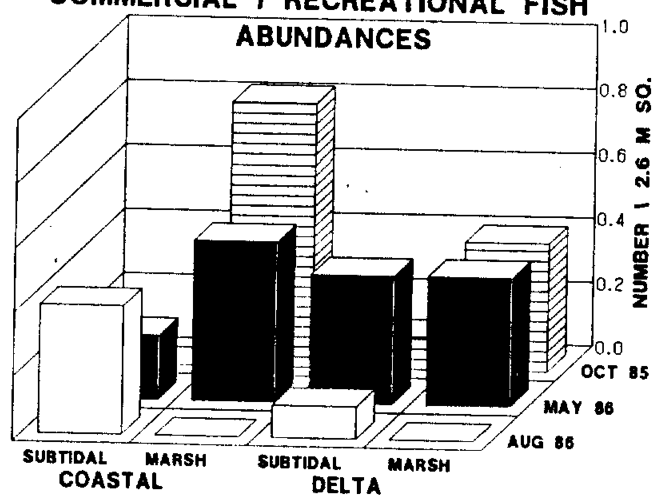




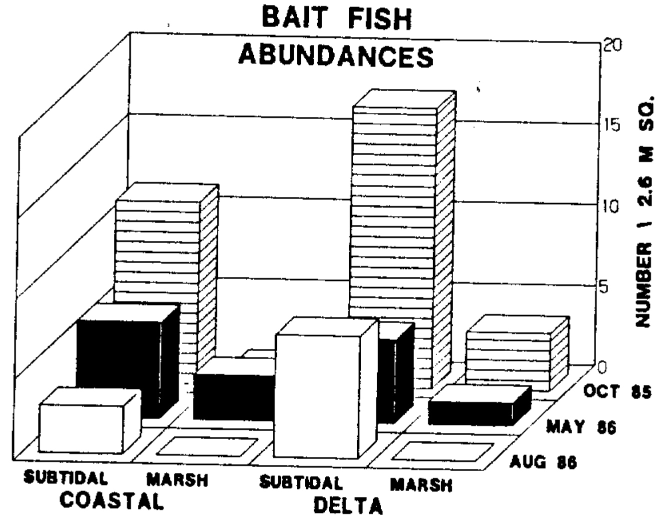
ALL FISH ABUNDANCES

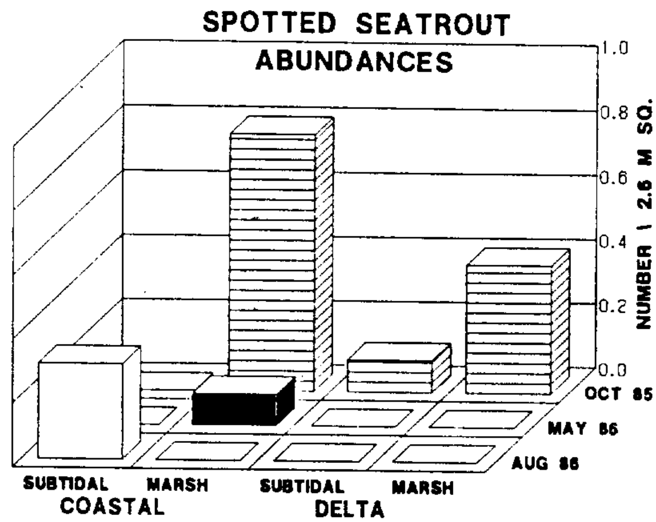


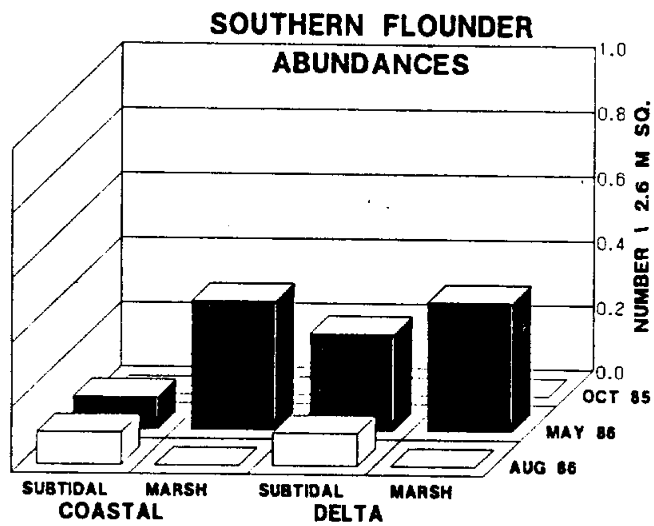
COMMERCIAL / RECREATIONAL FISH ABUNDANCES

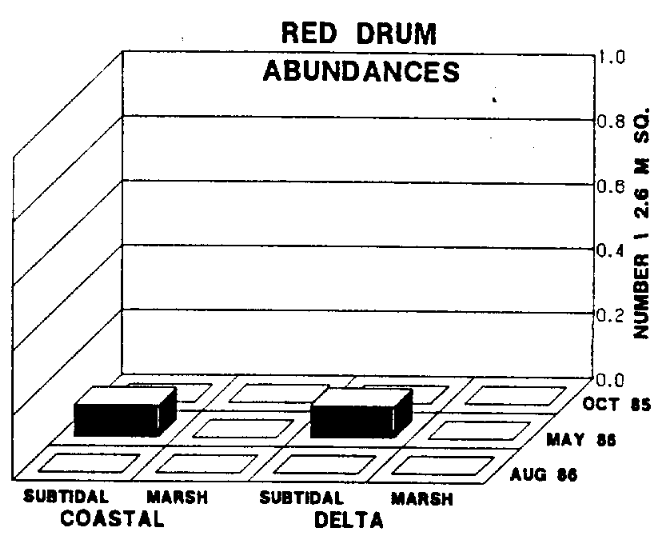


BAIT FISH ABUNDANCES

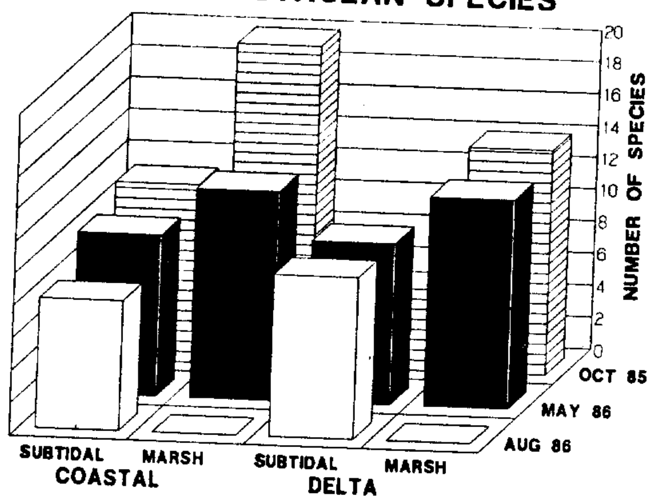


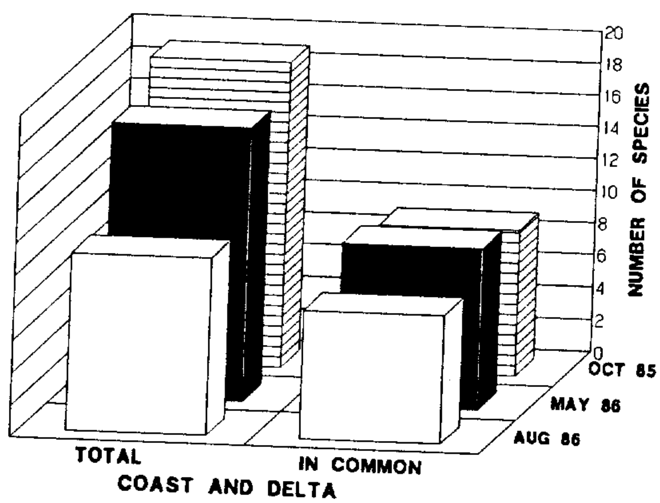

SPOTTED SEATROUT
ABUNDANCES
1.0
0.8
0.6
0.4
0.2
0.0
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA

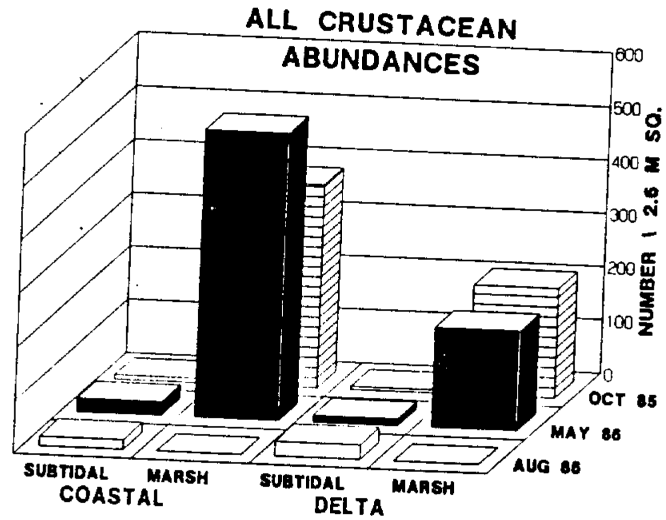

SOUTHERN FLOUNDER
ABUNDANCES
1.0
0.8
0.6
0.4
0.2
0.0
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA

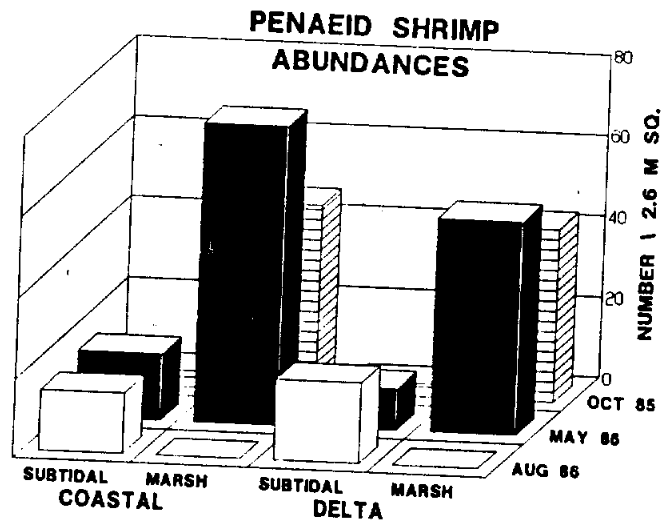

RED DRUM
ABUNDANCES
1.0
0.8
0.6
0.4
0.2
0.0
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA

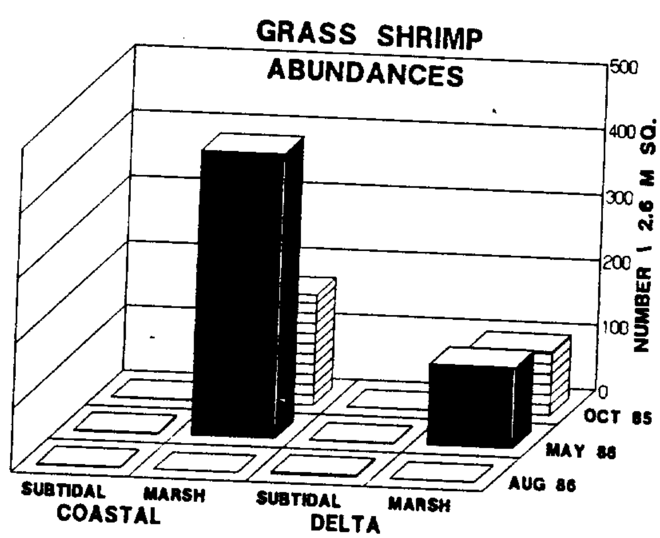
CRUSTACEAN SPECIES

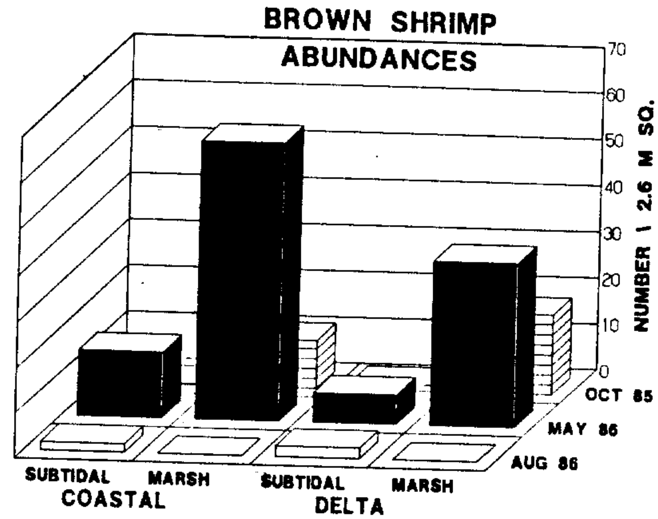


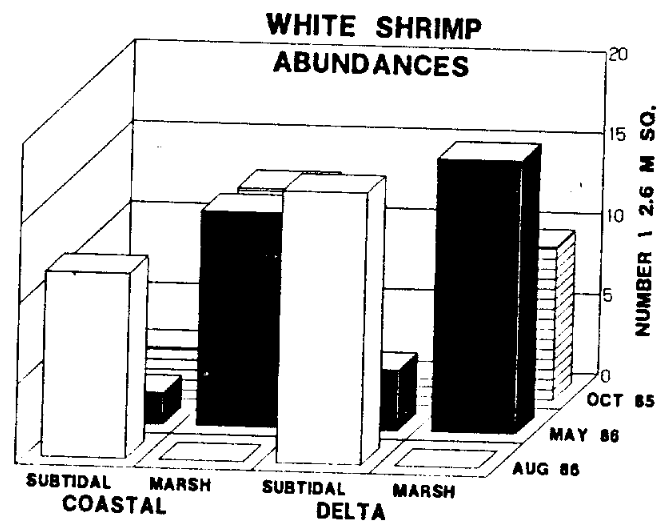


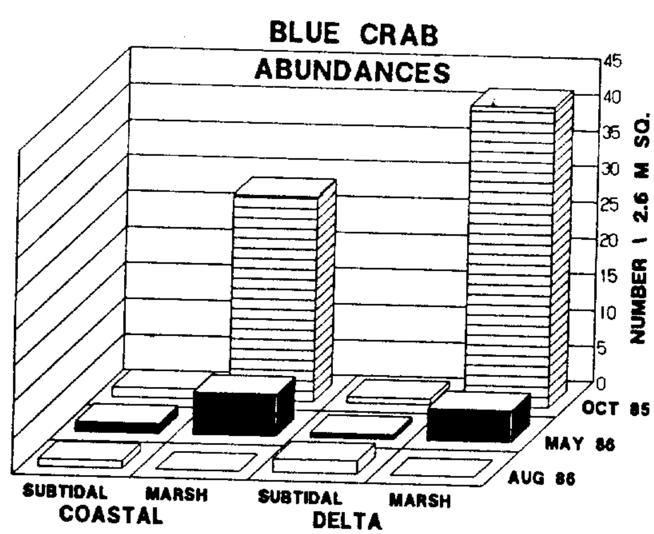

ALL CRUSTACEAN
ABUNDANCES
0
100
200
300
400
500
600
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA


PENAEID SHRIMP
ABUNDANCES
0
20
40
60
80
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA

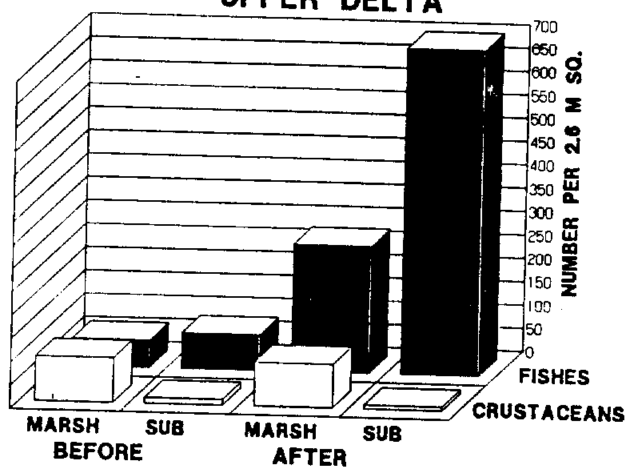

GRASS SHRIMP
ABUNDANCES
0
100
200
300
400
500
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA


BROWN SHRIMP
ABUNDANCES
NUMBER \ 2.6 M SQ.
0
10
20
30
40
50
60
70
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA

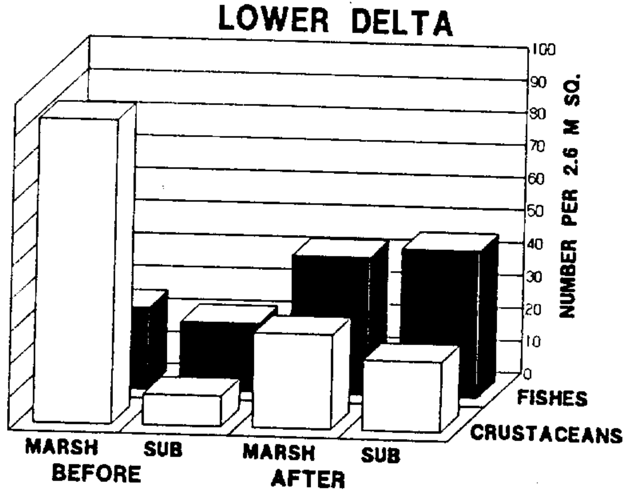

WHITE SHRIMP
ABUNDANCES
NUMBER \ 2.6 M SQ.
0
5
10
15
20
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA


BLUE CRAB
ABUNDANCES
NUMBER \ 2.6 M SQ.
0
5
10
15
20
25
30
35
40
45
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA

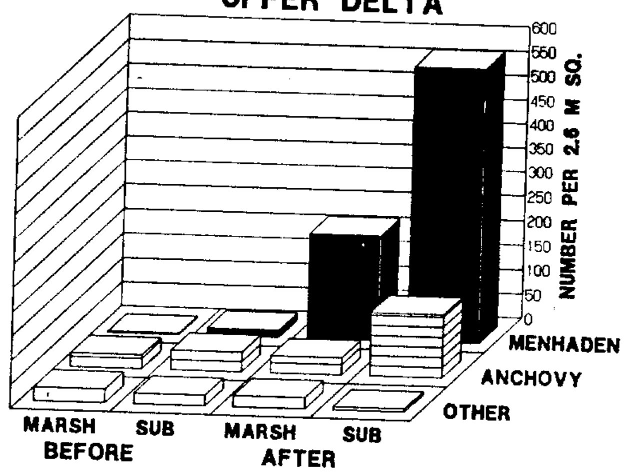
FLOOD EFFECTS: UPPER DELTA



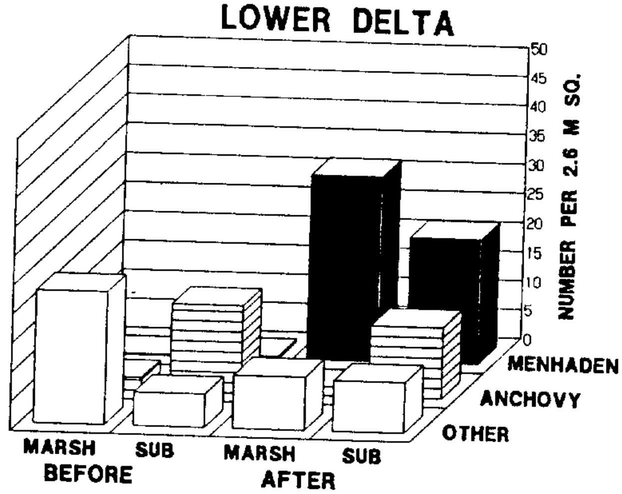
LOWER DELTA



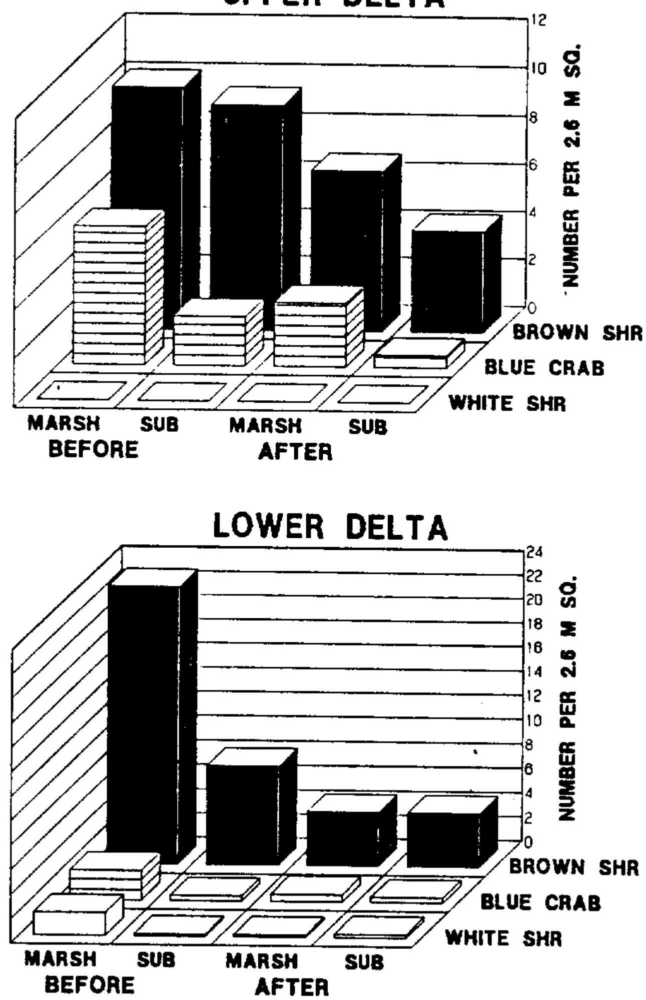
SELECTED FISHES
UPPER DELTA



LOWER DELTA



SELECTED CRUSTACEANS
UPPER DELTA



APPENDIX I: Principal Keys and References Used to Identify Galveston Bay Aquatic Fauna.

Fishes:

Hoese, H.D. and R.H. Moore 1977. Fishes of the Gulf of Mexico, Texas, Louisiana, and adjacent waters. Texas A&M Press, College Station, Texas. 327 pp.

Murdy, E.O. 1983. Saltwater fishes of Texas: a dichotomous key. Texas A&M Sea Grant College Program TAMU-SG-83-607, College Station.

U.S. Fish and Wildlife Service 1978. Development of fishes of the Mid-Atlantic Bight: an atlas of egg, larval and juvenile stages. Volumes I-VII. U.S. Fish Wildl. Serv., Biol. Serv. Program, FWS/OBS-78/12.

Crustaceans:

Bousfield, E.L. 1973. Shalow-water gammaridean Amphipoda of New England. Cornell University Press, Ithaca, New York. 312 pp.

Chaney, A.H. 1983. Key to the common inshore crabs of Texas. pp. 1-30 In: A.H. Chaney, Keys to selected marine invertebrates of Texas. Caesar Kleberg Wildlife Research Institute Tech. Bull. No. 4, Kingsville, Texas. 86 pp.

Felder, D.L. 1973. An annotated key to crabs and lobsters (Decapoda, Reptantia) from coastal waters of the northwestern Gulf of Mexico. Center for Wetland Resources, Louisiana State University. LSU-SG-73-02. Baton Rouge, Louisana. 103 pp.

Heard, R.W. 1982. Guide to common tidal marsh invertebrates of the northeastern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium. MASGP-79-004. Ocean Springs, Mississippi. 82 pp.

Schultz, G.A. 1969. The marine isopod crustaceans. William C. Brown Co. Publ., Dubuque, Iowa. 359 pp.

Williams, A.B. 1984. Shrimps, lobsters and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press. Washington, D.C. 550 pp.

Molluscs:

Andrews, J. 1981. Texas shells. University of Texas Press. Austin, Texas. 175 pp.

Annelids:

Fauchald, K. 1977. The polychaete worms. Definitions and keys to the orders, families and genera. Natural History Museum of Los Angeles County in conjunction with the Allan Hancock Foundation. Science Series 28, University of Southern California, Los Angeles, California. 188 pp.

Uebelacker, J.M. and P.G. Johnson (eds.) 1984. Taxonomic guide to the polychaetes of the northern Gulf of Mexico. Vol. I - VI. Minerals Management Service, U.S. Dept. Interior, Gulf of Mexico Regional Office, Metaire, Louisiana.

Plants:

Charbreck, R.H. and R.E. Condrey 1979. Common vascular plants of the Louisiana marsh. Sea Grant Pub.No. LSU-T-79-003. Louisiana State Center for Wetland Resources, Baton Rouge, Louisiana. 116 pp.

Edwards, P. 1976. Illustrated guide to the seaweeds and seagrasses in the vicinity of Port Aransas, Texas. Univ. Texas Press, Austin, Texas. 126 pp.

Eleuterius, L.N. 1980. Tidal marsh plants of Mississippi and adjacent states. Mississippi-Alabama Sea Grant Consortium Pub. No. MASGP-77-039. Gulf Coast Research Laboratory, Ocean Springs, Mississippi. 130 pp.

Tarver, D.P., J.A. Rodgers, M.J. Mahler and R. L. Lazor 1986. Aquatic and wetland plants of Florida. Published by the Bureau of Aquatic Plant Research and Control, Florida Department of Natural Resources, Tallahassee, Florida. 127pp.

LAVACA BAY STUDY
Spartina vs. non-vegetated sites
August 19-20, 1986
Macrofauna/2.8 m sq.
Paired Samples

SPECIES	CODE	CHOCOLATE BAY (N = 4)				KELLER BAY (N = 4)				POWDERHORN LAKE (N = 2)				OVERALL MENs AND S.E.s Based on n = 10			
		Spartina		Non-vegetated		Spartina		Non-vegetated		Spartina		Non-vegetated		Spartina		Non-vegetated	
		MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																	
Anchoa mitchilli	S120	0	0	1	0.41	0	0	1.8	1.44	0	0	41.5	41.5	0	0	9.4	8.20
Gobionellus boleosoma	S116	0	0	0	0	0	0	0	0	23.5	10.5	2	1	4.7	3.50	0.4	0.31
Gobiosoma bosci	S105	3	1.22	0	0	2	2	1	0.41	0.5	0.5	0	0	2.1	0.91	0.4	0.22
Fundulus grandis	S117	0.5	0.5	0	0	0.8	0.25	0	0	3.5	3.5	0	0	1.2	0.68	0	0
Symphurus plagiusa	S113	0	0	1	0.58	0	0	1.8	1.75	0	0	0	0	0	0	1.1	0.71
Cynoscion nebulosus	S125	1	0.71	0	0	0	0	0.3	0.25	0	0	0	0	0.4	0.31	0.1	0.1
Menidia beryllina	S110	0	0	0	0	0.3	0.25	0	0	0	0	2	2	0.1	0.1	0.4	0.4
Sphoeroides parvus	S158	0	0	0	0	1.3	1.25	0	0	0	0	0	0	0.5	0.5	0	0
Arius felis	S135	0.5	0.5	0.3	0.25	0	0	0	0	0	0	0	0	0.2	0.2	0.1	0.1
Achirus lineatus	S127	0	0	0.3	0.25	0	0	0.3	0.25	0	0	0	0	0	0	0.2	0.13
Eucinostomus argenteus	S151	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.2	0.13
Mugil cephalus	S106	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1
Syngnathus scovelli	S137	0	0	0	0	0	0	0.5	0.29	0	0	0	0	0	0	0.2	0.13
Chasmodes bosquianus	S164	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.1	0	0
Lagodon rhomboides	S103	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.1	0.1
Leiostomus xanthurus	S101	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.1	0.1
Myrophis punctatus	S114	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.1
Opsanus beta	S128	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.1	0	0
Unknown fish species	S152	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0	0
Cyprinodontidae		0.5	0.5	0	0	0.8	0.25	0	0	3.5	3.5	0	0	1.2	0.68	0	0
Gobiidae		3	1.22	0	0	2	2	1	0.41	24	10	2	1	6.8	3.35	0.8	0.33
Sciaenidae		1	0.71	0	0	0	0	0.3	0.25	0	0	0.5	0.5	0.4	0.31	0.2	0.13
Bait Fishes		0.3	0.25	1.3	0.48	0	0	1.8	1.44	0	0	42	41	0.1	0.1	9.6	8.17
Commercial Sports Fishes		1	0.71	0	0	0	0	0.3	0.25	0	0	0	0	0.4	0.31	0.1	0.1
TOTAL FISHES:		5.5	1.04	3	0	4.8	4.09	5.5	3.28	27.5	6.5	47.5	43.5	9.6	3.5	12.9	8.77
CRUSTACEANS:																	
Palaemonetes pugio	S403	148.5	19.05	1.3	0.75	281.5	78.75	1.5	0.64	190	7	1	1	210	35.79	1.3	0.40
Penaeus setiferus	S401	19.8	9.85	6.3	1.89	3.8	2.18	1.3	0.95	2	1	0	0	9.8	4.58	3	1.18
Penaeus aztecus	S400	13.3	4.03	0.3	0.25	6.5	2.18	4	2.16	11.5	2.5	1.5	0.5	10.2	2.00	2	0.98
Callinectes sapidus	S404	2.8	1.03	0	0	11	2.86	1.8	1.44	1.5	1.5	0	0	5.8	1.82	0.7	0.60
Clibanarius vittatus	S408	0	0	0	0	6	2	0.3	0.25	11.5	4.5	0	0	4.7	1.75	0.1	0.1
Penaeus duorarum	S402	3.8	1.03	0	0	1.8	1.18	0.8	0.75	6	1	4	0	3.4	0.79	1.1	0.57
Petrolisthes galathinus	S434	0	0	0	0	3.3	3.25	0	0	3.5	3.5	0	0	2	1.41	0	0
Alphaeus heterochaelis	S405	0	0	0	0	2.3	1.93	0.3	0.25	0	0	0	0	0.9	0.79	0.1	0.1
Neopanope texana	S435	0	0	0	0	1.5	1.19	0	0	1.5	0.5	0.5	0.5	0.9	0.5	0.1	0.1
Panopeus herbstii	S440	0	0	0	0	0	0	0	0	2	2	0	0	0.4	0.4	0	0
Uca pugnax	S406	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.1	0.1	0	0
Unknown crustacean species	S431	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0	0
Grass Shrimp		148.5	19.05	1.3	0.75	281.5	78.75	1.5	0.65	190	7	1	1	210	35.78	1.3	0.4
Penaeid Shrimp		36.8	9.83	6.5	2.06	12	4.14	6	3.16	19.5	2.5	5.5	0.5	23.4	5.42	6.1	1.39
TOTAL CRUSTACEANS:		188.3	24.81	7.8	2.69	317.5	85.85	9.8	3.99	230	5	7	0	248.3	38.03	8.4	1.8

APPENDIX II. Means and standard errors of macrofaunal densities comparing microhabitats of coast and delta marshes in Lavaca Bay in the fall of 1985, and spring and summer of 1986.

LAVACA BAY STUDY COASTAL LOCATIONS October 15-18, 1985 Macrofauna/2.8 m sq. (n=4) Samples not paired SPECIES	CODE	CHOCOLATE BAY Spartina MEAN	S.E.	Non-vegetated MEAN	S.E.	KELLER BAY Spartina MEAN	S.E.	Non-vegetated MEAN	S.E.	POWDERHORN LAKE Spartina MEAN	S.E.	Non-vegetated MEAN	S.E.	OVERALL MEANs AND S.E.s Based on n = 12 Spartina MEAN	S.E.	Non-vegetated MEAN	S.E.
FISHES:																	
Anchoa mitchilli	S120	1.3	0.75	28.8	20.33	0.3	0.25	2.8	2.43	0.3	0.25	2.3	1.65	0.6	0.29	11.3	7.23
Gobiosoma bosci	S105	15.5	5.42	0	0	3.8	2.59	0.3	0.25	10.5	4.98	0	0	9.9	2.76	0.1	0.08
Gobionellus boleosoma	S116	6	1.68	0	0	2.8	0.85	0	0	14	3.67	0.8	0.75	7.6	1.89	0.3	0.25
Symphurus plagiusa	S113	1.3	0.25	0.3	0.25	1.8	1.03	0.3	0.25	0.5	0.29	0.3	0.25	1.2	0.37	0.3	0.13
Microgobius gulosus	S126	0	0	1.5	0.5	0	0	0.5	0.5	0	0	1	0.71	0	0	1	0.33
Cynoscion nebulosus	S125	0.8	0.48	0	0	0.5	0.29	0	0	1	0.41	0	0	0.8	0.22	0	0
Syngnathus louisianae	S146	0.5	0.29	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0.4	0.19	0.1	0.08
Mugil cephalus	S106	0.5	0.29	0	0	0	0	0	0	0.5	0.29	0.3	0.25	0.3	0.14	0.1	0.08
Eucinostomus argenteus	S151	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0.5	0.5	0.2	0.11	0.2	0.17
Menidia beryllina	S110	0.3	0.25	0	0	0	0	0	0	0	0	0.5	0.5	0.1	0.08	0.2	0.17
Syngnathus scovelli	S137	0	0	0	0	0.8	0.48	0	0	0	0	0	0	0.3	0.18	0	0
Bathygobius soporator	S160	0	0	0	0	0	0	0	0	0.5	0.29	0	0	0.2	0.11	0	0
Fundulus grandis	S117	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.11	0	0
Lagodon rhomboides	S103	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.11	0	0
Leiostomus xanthurus	S101	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.2	0.17
Micropogonias undulatus	S108	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.2	0.17	0	0
Achirus lineatus	S127	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Archosargus probatocephalus	S130	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08
Sphoeroides parvus	S158	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Syngnathus floridae	S122	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Cyprinodontidae		0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.11	0	0
Gobiidae		21.5	6.9	1.5	0.5	6.5	3.43	0.8	0.48	25	8.58	1.8	1.03	17.7	4.24	1.3	0.4
Sciaenidae		0.8	0.48	0	0	1	0.41	0.5	0.5	1	0.41	0	0	0.9	0.23	0.2	0.17
Bait Fishes		2	1.08	28.8	20.33	0.3	0.25	2.8	2.43	1	0.71	2.5	1.55	1.1	0.45	11.3	7.22
Commercial/Sports Fishes		0.8	0.48	0	0	0.5	0.29	0	0	1	0.41	0	0	0.8	0.22	0	0
TOTAL FISHES:		27	7.74	30.8	19.71	10.8	4.21	4.3	2.29	28.8	9.28	5.8	2.39	22.2	4.57	13.6	7.05
CRUSTACEANS:																	
Palaemonetes pugio	S403	8.3	1.65	0	0	172.8	110.56	0	0	210.5	45.95	0.3	0.25	130.5	44.77	0.1	0.08
Hippolyte zostericola	S432	4.3	1.55	0	0	96.3	36.97	1	0.41	106.5	67.59	0	0	69	27.06	0.3	0.19
Tozeuma carolinesis	S420	2	0.82	0	0	80.8	19.41	0.8	0.75	93.3	77.09	0	0	58.7	26.89	0.3	0.25
Palaemonetes vulgaris	S436	0.5	0.29	0	0	45.3	35.67	0	0	54.8	14.41	2.5	2.5	33.5	13.62	0.8	0.83
Callinectes sapidus	S404	13.8	4.55	1.5	0.87	43.3	15.82	2.5	0.64	28.5	7.09	0	0	28.5	6.51	1.3	0.45
Penaeus duorarum	S402	30.8	6.76	2.5	0.87	21.3	7.20	0.3	0.25	17	2.68	0.5	0.5	23	3.54	1.1	0.43
Penaeus setiferus	S401	11.3	3.70	2.8	2.10	11.8	6.03	0.3	0.25	15	8.07	4.8	4.75	12.7	3.28	2.6	1.66
Penaeus aztecus	S400	3.5	1.04	0.3	0.25	2.3	0.75	0.5	0.29	25.8	11.65	0.3	0.25	10.5	4.81	0.3	0.14
Palaemonetes intermedius	S437	0.5	0.5	0	0	6.5	6.17	0	0	9.5	5.85	0	0	5.5	2.81	0	0
Neopanope texana	S435	0	0	0	0	1.8	1.44	0	0	6.5	1.94	0	0	2.8	1.1	0	0
Alphaeus heterochaelis	S405	0	0	0	0	1.3	1.25	0	0	4.3	2.84	0	0	1.8	1.08	0	0
Clibanarius vittatus	S408	0	0	0	0	2.0	1.22	0.3	0.25	1.5	1.5	0.3	0.25	1.2	0.64	0.2	0.11
Uca pugnax	S406	0	0	0	0	0	0	0	0	3.5	3.5	0	0	1.2	1.17	0	0
Pagurus spp.	S429	0	0	0	0	0.3	0.25	1.8	1.75	0	0	0	0	0.1	0.08	0.6	0.58
Libinia dubia	S438	0	0	0	0	0.5	0.29	0	0	0.3	0.25	0	0	0.3	0.13	0	0
Eurypanopeus depressus	S439	0	0	0	0	0	0	0	0	0.5	0.29	0	0	0.2	0.11	0	0
Unknown crustacean species	S431	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.2	0.17
Latreutes parvulus	S430	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08	0	0
Panopeus herbstii	S440	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Petrolisthes galathinus	S434	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Sesarma reticulatum	S407	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Grass Shrimp		9.3	1.89	0	0	224.5	150.85	0	0	274.8	39.25	2.8	2.75	169.5	58.44	0.9	0.92
Penaeid Shrimp		45.5	9.84	5.5	2.33	35.3	11.41	1	0.41	57.8	17.56	5.5	4.56	46.2	7.51	4	1.67
TOTAL CRUSTACEANS:		74.8	13.49	7.5	1.85	486	217.01	7.3	2.36	578	112.53	8.5	4.17	379.6	99	7.8	1.56

APPENDIX II. Means and standard errors of macrofaunal densities comparing microhabitats of coast and delta marshes in Lavaca Bay in the fall of 1985, and spring and summer of 1986.

LAVACA BAY STUDY DELTA LOCATIONS October 15-18, 1985 Macrofauna/2.8 m sq. (n=4) Samples not paired		LAVACA DELTA EAST				LAVACA DELTA RIVER				LAVACA DELTA WEST				OVERALL MEANs AND S.E.s Based on n = 12			
		Juncus		Non-vegetated		Juncus		Non-vegetated		Juncus		Non-vegetated		Juncus		Non-vegetated	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																	
Gobiosoma bosci	S105	45.8	10.09	2.8	1.89	25.8	5.78	0.5	0.29	16.8	4.21	3	1.78	29.4	5.22	2.1	0.86
Anchoa mitchilli	S120	9.3	2.18	15	14.02	0	0	20.5	14.06	1.5	1.5	16.8	5.25	3.6	1.46	17.4	6.23
Fundulus grandis	S117	1	0.71	0	0	8	7.67	0	0	0.3	0.25	0	0	3.1	2.55	0	0
Symphurus plagiusa	S113	0.3	0.25	0	0	1.8	1.44	2.3	0.95	1	0.71	1.3	0.75	1	0.52	1.2	0.46
Microgobius gulosus	S126	0	0	3	0.82	0	0	2.5	0.87	0	0	0.3	0.25	0	0	1.9	0.51
Adina xenica	S133	0	0	0	0	4.8	4.42	0	0	0	0	0	0	1.6	1.49	0	0
Gobionellus boleosoma	S116	0.3	0.25	0	0	1.5	0.87	0	0	0.3	0.25	0	0	0.7	0.33	0	0
Cynoscion nebulosus	S125	0.8	0.48	0	0	0	0	0.3	0.25	0.5	0.5	0	0	0.4	0.23	0.1	0.08
Myrophis punctatus	S114	0.3	0.25	0	0	0.3	0.25	0.3	0.25	0	0	0.3	0.25	0.2	0.11	0.2	0.11
Fundulus pulvereus	S142	0	0	0	0	1	1	0	0	0	0	0	0	0.3	0.33	0	0
Fundulus similis	S107	0	0	0	0	1	1	0	0	0	0	0	0	0.3	0.33	0	0
Gobiesox sturmosus	S159	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.2	0.17	0	0
Arius felis	S135	0.3	0.25	0	0	0	0	0	0	0	0	0.3	0.25	0.1	0.08	0.1	0.08
Citharicthys spilopterus	S115	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08
Cyprinodon variegatus	S111	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08	0	0
Sphoeroides parvus	S158	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08
Cyprinodontidae		1	0.71	0	0	15	13.02	0	0	0.3	0.25	0	0	5.4	4.43	0	0
Gobiidae		46	9.86	5.8	1.8	27.3	5.62	3	0.58	17	4.18	3.3	2.02	30.1	5.14	4	0.91
Sciaenidae		0.8	0.48	0	0	0	0	0.3	0.25	0.5	0.5	0	0	0.4	0.23	0.1	0.08
Bait Fishes		9.3	2.17	15	14.02	0	0	20.5	14.06	1.5	1.5	16.8	5.25	3.6	1.46	17.4	6.23
Commercial/Sports Fishes		0.8	0.48	0	0	0	0	0.3	0.25	0.5	0.5	0	0	0.4	0.23	0.1	0.08
TOTAL FISHES:		57.8	9.89	20.8	15.79	44.3	10.14	26.5	12.74	20.8	4.37	22.0	3.39	40.9	6.42	23.1	6.25
CRUSTACEANS:																	
Palaemonetes pugio	S403	96	22.47	0	0	59.8	17.96	0	0	127.3	49.08	0	0	94.3	19.06	0	0
Callinectes sapidus	S404	35	11.97	0.3	0.25	56.8	9.74	1	1	33.8	9.46	1.3	0.63	41.8	6.32	0.8	0.39
Neopanope texana	S435	25.5	8.25	0.3	0.25	7.8	4.37	1.3	0.48	33	15.24	1.8	1.75	22.1	6.26	1.1	0.58
Penaeus aztecus	S400	25.8	6.05	1.5	0.29	12	4.55	2	0.91	14.5	4.41	0.8	0.48	17.4	3.20	1.4	0.36
Penaeus duorarum	S402	18.8	4.31	0.5	0.29	19	5.92	0.5	0.5	9.5	3.4	1.5	0.96	15.8	2.78	0.8	0.37
Penaeus setiferus	S401	13.5	4.91	0.8	0.48	2	1.08	0.8	0.48	13	10.16	1.8	1.03	9.5	3.77	1.1	0.4
Palaemonetes intermedius	S437	0.8	0.75	0	0	0	0	0	0	2.5	1.66	0	0	1.1	0.63	0	0
Palaemonetes vulgaris	S436	1.5	1.5	0	0	0	0	0	0	1.8	1.03	0	0	1.1	0.6	0	0
Clibanarius vittatus	S408	0	0	0	0	1.3	0.48	0	0	1.3	1.25	0	0	0.8	0.44	0	0
Sesarma reticulatum	S407	0	0	0	0	0	0	0	0	1	0.58	0	0	0.3	0.22	0	0
Petrolisthes galathinus	S434	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.2	0.17	0	0
Uca pugnax	S406	0	0	0	0	0	0	0	0	0.5	0.29	0	0	0.2	0.11	0	0
Panopeus herbstii	S440	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Grass Shrimp		98.3	23.01	0	0	59.8	17.96	0	0	131.5	49	0	0	96.5	19.34	0	0
Penaeid Shrimp		58	14.26	2.8	0.48	33	9.51	3.3	1.11	37	17.02	4	1.63	42.7	8	3.3	0.63
TOTAL CRUSTACEANS:		216.8	30.17	3.3	0.48	158.5	27.31	5.5	0.87	238.8	55.54	7.0	3.34	204.7	23.14	5.3	1.15

APPENDIX II. Means and standard errors of macrofaunal densities comparing microhabitats of coast and delta marshes in Lavaca Bay in the fall of 1985, and spring and summer of 1986.

LAVACA BAY STUDY
COASTAL LOCATIONS
May 26-30, 1986
Macrofauna/2.8 m sq. (n=4)
Paired samples

SPECIES	CODE	CHOCOLATE BAY Spartina MEAN	CHOCOLATE BAY Spartina S.E.	CHOCOLATE BAY Non-vegetated MEAN	CHOCOLATE BAY Non-vegetated S.E.	KELLER BAY Spartina MEAN	KELLER BAY Spartina S.E.	KELLER BAY Non-vegetated MEAN	KELLER BAY Non-vegetated S.E.	POWDERHORN LAKE Spartina MEAN	POWDERHORN LAKE Spartina S.E.	POWDERHORN LAKE Non-vegetated MEAN	POWDERHORN LAKE Non-vegetated S.E.	OVERALL MEANS AND S.E.s (Based on n = 12) Spartina MEAN	OVERALL Spartina S.E.	OVERALL Non-vegetated MEAN	OVERALL Non-vegetated S.E.
FISHES:																	
Brevoortia patronus	S100	0	0	44.5	44.17	0	0	0.5	0.5	0	0	0.8	0.75	0	0	15.3	14.71
Anchoa mitchilli	S120	1.8	1.03	4.5	1.94	0	0	10.5	7.01	0	0	2	2	0.6	0.4	5.7	2.51
Bairdiella chrysoura	S131	1.8	1.18	0	0	9.5	7.92	2.3	2.25	2.8	2.14	0	0	4.7	2.71	0.8	0.75
Gobiosoma bosci	S105	1	0.71	0	0	4.3	2.63	5.3	4.31	1.5	0.64	1	0.71	2.3	0.95	2.1	1.48
Lagodon rhomboides	S103	1	0.41	0	0	1.5	0.5	0.3	0.25	3.8	1.44	0.8	0.25	2.1	0.6	0.3	0.14
Fundulus grandis	S117	2.3	1.32	0	0	2.3	1.93	0	0	0	0	0	0	1.5	0.77	0	0
Menidia beryllina	S110	0	0	1.3	0.75	1.3	1.25	0.5	0.5	0	0	1	0.71	0.4	0.42	0.9	0.36
Gobionellus boleosoma	S116	0	0	0	0	0	0	0	0	2	0.41	1	0.41	0.7	0.31	0.3	0.19
Leiostomus xanthurus	S101	0.3	0.25	0.8	0.48	0	0	0	0	0	0	0.5	0.5	0.1	0.08	0.4	0.23
Orthopristis chrysoptera	S123	0	0	0	0	0	0	0.3	0.25	1	0.71	0.3	0.25	0.3	0.26	0.2	0.11
Paralichthys lethostigma	S104	0.5	0.29	0	0	0.8	0.48	0	0	0	0	0.3	0.25	0.4	0.19	0.1	0.08
Syngnathus scovelli	S137	0	0	0	0	0.5	0.5	0	0	1	0.71	0	0	0.5	0.29	0	0
Arius felis	S135	0	0	0.3	0.25	0.5	0.5	0.3	0.25	0	0	0	0	0.2	0.17	0.2	0.11
Cyprinodon variegatus	S111	0	0	0.3	0.25	0.5	0.5	0	0	0	0	0	0	0.2	0.17	0.1	0.08
Gobiesox sturmosus	S159	0	0	0	0	0.3	0.25	0	0	0.5	0.5	0	0	0.3	0.18	0	0
Archosargus probatocephalus	S130	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.11	0	0
Citharicthys spilopterus	S115	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.2	0.17
Mugil cephalus	S106	0.3	0.25	0	0	0.3	0.25	0	0	0	0	0	0	0.2	0.11	0	0
Symphurus plagiusa	S113	0	0	0	0	0	0	0.3	0.25	0.3	0.25	0	0	0.1	0.08	0.1	0.08
Adina xenica	S133	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Chaetodipterus faber	S163	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08	0	0
Cynoscion arenarius	S143	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08
Cynoscion nebulosus	S125	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08	0	0
Sciaenops ocellatus	S121	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08
Syngnathus louisianae	S146	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Unknown fish species	S152	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08
Cyprinodontidae		2.3	1.31	0.3	0.25	2.8	2.43	0	0	0.3	0.25	0	0	1.8	0.9	0.1	0.08
Gobiidae		1	0.71	0	0	4.3	2.63	5.3	4.31	3.5	0.5	2	0.82	2.9	0.93	2.4	1.47
Sciaenidae		2	1.41	1	0.71	9.8	8.17	2.3	2.25	2.8	2.14	0.8	0.48	4.8	2.79	1.3	0.75
Bait Fishes		3	1.22	4.5	1.94	-1.8	0.25	10.8	7.25	3.8	1.44	2.8	2.1	2.8	0.63	6	2.57
Commercial/Sports Fishes		0.5	0.29	0	0	1	0.58	0	0	0	0	0.5	0.29	0.5	0.23	0.2	0.11
TOTAL FISHES:		9.3	0.75	51.8	45.46	22	11.37	20.3	9.76	13.3	5.25	8.3	3.12	14.8	4.11	26.8	15.10
CRUSTACEANS:																	
Palaemonetes pugio	S403	224	61.56	1	0.58	380.5	206.16	4.8	4.11	619.3	187.46	1	0.71	407.9	99.02	2.3	1.38
Penaeus aztecus	S400	58.8	14.33	5.8	1.38	51	15.91	16	13.39	72.8	24	22.8	19.75	60.8	10.07	14.8	7.51
Palaemonetes vulgaris	S436	0	0	0	0	0.8	0.75	0	0	55.3	30.03	0	0	18.7	11.95	0	0
Penaeus setiferus	S401	34	15.48	4.3	1.03	6.3	2.18	1	0.71	0	0	0.8	0.75	13.4	6.48	2	0.65
Hippolyte zostericola	S432	0	0	0	0	2.3	2.25	6	6	36	24.04	0	0	12.8	8.81	2	2
Palaemonetes intermedius	S437	1.3	1.25	0	0	2.5	2.5	0.8	0.75	34.3	19.78	0	0	12.7	7.58	0.3	0.25
Callinectes sapidus	S404	3.3	0.48	0.3	0.25	5.8	2.25	1.5	0.64	8.3	2.32	2.5	1.56	5.8	1.16	1.4	0.58
Clibanarius vittatus	S408	1.3	0.63	0	0	3	1.15	0.3	0.25	8	3.51	2.5	1.66	4.1	1.42	0.9	0.61
Tozeuma carolinesis	S420	0	0	0	0	0	0	9.8	9.42	0	0	0	0	0	0	3.3	3.16
Alphaeus heterochaelis	S405	0.3	0.25	0	0	4.8	4.75	0	0	4	0.91	0	0	3	1.58	0	0
Neopanope texana	S435	0	0	0	0	0.3	0.25	0	0	1.5	1.19	0	0	0.6	0.42	0	0
Sesarma reticulatum	S407	0	0	0	0	0	0	0	0	1	1	0	0	0.3	0.33	0	0
Pagurus spp.	S429	0	0	0	0	0.3	0.25	0	0	0	0	0.5	0.29	0.1	0.08	0.2	0.11
Unknown crustacean species	S431	0	0	0	0	0	0	0.8	0.48	0	0	0	0	0	0	0.3	0.18
Panopeus herbstii	S440	0	0	0	0	0	0	0	0	0.5	0.29	0	0	0.2	0.11	0	0
Eurypanopeus depressus	S439	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08	0	0
Grass Shrimp		225.3	61.74	1	0.58	383.8	205.8	5.5	4.86	708.8	231.03	1	0.71	439.3	112.83	2.5	1.62
Penaeid Shrimp		92.8	25.52	10	0.71	57.3	15.5	17	14.04	72.8	24	23.5	20.5	74.3	12.35	16.8	7.68
TOTAL CRUSTACEANS:		322.8	86.32	11.3	1.31	457.3	224.61	40.8	35.48	841	255.75	30	24	540.3	124.87	27.3	13.43

APPENDIX II. Means and standard errors of macrofaunal densities comparing microhabitats of coast and delta marshes in Lavaca Bay in the fall of 1985, and spring and summer of 1986.

LAVACA BAY STUDY DELTA LOCATIONS May 26-30, 1986 Macrofauna/2.8 m sq. (n=4) Paired samples		LAVACA DELTA EAST				LAVACA DELTA RIVER				LAVACA DELTA WEST				OVERALL MEANs AND S.E.s Based on n = 12			
		Juncus		Non-vegetated		Juncus		Non-vegetated		Juncus		Non-vegetated		Juncus		Non-vegetated	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																	
Brevoortia patronus	S100	0	0	0.3	0.25	0	0	46.5	46.5	0	0	10.5	6.06	0	0	19.1	15.35
Anchoa mitchilli	S120	0	0	0	0	0.3	0.25	4.3	4.25	0.8	0.75	10.5	10.5	0.3	0.26	4.9	3.66
Gobiosoma bosci	S105	4	0.71	2.5	1.89	2.3	0.85	1.3	0.95	3	1.78	0.8	0.48	3.1	0.67	1.5	0.69
Menidia beryllina	S110	1.5	1.5	1.3	0.75	0	0	0.3	0.25	0	0	1.3	1.25	0.5	0.5	0.9	0.47
Lagodon rhomboides	S103	1.5	0.64	0.3	0.25	1.5	0.64	0	0	0.3	0.25	0.5	0.29	1.1	0.34	0.3	0.13
Opsanus beta	S128	0.3	0.25	2.8	2.43	0	0	0	0	0	0	0	0	0.1	0.08	0.9	0.83
Paralichthys lethostigma	S104	0.3	0.25	0.8	0.25	1	1	0.3	0.25	0	0	0	0	0.4	0.34	0.3	0.14
Fundulus grandis	S117	0.3	0.25	0	0	1	0.41	0	0	0.8	0.75	0	0	0.7	0.28	0	0
Sphoeroides parvus	S158	0	0	0.8	0.48	0	0	1	0.41	0	0	0	0	0	0	0.6	0.23
Bairdiella chrysoura	S131	0.8	0.75	0	0	0	0	0	0	0.5	0.5	0	0	0.4	0.29	0	0
Leiostomus xanthurus	S101	0.3	0.25	0	0	0	0	0.8	0.48	0	0	0	0	0.1	0.08	0.3	0.18
Cyprinodon variegatus	S111	0	0	0	0	0.8	0.48	0	0	0	0	0	0	0.3	0.18	0	0
Arius felis	S135	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08
Gobiosoma robustum	S162	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Myrophis punctatus	S114	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08
Sciaenops ocellatus	S121	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08
Syngnathus louisianae	S146	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Cyprinodontidae		0.3	0.25	0	0	1.8	0.48	0	0	0.8	0.75	0	0	0.9	0.34	0	0
Gobiidae		4.3	0.75	2.5	1.89	2.3	0.85	1.3	0.95	3	1.78	0.8	0.48	3.2	0.68	1.5	0.69
Sciaenidae		1	0.71	0	0	0	0	1	0.41	0.5	0.5	0	0	0.5	0.29	0.3	0.19
Bait Fishes		1.5	0.65	0.3	0.25	1.8	0.75	4.3	4.25	1	1	11	10.34	1.4	0.43	5.2	3.63
Commercial/Sports Fishes		0.3	0.25	0.8	0.25	1	1	0.5	0.29	0	0	0	0	0.4	0.34	0.4	0.15
TOTAL FISHES:		9.3	1.93	8.8	4.09	6.8	2.66	54.5	45.69	5.3	2.39	23.8	16.51	7.1	1.32	29	15.78
CRUSTACEANS:																	
Palaemonetes pugio	S403	165	29.92	1	0.41	168.3	55.84	0.3	0.25	37.3	30.92	0.5	0.29	123.5	28.11	0.6	0.19
Penaeus aztecus	S400	42.8	5.04	8.8	2.32	39.3	6.13	4.8	1.11	26.3	5.76	6.8	1.25	36.1	3.65	6.8	0.99
Penaeus setiferus	S401	47.3	30.33	11	5.8	3.5	2.18	0.5	0.5	0.3	0.25	0	0	17	11.22	3.8	2.33
Callinectes sapidus	S404	3.5	1.32	1.3	0.75	7.8	3.12	0.3	0.25	2	1	0.5	0.5	4.4	1.29	0.7	0.31
Neopanope texana	S435	6	3.24	3.3	3.25	2.8	0.95	0	0	2.3	1.03	0.3	0.25	3.7	1.18	1.2	1.08
Palaemonetes intermedius	S437	2.8	1.03	0	0	1.3	1.25	0	0	1	1	0	0	1.7	0.62	0	0
Rhithropanopeus harrisii	S445	0.5	0.5	2	2	0	0	0	0	0	0	0	0	0.2	0.17	0.7	0.67
Alphaeus heterochaelis	S405	0	0	1.5	0.96	0.3	0.25	0	0	0	0	0	0	0.1	0.08	0.5	0.36
Palaemonetes vulgaris	S436	0	0	0	0	1.3	1.25	0	0	0.3	0.25	0	0	0.5	0.42	0	0
Sesarma reticulatum	S407	0	0	0	0	0.5	0.5	0	0	0.8	0.75	0	0	0.4	0.29	0	0
Eurypanopeus depressus	S439	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0.3	0.33
Hippolyte zostericola	S432	0.8	0.75	0	0	0	0	0	0	0.3	0.25	0	0	0.3	0.26	0	0
Clibanarius vittatus	S408	0	0	0	0	0.5	0.29	0.3	0.25	0	0	0	0	0.2	0.11	0.1	0.08
Menippe mercenaria	S409	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08	0	0
Grass Shrimp		167.8	29.53	1	0.41	170.8	57.22	0.3	0.25	38.5	31.84	0.5	0.29	125.7	28.54	0.6	0.19
Penaeid Shrimp		90	34.21	19.8	5.76	42.8	7.49	5.3	1.49	26.5	5.85	6.8	1.25	53.1	13.44	10.6	2.69
TOTAL CRUSTACEANS:		268.5	14.1	28.8	6.79	225.5	60.73	7	2.65	70.3	34.78	8	1	188.1	33.5	14.6	3.75

APPENDIX II. Means and standard errors of macrofaunal densities comparing microhabitats of coast and delta marshes in Lavaca Bay in the fall of 1985, and spring and summer of 1986.

LAVACA BAY STUDY NON-VEGETATED SAMPLES COASTAL VS. DELTA LOCATIONS August 19-20, 1986 Macrofauna/2.8 m sq. (n=4) Samples not paired		COASTAL SITES						DELTA SITES						OVERALL MEANS AND S.E.s Based on n = 12			
		Chocolate Bay		Keller Bay		Powderhorn Lake		Lavaca Delta East		Lavaca Delta River		Lavaca Delta West		Coastal		Delta	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																	
Anchoa mitchilli	S120	0.8	0.48	0	0	0.5	0.5	1.3	0.95	4.5	2.22	17	17	0.4	0.23	7.6	5.57
Gobiosoma bosci	S105	0	0	0.3	0.25	0	0	2.3	1.93	1	0.71	10	8.12	0.1	0.08	4.4	2.8
Mugil cephalus	S106	0	0	0	0	7.5	4.35	0	0	0	0	0	0	2.5	1.69	0	0
Menidia beryllina	S110	0	0	0	0	0.5	0.5	5.5	5.17	0.3	0.25	0	0	0.2	0.17	1.9	1.74
Gobionellus boleosoma	S116	0	0	0	0	3.25	2.63	0	0	0	0	0	0	1.1	0.92	0	0
Symphurus plagiusa	S113	0	0	1	1	0.5	0.5	0	0	0.3	0.25	0.3	0.25	0.5	0.36	0.2	0.11
Cynoscion nebulosus	S125	0.3	0.25	0	0	0.75	0.48	0	0	0	0	0	0	0.3	0.19	0	0
Achirus lineatus	S127	0	0	0.3	0.25	0.5	0.5	0	0	0	0	0	0	0.3	0.18	0	0
Myrophis punctatus	S114	0	0	0	0	0	0	0.3	0.25	0	0	0.5	0.5	0	0	0.3	0.18
Leiostomus xanthurus	S101	0	0	0	0	0.5	0.29	0	0	0	0	0	0	0.2	0.11	0	0
Paralichthys lethostigma	S104	0	0	0	0	0.25	0.25	0.3	0.25	0	0	0	0	0.1	0.08	0.1	0.08
Cynoscion nothus	S156	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Eucinostomus argenteus	S151	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.08
Orthopristis chrysoptera	S123	0	0	0	0	0.25	0.25	0	0	0	0	0	0	0.1	0.08	0	0
Cyprinodontidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiidae		0	0	0.3	0.25	4.3	2.39	2.3	1.93	1	0.71	10	8.12	1.5	0.93	4.4	2.8
Sciaenidae		0.5	0.5	0	0	1.3	0.63	0	0	0	0	0	0	0.6	0.29	0	0
Bait Fishes		0.8	0.48	0	0	8	4.62	1.3	0.95	4.5	2.22	17	17	2.9	1.77	7.6	5.57
Commercial/Sports Fishes		0.3	0.25	0	0	1	0.58	0.3	0.25	0	0	0	0	0.4	0.23	0.1	0.08
TOTAL FISHES:		1.3	0.48	1.5	1.19	15.5	8.67	9.8	5.53	6	2.12	27.8	16.02	6.1	3.32	14.5	5.89
CRUSTACEANS:																	
Penaeus setiferus	S401	16.8	12.01	0.5	0.5	17.5	15.19	29.5	24.97	1	0.71	20.5	17.86	11.6	6.3	17	9.93
Palaemonetes pugio	S403	5	3.14	0	0	0.5	0.29	8.3	8.25	0.3	0.25	0.8	0.48	1.8	1.17	3.1	2.73
Penaeus aztecus	S400	1.3	1.25	3.8	2.25	0.75	0.25	1.5	0.96	2.8	1.6	3	1.08	1.9	0.87	2.4	0.68
Penaeus duorarum	S402	1	0.58	2	1.15	3	3	1.8	1.44	0.8	0.25	0.8	0.75	2	1.02	1.1	0.51
Callinectes sapidus	S404	0.3	0.25	0.8	0.75	2.25	1.03	0	0	4.8	4.75	1	0.71	1.1	0.47	1.9	1.57
Neopanope texana	S435	0	0	0	0	0.25	0.25	1.3	0.75	0.5	0.5	4.3	2.21	0.1	0.08	2	0.87
Panopeus herbstii	S440	0	0	0	0	0	0	0	0	0	0	0.8	0.48	0	0	0.3	0.18
Eurypanopeus depressus	S439	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.2	0.17
Clibanarius vittatus	S408	0	0	0	0	0.25	0.25	0	0	0	0	0.3	0.25	0.1	0.08	0.1	0.08
Alphaeus heterochaelis	S405	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08
Tozeuma carolinesis	S420	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Grass Shrimp		5	3.14	0	0	0.5	0.29	8.3	8.25	0.3	0.25	0.8	0.48	1.8	1.17	3.1	2.73
Penaeid Shrimp		19	11.68	6.3	3.61	21.3	14.61	32.8	27.28	4.5	2.33	24.3	18.06	15.5	6.08	20.5	10.51
TOTAL CRUSTACEANS:		24.3	13.81	7.3	3.99	24.5	15.82	42.3	36.11	10	7.22	32	17.55	18.7	6.89	28.1	12.95

APPENDIX III. Means and standard errors of macrofaunal densities comparing _Spartina_ and _Juncus_ microhabitats within marshes in Lavaca Bay in the fall of 1985 and spring of 1986.

LAVACA BAY STUDY Juncus vs. Spartina October 15-18, 1985 Macrofauna/2.8 m sq. (n=4) Samples not paired		Chocolate Bay Site				Lavaca Delta River				OVERALL MEANs AND S.E.s (n=8)			
		Juncus		Spartina		Juncus		Spartina		Juncus		Spartina	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:													
Gobiosoma bosci	S105	16.3	5.95	15.5	5.42	25.8	5.78	23.5	8.82	15.9	3.73	24.6	4.9
Fundulus grandis	S117	0	0	0.3	0.25	8	7.67	12.3	5.36	0.1	0.13	10.1	4.41
Gobioneilus boleosoma	S116	0.8	0.75	6	1.68	1.5	0.87	2.8	1.8	3.4	1.31	2.1	0.95
Anchoa mitchilli	S120	7.5	3.66	1.3	0.75	0	0	0	0	4.4	2.1	0	0
Symphurus plagiusa	S113	0	0	1.3	0.25	1.8	1.44	3	1.47	0.6	0.26	2.4	0.98
Adina xenica	S133	0	0	0	0	4.8	4.42	0	0	0	0	2.4	2.24
Cynoscion nebulosus	S125	1.5	0.87	0.8	0.48	0	0	0.5	0.5	1.1	0.48	0.3	0.25
Fundulus pulvereus	S142	0	0	0	0	1	1	0	0	0	0	0.5	0.5
Fundulus similis	S107	0	0	0	0	1	1	0	0	0	0	0.5	0.5
Gobiesox sturmosus	S159	0	0	0	0	0	0	1	0.41	0	0	0.5	0.27
Sphoeroides parvus	S158	0.3	0.25	0.3	0.25	0	0	0.3	0.25	0.3	0.16	0.1	0.13
Syngnathus louisianae	S146	0	0	0.5	0.29	0	0	0.3	0.25	0.3	0.16	0.1	0.13
Cyprinodon variegatus	S111	0	0	0	0	0.3	0.25	0.3	0.25	0	0	0.3	0.16
Microgobius gulosus	S126	0.5	0.5	0	0	0	0	0	0	0.3	0.25	0	0
Mugil cephalus	S106	0	0	0.5	0.29	0	0	0	0	0.3	0.16	0	0
Eucinostomus argenteus	S151	0	0	0.3	0.25	0	0	0	0	0.1	0.13	0	0
Lagodon rhomboides	S103	0	0	0.3	0.25	0	0	0	0	0.1	0.13	0	0
Menidia beryllina	S110	0	0	0.3	0.25	0	0	0	0	0.1	0.13	0	0
Monacanthus hispidus	S161	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.13
Myrophis punctatus	S114	0	0	0	0	0.3	0.25	0	0	0	0	0.1	0.13
Paralichthys lethostigma	S104	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.13
Poecilia latipinna	S141	0.3	0.25	0	0	0	0	0	0	0.1	0.13	0	0
Syngnathus scovelli	S137	0.3	0.25	0	0	0	0	0	0	0.1	0.13	0	0
Cyprinodontidae		0	0	0.3	0.25	15	13.02	12.5	5.3	0.1	0.13	13.8	6.52
Gobiidae		17.5	5.56	21.5	6.9	27.3	5.62	26.3	10.36	19.5	4.17	26.8	5.46
Sciaenidae		1.5	0.87	0.8	0.48	0	0	0.5	0.5	1.1	0.48	0.3	0.25
Bait Fishes		7.5	3.66	2	1.08	0	0	0	0	4.8	2.05	0	0
Commercial Sports Fishes		1.5	0.87	0.8	0.48	0	0	0.8	0.48	1.1	0.48	0.4	0.26
TOTAL FISHES:		27.3	3.54	27	7.74	44.3	10.14	44.3	11.24	35.8	5.92	35.6	7.11
CRUSTACEANS:													
Palaemonetes pugio	S403	24.5	8.26	8.3	1.65	59.8	17.96	120.8	15.41	16.4	4.96	90.3	15.9
Callinectes sapidus	S404	29.8	7.54	13.8	4.55	56.8	9.74	35	15.98	21.8	5.08	45.9	9.59
Penaeus duorarum	S402	18.5	6.7	30.8	6.76	19	5.92	17	3.39	24.6	4.98	18	3.18
Penaeus aztecus	S400	7	3.24	3.5	1.04	12	4.55	28.8	9.99	5.3	1.71	20.4	5.98
Penaeus setiferus	S401	6.5	3.66	11.3	3.71	2	1.08	2	2	8.9	2.57	2	1.05
Neopanope texana	S435	1	0.58	0	0	7.8	4.37	6	2.48	0.5	0.33	6.9	2.35
Palaemonetes vulgaris	S436	0.3	0.25	0.5	0.29	0	0	5.5	3.28	0.4	0.18	2.8	1.84
Hippolyte zostericola	S432	0	0	4.3	1.55	0	0	0	0	2.1	1.08	0	0
Palaemonetes intermedius	S437	0.3	0.25	0.5	0.5	0	0	2	0.71	0.4	0.26	1	0.5
Clibanarius vittatus	S408	0	0	0	0	1.3	0.48	1	0.41	0	0	1.1	0.3
Tozeuma carolinesis	S420	0.3	0.25	2	0.82	0	0	0	0	1.1	0.52	0	0
Eurypanopeus depressus	S439	0	0	0	0	0	0	0.5	0.5	0	0	0.3	0.25
Alphaeus heterochaelis	S405	0.3	0.25	0	0	0	0	0	0	0.1	0.13	0	0
Grass Shrimp		25	8.24	9.3	1.89	59.8	17.96	128.3	16.39	17.1	4.92	94	17.15
Penaeid Shrimp		32	7.94	45.5	9.84	33	9.51	47.8	13.83	38.8	6.39	40.4	8.25
TOTAL CRUSTACEANS:		88.3	9.91	74.8	13.49	158.5	27.31	218.5	9.46	81.5	8.16	188.5	17.54

APPENDIX III. Means and standard errors of macrofaunal densities comparing <u>Spartina</u> and <u>Juncus</u> microhabitats within marshes in Lavaca Bay in the fall of 1985 and spring of 1986.

LAVACA BAY STUDY Spartina vs. Juncus May 28-29, 1986 Macrofauna/2.8 m sq. (n=4) Paired Samples		Chocolate Bay Site				Lavaca Delta River				OVERALL MEANs AND S.E.s (n=8)			
		Juncus		Spartina		Juncus		Spartina		Juncus		Spartina	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:													
Lagodon rhomboides	S103	0.5	0.29	1	0.41	1.5	0.64	10.5	6.03	1	0.38	5.8	3.33
Gobiosoma bosci	S105	6.3	3.88	1	0.71	2.3	0.85	1	0.71	4.3	1.99	1	0.46
Fundulus grandis	S117	3	2.68	2.3	1.32	1	0.41	1	0.71	2	1.31	1.6	0.73
Anchoa mitchilli	S120	3	3	1.8	1.03	0.3	0.25	0	0	1.6	1.49	0.9	0.58
Paralichthys lethostigma	S104	0.5	0.29	0.5	0.29	1	1	1.3	0.63	0.8	0.49	0.9	0.35
Bairdiella chrysoura	S131	0	0	1.8	1.18	0	0	0	0	0	0	0.9	0.64
Cyprinodon variegatus	S111	0	0	0	0	0.8	0.48	0.5	0.5	0.4	0.26	0.3	0.25
Brevoortia patronus	S100	0.5	0.5	0	0	0	0	0.3	0.25	0.3	0.25	0.1	0.13
Mugil cephalus	S106	0.5	0.29	0.3	0.25	0	0	0	0	0.3	0.16	0.1	0.13
Orthopristis chrysoptera	S123	0	0	0	0	0	0	0.8	0.48	0	0	0.4	0.26
Archosargus probatocephalus	S130	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.13
Leiostomus xanthurus	S101	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.13
Menidia beryllina	S110	0.3	0.25	0	0	0	0	0	0	0.1	0.13	0	0
Syngnathus louisianae	S146	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.13
Cyprinodontidae		3	2.68	2.3	1.31	1.8	0.48	1.5	0.65	2.4	1.28	1.9	0.69
Gobiidae		6.3	3.88	1	0.71	2.3	0.85	1	0.71	4.3	1.99	1	0.46
Sciaenidae		0	0	2	1.41	0	0	0	0	0	0	1	0.76
Bait Fishes		4	3.03	3	1.22	1.8	0.75	10.5	6.03	2.9	1.51	6.8	3.18
Commercial Sports Fishes		0.5	0.29	0.5	0.29	1	1	1.3	0.63	0.8	0.49	0.9	0.35
TOTAL FISHES:		14.5	3.5	9.3	0.75	6.8	2.66	15.3	6.57	10.6	2.51	12.3	3.27
CRUSTACEANS:													
Palaemonetes pugio	S403	357.5	148.67	224	61.56	168.3	55.84	84.8	13.12	262.9	81.75	154.4	39.26
Penaeus aztecus	S400	32.8	13.55	58.8	14.33	39.3	6.13	19.8	7.66	36	6.99	39.3	10.53
Penaeus setiferus	S401	16.8	8.89	34	15.48	3.5	2.18	0.8	0.75	10.1	4.92	17.4	9.54
Callinectes sapidus	S404	7	2.04	3.3	0.48	7.8	3.12	3.3	1.03	7.4	1.73	3.3	0.53
Neopanope texana	S435	1.3	0.75	0	0	2.8	0.95	3.5	2.60	2	0.63	1.8	1.37
Palaemonetes intermedius	S437	0.5	0.5	1.3	1.25	1.3	1.25	0.5	0.5	0.9	0.64	0.9	0.64
Clibanarius vittatus	S408	0	0	1.3	0.63	0.5	0.29	0.5	0.29	0.3	0.16	0.9	0.35
Panopeus herbstii	S440	0	0	0	0	0	0	2	2	0	0	1	1
Eurypanopeus depressus	S439	0	0	0	0	0	0	1.3	1.25	0	0	0.6	0.63
Palaemonetes vulgaris	S436	0	0	0	0	1.3	1.25	0	0	0.6	0.63	0	0
Alphaeus heterochaelis	S405	0	0	0.3	0.25	0.3	0.25	0	0	0.1	0.13	0.1	0.13
Sesarma reticulatum	S407	0	0	0	0	0.5	0.5	0	0	0.3	0.25	0	0
Menippe mercenaria	S409	0	0	0	0	0.3	0.25	0	0	0.1	0.13	0	0
Grass Shrimp		358	148.28	225.3	61.74	170.8	57.22	85.3	12.69	264.4	81.64	155.3	39.39
Penaeid Shrimp		49.5	15.97	92.8	25.52	42.8	7.49	20.5	7.8	46.1	8.26	56.6	18.41
TOTAL CRUSTACEANS:		415.8	156.24	322.8	86.32	225.5	60.73	116.3	19.56	320.6	85.52	219.5	56.58

APPENDIX IV. Means and standard errors of macrofaunal densities before and after flooding in Lavaca River delta marshes during October 1986 (Flood #1), May 1987 (Flood #2), and June 1987 (Flood #3).

LAVACA BAY STUDY
FRESHENING EVENT ONE
BEFORE EVENT
Macrofauna/2.8 m sq. (n=4)
October 21-22, 1986

SPECIES	CODE	LOWER DELTA								UPPER DELTA								OVERALL MEANS & S.E.s (n=16)			
		INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH							
		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
		MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																					
Gobiosoma bosci	S105	13.5	8.45	4	3.08	59.8	31.91	14.5	6.81	31	7.49	9.5	7.01	36.3	12.64	8.3	3.94	35.1	9.14	9.1	2.64
Anchoa mitchilli	S120	0	0	5	4.06	0	0	0	0	0.5	0.5	68	61.71	2.5	2.18	1.5	1.19	0.8	0.57	18.6	15.67
Cyprinodon variegatus	S111	13.8	8.51	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	3.5	2.44	0	0
Fundulus grandis	S117	6	4.71	0	0	1.8	1.44	0	0	0	0	0	0	0	0	0	0	1.9	1.27	0	0
Menidia beryllina	S110	1.5	1.5	0.3	0.25	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.4	0.38	0.1	0.06
Microgobius gulosus	S126	0	0	0	0	0	0	1.3	1.25	0	0	0	0	0	0	0	0	0	0	0.3	0.31
Paralichthys lethostigma	S104	0	0	0	0	0	0	0	0	0.8	0.48	0.3	0.25	0	0	0	0	0.2	0.14	0.1	0.06
Symphurus plagiusa	S113	0	0	0	0	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0.1	0.06	0.2	0.14
Cynoscion nebulosus	S125	0	0	0	0	0.5	0.29	0	0	0	0	0.3	0.25	0	0	0	0	0.1	0.08	0.1	0.06
Gobionellus boleosoma	S116	0	0	0	0	0.5	0.29	0.3	0.25	0	0	0	0	0	0	0	0	0.1	0.08	0.1	0.06
Syngnathus scovelli	S137	0	0	0	0	0.3	0.25	0	0	0.5	0.29	0	0	0	0	0	0	0.2	0.10	0	0
Achirus lineatus	S127	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.08
Fundulus pulvereus	S142	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.1	0.13	0	0
Syngnathus floridae	S122	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.29	0	0	0.1	0.08	0	0
Citharicthys spilopterus	S115	0	0	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0.1	0.06
Gobiosoma robustum	S162	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Lagodon rhomboides	S103	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Leiostomus xanthurus	S101	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06
Micropogonias undulatus	S108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.06
Cyprinodontidae		19.8	10.31	0	0	1.8	1.44	0	0	0.5	0.5	0	0	0.3	0.25	0	0	5.6	3.15	0	0
Gobiidae		13.5	8.45	4	3.08	60.3	32.2	16.3	8.23	31	7.49	9.5	7.01	36.3	12.64	8.3	3.94	35.3	9.21	9.5	2.90
Sciaenidae		0	0	0	0	0.5	0.29	0	0	0	0	0.5	0.5	0	0	0.3	0.25	0.1	0.09	0.2	0.14
Bait Fishes		0	0	5	4.06	0	0	0.3	0.25	0.5	0.5	68	61.71	2.5	2.18	1.5	1.19	0.8	0.57	18.7	15.67
Commercial Sports Fishes		0	0	0	0	0.5	0.29	0	0	0.8	0.48	0.5	0.29	0	0	0	0	0.3	0.15	0.1	0.09
TOTAL FISHES:		34.8	5.6	9.5	6.86	63.3	32.21	17.3	8.56	33.3	8.62	78.5	69.28	39.8	13.86	10.3	4.77	42.8	8.75	28.9	17.39
CRUSTACEANS:																					
Palaemonetes pugio	S403	51	17.57	0.5	0.5	65.8	5.81	0	0	16	8.38	0	0	140.5	56.82	0.3	0.25	68.31	17.88	0.2	0.14
Penaeus setiferus	S401	5	2.2	6.5	2.47	6.3	6.25	2	0.71	2.8	0.75	0.8	0.75	5.5	1.44	1.8	0.63	4.88	1.56	2.8	0.84
Callinectes sapidus	S404	3	1	0	0	3.5	2.22	0.3	0.25	4.8	0.63	0.3	0.25	7.3	2.87	0.5	0.29	4.63	0.95	0.3	0.11
Penaeus aztecus	S400	1	0.41	0	0	2.3	1.65	0	0	3.8	2.25	0	0	4	1.35	0.3	0.25	2.75	0.77	0.1	0.06
Neopanope texana	S435	0	0	0	0	2.5	1.89	1.3	1.25	1	0.58	0.3	0.25	0.3	0.25	0.3	0.25	0.94	0.51	0.4	0.32
Penaeus duorarum	S402	0.5	0.5	0	0	0.5	0.5	0	0	0.8	0.75	0	0	0.3	0.25	0.3	0.25	0.5	0.24	0.1	0.06
Palaemonetes intermedius	S437	0	0	0	0	0.3	0.25	0.8	0.75	0.5	0.29	0	0	0.5	0.5	0	0	0.31	0.15	0.2	0.19
Panopeus herbstii	S440	0	0	0	0	0	0	1.8	1.44	0	0	0.3	0.25	0	0	0	0	0	0	0.5	0.38
Palaemonetes vulgaris	S436	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.13	0.13	0	0
Sesarma reticulatum	S407	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.13	0.13	0	0
Rhithropanopeus harrisii	S445	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.06	0.06	0	0
Uca minax	S444	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.06	0.06	0	0
Xanthidae, unknown species	S412	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.06	0.06	0	0
Grass Shrimp		51	17.57	0.5	0.5	66	5.96	0.8	0.75	16.5	8.37	0	0	141.5	56.35	0.3	0.25	68.8	17.85	0.4	0.22
Penaeid Shrimp		6.5	2.53	6.5	2.47	9	8.35	2	0.71	7.3	2.5	0.8	0.75	9.8	1.93	2.3	0.85	8.1	2.1	2.9	0.84
TOTAL CRUSTACEANS:		60.5	18.98	7	2.86	82	10.52	6	1.22	29.5	9.94	1.5	0.5	159	52.57	3.25	0.85	82.8	17.86	4.4	0.92

APPENDIX IV. Means and standard errors of macrofaunal densities before and after flooding in Lavaca River delta marshes during October 1986 (Flood #1), May 1987 (Flood #2), and June 1987 (Flood #3).

LAVACA BAY STUDY
FRESHENING EVENT ONE
AFTER EVENT
Macrofauna/2.8 m sq. (n=4)
November 3-6, 1986

SPECIES	CODE	LOWER DELTA								UPPER DELTA								OVERALL MEANS & S.E.s (n=16)			
		INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH							
		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
		MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																					
Gobiosoma bosci	S105	50	11.2	2	0.82	21.3	8.5	6	3.24	37.3	5.07	3.5	1.32	39.8	10.13	2	0.71	37.1	4.84	3.4	0.92
Anchoa mitchilli	S120	1	0.71	67.8	52.8	0	0	0.5	0.29	10.5	10.5	16	7.72	10.8	6.97	7	3	5.6	3.11	22.8	13.77
Micropogonias undulatus	S108	0	0	13	6.42	0.8	0.75	0.8	0.75	0	0	0	0	0.5	0.5	0	0	0.3	0.22	3.4	2.03
Syngnathus scovelli	S137	0	0	0.3	0.25	0.3	0.25	0	0	1.8	1.18	0.3	0.25	1.5	0.96	0	0	0.9	0.40	0.1	0.08
Fundulus grandis	S117	2.5	1.66	0	0	0	0	0	0	0.3	0.25	0	0	0.3	0.25	0	0	0.8	0.46	0	0
Menidia beryllina	S110	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0.8	0.75	0.3	0.25	0.2	0.19	0.1	0.08
Gobionellus boleosoma	S116	0.5	0.5	0.3	0.25	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0.1	0.13	0.1	0.08
Cyprinodon variegatus	S111	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Cynoscion nebulosus	S125	0.3	0.25	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0.1	0.06
Eucinostomus argenteus	S151	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.14
Unknown fish species	S152	0	0	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.2	0.14
Fundulus pulvereus	S142	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.1	0.13	0	0
Symphurus plagiusa	S113	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.1	0.13	0	0
Microgobius gulosus	S126	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Mugil cephalus	S106	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Paralichthys lethostigma	S104	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Cyprinodontidae		3.5	2.6	0	0	0	0	0	0	0.8	0.75	0	0	0.3	0.25	0	0	1.1	0.71	0	0
Gobiidae		50.5	11.43	2.5	0.87	21.3	8.5	6.3	3.47	37.3	5.07	3.5	1.32	25.5	11.91	2	0.71	37.2	4.88	3.6	0.97
Sciaenidae		0.3	0.25	13.3	6.57	1	0.71	0.8	0.75	0	0	0	0	0.5	0.5	0	0	0.4	0.22	3.5	2.08
Bait Fishes		1	0.71	68	52.7	0	0	0.5	0.29	10.5	10.5	16	7.72	10.8	6.97	7	3	5.6	3.11	22.9	13.77
Commercial Sports Fishes		0.3	0.25	0.3	0.25	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0.1	0.09	0.1	0.09
FISH TOTALS:		55.3	13.14	84.8	54.64	22.5	9.44	8.5	4.27	50.3	12.09	19.8	8.86	54	16.14	9.5	3.43	45.5	6.74	30.6	14.87
CRUSTACEANS:																					
Palaemonetes pugio	S403	153	49.12	0.3	0.25	36.5	26.75	0	0	47.5	26.78	0	0	115.5	63.09	0	0	88.1	23.36	0.1	0.06
Callinectes sapidus	S404	4.3	0.85	0	0	5	3.19	1.3	0.48	2.5	1.32	0.3	0.25	103.8	97.78	0	0	28.9	24.56	0.4	0.18
Penaeus setiferus	S401	1.3	0.48	1.8	1.75	8	5.66	0.8	0.48	1.3	0.95	0.3	0.25	2.5	0.65	2	1.41	3.3	1.48	1.2	0.55
Penaeus aztecus	S400	2.3	0.85	0.8	0.48	0.3	0.25	0.3	0.25	1.5	0.65	0.3	0.25	2.5	0.65	0.3	0.25	1.6	0.36	0.4	0.16
Rhithropanopeus harrisii	S445	0.5	0.5	0	0	3.8	2.17	0.3	0.25	1.3	0.75	0	0	0.3	0.25	0	0	1.4	0.64	0.1	0.06
Palaemonetes intermedius	S437	0	0	0	0	0	0	0	0	2.5	1.04	0	0	2	2	0	0	1.1	0.58	0	0
Penaeus duorarum	S402	0.3	0.25	0	0	1.3	1.25	0.8	0.75	0.5	0.5	0	0	0.8	0.48	0	0	0.7	0.34	0.2	0.19
Sesarma reticulatum	S407	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Neopanope texana	S435	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0.1	0.06	0.1	0.06
Xanthidae, unknown species	S412	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0.3	0.25	0.1	0.06	0.1	0.06
Grass Shrimp		153	49.12	0.3	0.25	36.5	26.75	0	0	50	26.03	0	0	117.5	63.26	0	0	89.3	23.31	0.1	0.06
Penaeid Shrimp		3.8	1.31	2.5	1.89	9.5	5.85	1.8	1.18	3.3	1.18	0.5	0.5	5.8	0.75	2.3	1.31	5.6	1.52	1.8	0.62
CRUSTACEAN TOTALS:		161.5	48.74	2.8	2.14	55.8	31.86	3.5	0.65	57	26.59	0.8	0.75	227.8	78.27	2.5	1.32	125.5	29.43	2.4	0.66

APPENDIX IV. Means and standard errors of macrofaunal densities before and after flooding in Lavaca River delta marshes during October 1986 (Flood #1), May 1987 (Flood #2), and June 1987 (Flood #3).

LAVACA BAY STUDY
FRESHENING EVENT TWO
BEFORE EVENT
Macrofauna/2.8 m sq. (n=4)
May 12-13, 1987

		LOWER DELTA								UPPER DELTA								OVERALL MEANS & S.E.s (n=16)			
		INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH							
		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																					
Brevoortia patronus	S100	10.3	10.25	23.3	15.4	9.3	7.11	21	21	1	0.71	0.5	0.5	0	0	5.5	5.5	5.1	3.04	12.6	6.46
Anchoa mitchilli	S120	1.3	0.95	1	0.71	2	1.35	1	0.71	1.5	0.87	0.5	0.5	18.8	15.85	14	13.67	5.9	4.05	4.1	3.4
Cyprinodon variegatus	S111	7.8	7.42	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	2.1	1.87	0	0
Lagodon rhomboides	S103	0.8	0.75	0	0	6.3	2.32	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	1.9	0.85	0.1	0.06
Menidia beryllina	S110	1	0.71	0	0	0	0	0	0	0	0	2.5	1.44	1	0.71	3.3	2.93	0.5	0.26	1.4	0.82
Myrophis punctatus	S114	0.8	0.75	0.3	0.25	3	2.68	0.5	0.29	0.8	0.75	0.5	0.29	0	0	0	0	1.1	0.71	0.3	0.12
Mugil cephalus	S106	3.8	2.17	0.5	0.29	0	0	0	0	0.3	0.25	0	0	0	0	0.3	0.25	1	0.64	0.2	0.1
Fundulus grandis	S117	0.5	0.29	0	0	0	0	0	0	0.8	0.75	1.5	0.87	0.3	0.25	0	0	0.4	0.2	0.4	0.26
Leiostomus xanthurus	S101	0.5	0.29	2	1.15	0	0	0.8	0.75	0	0	0	0	0	0	0	0	0.1	0.09	0.7	0.37
Adinia xenica	S133	2	2	0	0	0	0	0	0	0.8	0.75	0	0	0	0	0	0	0.7	0.52	0	0
Gobiosoma bosci	S105	0	0	0	0	0.8	0.48	0.8	0.75	0	0	0.3	0.25	0.3	0.25	0	0	0.3	0.14	0.3	0.19
Gobiosoma robustum	S162	0	0	0	0	2.5	2.5	0	0	0	0	0	0	0	0	0	0	0.6	0.63	0	0
Micropogonias undulatus	S108	0	0	0	0	0	0	0.5	0.29	0.5	0.5	0.3	0.25	0.3	0.25	0.5	0.29	0.2	0.14	0.3	0.12
Arius felis	S135	0	0	0	0	0	0	1	1	0	0	0	0	0.3	0.25	0	0	0.1	0.06	0.3	0.25
Membras martinica	S129	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0.4	0.38	0	0
Sciaenops ocellatus	S121	0	0	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06	0.1	0.06
Stellifer lanceolatus	S139	0	0	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.2	0.14
Gobiesox strumosus	S159	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Hyporhamphus unifasciatus	S155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.06
Ictalurus furcatus	S167	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.06	0	0
Paralichthys lethostigma	S104	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.1	0.13	0	0
Sphoeroides parvus	S158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.06
Syngnathus louisianae	S146	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Syngnathus scovelli	S137	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06	0	0
Synodus foetens	S124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.06
Unknown fish species	S152	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.13	0	0
Cyprinodontidae		10.3	7.11	0	0	0	0	0	0	1.5	1.5	1.5	0.87	0.8	0.75	0	0	3.1	1.95	0.4	0.26
Gobiidae		0	0	0	0	3.3	2.29	0.8	0.75	0	0	0.3	0.25	0.3	0.25	0	0	0.9	0.63	0.3	0.19
Sciaenidae		0.5	0.29	2.8	1.6	0	0	1.5	0.65	0.8	0.75	0.3	0.25	0.3	0.25	0.5	0.29	0.4	0.2	1.3	0.47
Bait Fishes		5.8	2.66	1.5	0.65	8.3	2.78	1.3	0.63	2.3	0.85	0.5	0.5	19	15.8	14.3	13.59	8.8	3.98	4.4	3.39
Commercial Sports Fishes		0	0	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0.2	0.14	0.1	0.06
FISH TOTALS:		29	12.56	27.8	16.68	26.3	5.72	26	22.7	6.5	1.44	6	2.68	21.8	15.88	24.3	18.59	20.9	5.22	21	7.9
CRUSTACEANS:																					
Palaemonetes pugio	S403	52	17.65	0.5	0.29	112.8	38.54	0	0	30.3	16.98	0.3	0.25	26.3	18.39	0.5	0.5	55.3	14.17	0.3	0.15
Penaeus aztecus	S400	20	5.93	5.8	3.75	64	15.31	13.5	2.36	9.3	3.2	7.8	3.2	1.3	1.25	0.8	0.75	23.6	7.3	6.9	1.71
Callinectes sapidus	S404	2.5	0.87	0	0	8.8	1.75	0.3	0.25	5	2.08	3.8	1.44	4.5	1.66	2	0.91	5.2	0.94	1.5	0.55
Rhithropanopeus harrissi	S445	0.5	0.29	0	0	1.8	1.11	0.3	0.25	0	0	0	0	0	0	0	0	0.6	0.32	0.1	0.06
Neopanope texana	S435	0	0	0	0	0.5	0.5	0.3	0.25	0.5	0.5	0.3	0.25	0	0	0.3	0.25	0.3	0.17	0.2	0.1
Clibanarius vittatus	S408	0	0	0	0	0.8	0.48	0	0	0	0	0	0	0	0	0	0	0.2	0.14	0	0
Palaemonetes intermedius	S437	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.1	0.13	0	0
Penaeidae		52	17.65	0.5	0.29	112.8	38.54	0	0	30.8	16.99	0.3	0.25	26.3	18.39	0.5	0.5	55.4	14.16	0.3	0.15
Palaemonidae		20	5.93	5.8	3.75	64	15.31	13.5	2.36	9.3	3.2	7.8	3.2	1.3	1.25	0.8	0.75	23.6	7.3	6.9	1.71
CRUSTACEAN TOTALS:		75	19.99	6.3	3.59	188.5	49.84	14.3	2.84	45.5	22.03	12	5.02	32	19.97	3.5	2.25	85.3	21.01	9	1.95

APPENDIX IV. Means and standard errors of macrofaunal densities before and after flooding in Lavaca River delta marshes during October 1986 (Flood #1), May 1987 (Flood #2), and June 1987 (Flood #3).

LAVACA BAY STUDY
FRESHENING EVENT TWO
AFTER EVENT
Macrofauna/2.8 m sq. (n=4)
May 25-26, 1987

SPECIES	CODE	LOWER DELTA INNER MARSH VEGETATED MEAN	S.E.	LOWER DELTA INNER MARSH NON-VEG MEAN	S.E.	LOWER DELTA OUTER MARSH VEGETATED MEAN	S.E.	LOWER DELTA OUTER MARSH NON-VEG MEAN	S.E.	UPPER DELTA INNER MARSH VEGETATED MEAN	S.E.	UPPER DELTA INNER MARSH NON-VEG MEAN	S.E.	UPPER DELTA OUTER MARSH VEGETATED MEAN	S.E.	UPPER DELTA OUTER MARSH NON-VEG MEAN	S.E.	OVERALL MEANS & S.E.s (n=16) VEGETATED MEAN	S.E.	OVERALL MEANS & S.E.s (n=16) NON-VEG MEAN	S.E.
FISHES:																					
Anchoa mitchilli	S120	0.8	0.75	0.5	0.29	3.5	3.18	29.5	23.03	2.3	1.31	61.3	21.13	55.5	39.38	18.5	2.1	15.5	10.67	27.4	9.03
Gobiosoma bosci	S105	0	0	0	0	15.5	8.97	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89	10.8	5.52	6.9	4.39
Brevoortia patronus	S100	0	0	0.8	0.75	0.3	0.25	0	0	1.8	1.44	3	2.68	2.3	2.25	27	24.09	1.1	0.65	7.7	6.15
Cyprinodon variegatus	S111	6	4.34	0	0	0	0	0	0	9.3	3.52	15.3	8.86	0.3	0.25	0	0	3.9	1.61	3.8	2.61
Fundulus grandis	S117	4.5	2.18	0	0	0	0	0	0	6.5	4.27	0.3	0.25	0	0	0	0	2.8	1.30	0.1	0.06
Gobiesox strumosus	S159	0	0	0	0	1.8	1.44	0.3	0.25	0	0	0	0	6	3.46	0	0	1.9	1.05	0.1	0.06
Mugil cephalus	S106	2.3	1.03	2	1.08	0.8	0.75	0	0	0.5	0.29	0.3	0.25	0.3	0.25	0	0	0.9	0.36	0.6	0.33
Leiostomus xanthurus	S101	0	0	0.3	0.25	3.3	3.25	0.5	0.5	0.5	0.29	0	0	1	1	0	0	1.2	0.83	0.2	0.14
Bathygobius soporator	S160	0	0	0	0	5.3	5.25	0	0	0	0	0	0	0	0	0	0	1.3	1.31	0	0
Lagodon rhomboides	S103	0.3	0.25	0.3	0.25	2.8	0.75	0	0	1	0.58	0	0	0.5	0.29	0.3	0.25	1.1	0.34	0.1	0.08
Micropogonias undulatus	S108	0.5	0.5	2.5	1.89	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25	0.1	0.13	0.8	0.51
Myrophis punctatus	S114	0	0	0.8	0.48	0.8	0.48	0.5	0.29	0	0	1.3	0.48	0	0	0.3	0.25	0.2	0.14	0.7	0.20
Menidia beryllina	S110	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0	0	3	3	0.1	0.06	0.8	0.75
Bairdiella chrysoura	S131	0	0	0	0	0	0	0	0	1.8	1.75	0	0	0	0	0	0	0.4	0.44	0	0
Cynoscion nebulosus	S125	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0	0.3	0.22	0	0
Syngnathus louisianae	S146	0	0	0	0	0	0	0	0	1.3	1.25	0	0	0	0	0	0	0.3	0.31	0	0
Elops saurus	S109	0	0	0	0	0	0	0	0	0	0	1	0.58	0	0	0	0	0	0	0.3	0.17
Sphoeroides parvus	S158	0	0	0	0	0.8	0.75	0	0	0	0	0	0	0	0	0	0	0.2	0.19	0	0
Strongylura marina	S168	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.5	0.29	0	0	0.2	0.10	0	0
Adina xenica	S133	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06	0	0
Anguilla rostrata	S169	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Arius felis	S135	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Lepisosteus oculatus	S150	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06
Opsanus beta	S128	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Orthopristis chrysoptera	S123	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Syngnathus floridae	S122	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Cyprinodontidae		10.5	6.3	0	0	0	0	0	0	16	6.92	15.5	9.03	0.3	0.25	0	0	6.7	2.74	3.9	2.66
Gobiidae		0	0	0	0	21	10.98	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89	12.2	5.81	6.9	4.39
Sciaenidae		0.5	0.5	2.8	1.8	3.3	3.25	1	0.58	2.3	1.6	0	0	2.3	1.65	0.3	0.25	2.1	0.93	1	0.51
Bait Fishes		3.3	1.8	2.8	1.11	7	4.67	29.5	23.03	3.8	2.17	61.5	21	56.3	39.15	18.8	2.02	17.6	10.56	28.1	8.92
Commercial Sports Fishes		0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0	0.3	0.22	0	0
FISH TOTALS:		14.8	5.07	7	1.35	35.5	17.39	35.3	22.07	46.3	21.98	86	16.13	74.3	42.82	69.8	39.53	42.7	12.76	49.5	13.35
CRUSTACEANS:																					
Palaemonetes pugio	S403	89	27.7	0.5	0.5	43	14.05	0.3	0.25	67.8	35.79	0.3	0.25	82.8	62.8	0.3	0.25	70.6	18.18	0.31	0.151
Penaeus aztecus	S400	17	3.34	7.8	1.8	28.8	12.54	8.5	3.12	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89	16.4	3.63	8.75	1.296
Callinectes sapidus	S404	1	0.41	0.5	0.5	3.8	0.63	0.3	0.25	5.5	3.84	3	1.58	5.8	3.38	1	0	4.0	1.26	1.19	0.467
Rhithropanopeus harrisii	S445	0	0	0	0	0.5	0.29	0.5	0.5	7.8	7.75	1.5	1.5	0.5	0.5	0	0	2.2	1.93	0.5	0.387
Penaeus setiferus	S401	0.3	0.25	0	0	3.5	3.5	0.5	0.29	0	0	0	0	0	0	0	0	0.9	0.87	0.13	0.085
Neopanope texana	S435	0	0	0	0	0	0	0	0	0	0	0	0	1.3	1.25	1.3	0.95	0.3	0.31	0.31	0.254
Palaemonetes intermedius	S437	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.5	0.5	0	0	0.3	0.17	0	0
Grass Shrimp		89	27.7	0.5	0.5	43	14.05	0.3	0.25	68.3	35.48	0.3	0.25	83.3	62.72	0.3	0.25	70.9	18.14	0.3	0.15
Penaeid Shrimp		17.3	3.15	7.8	1.8	32.3	13.48	9	3.34	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89	17.4	3.99	8.9	1.32
CRUSTACEAN TOTALS:		107.3	30.86	8.8	2.53	79.5	27.33	10	3.74	89.8	46.86	12.5	2.53	102.5	68.1	13.5	4.99	94.8	20.85	11.2	1.68

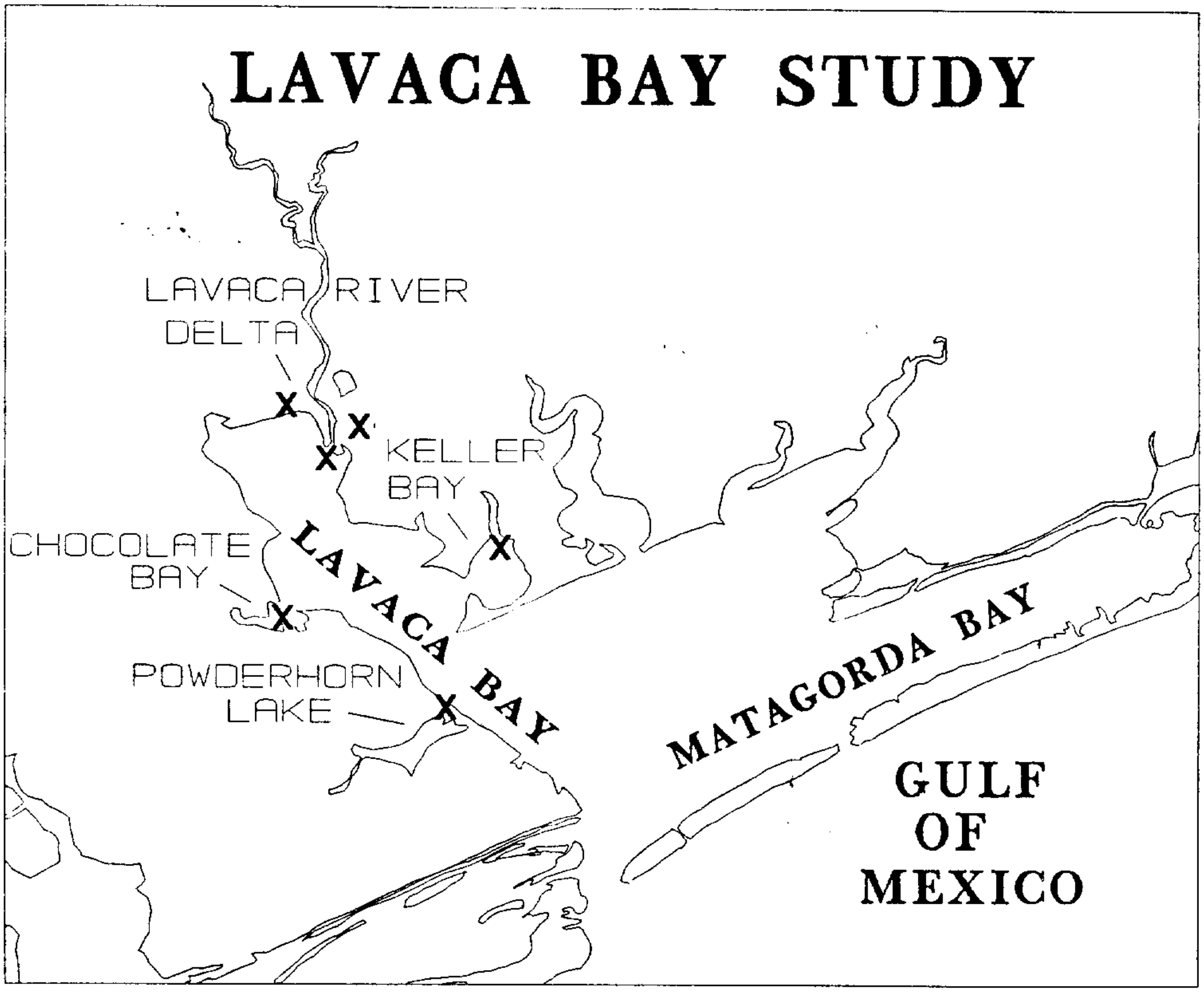
APPENDIX IV. Means and standard errors of macrofaunal densities before and after flooding in Lavaca River delta marshes during October 1986 (Flood #1), May 1987 (Flood #2), and June 1987 (Flood #3).

LAVACA BAY STUDY
FRESHENING EVENT THREE
BEFORE EVENT
Macrofauna/2.8 m sq. (n=4)
May 25-26, 1987

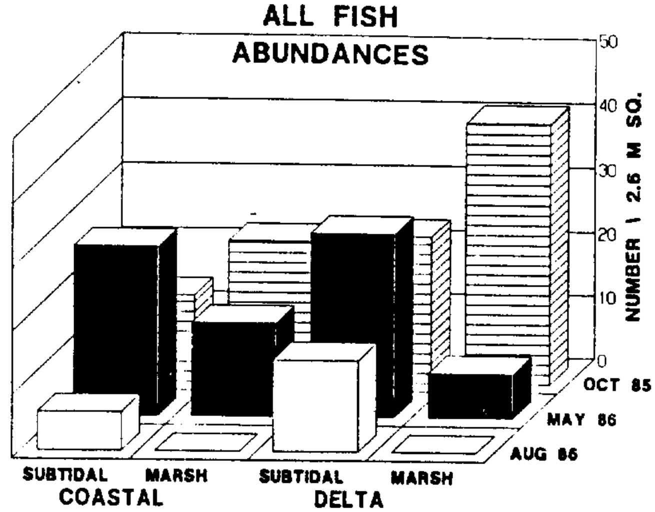
SPECIES	CODE	LOWER DELTA								UPPER DELTA								OVERALL MEANS & S.E.s (n=16)			
		INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH							
		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
		MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																					
Anchoa mitchilli	S120	0.8	0.75	0.5	0.29	3.5	3.18	29.5	23.03	2.3	1.31	61.3	21.13	55.5	39.38	18.5	2.1	15.5	10.67	27.4	9.03
Gobiosoma bosci	S105	0	0	0	0	15.5	8.97	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89	10.8	5.52	6.9	4.39
Brevoortia patronus	S100	0	0	0.8	0.75	0.3	0.25	0	0	1.8	1.44	3	2.68	2.3	2.25	27	24.09	1.1	0.65	7.7	6.15
Cyprinodon variegatus	S111	6	4.34	0	0	0	0	0	0	9.3	3.52	15.3	8.86	0.3	0.25	0	0	3.9	1.61	3.8	2.61
Fundulus grandis	S117	4.5	2.18	0	0	0	0	0	0	6.5	4.27	0.3	0.25	0	0	0	0	2.8	1.30	0.1	0.06
Gobiesox sturmosus	S159	0	0	0	0	1.8	1.44	0.3	0.25	0	0	0	0	6	3.46	0	0	1.9	1.05	0.1	0.06
Mugil cephalus	S106	2.3	1.03	2	1.08	0.8	0.75	0	0	0.5	0.29	0.3	0.25	0.3	0.25	0	0	0.9	0.36	0.6	0.33
Leiostomus xanthurus	S101	0	0	0.3	0.25	3.3	3.25	0.5	0.5	0.5	0.29	0	0	1	1	0	0	1.2	0.83	0.2	0.14
Bathygobius soporator	S160	0	0	0	0	5.3	5.25	0	0	0	0	0	0	0	0	0	0	1.3	1.31	0	0
Lagodon rhomboides	S103	0.3	0.25	0.3	0.25	2.8	0.75	0	0	1	0.58	0	0	0.5	0.29	0.3	0.25	1.1	0.34	0.1	0.08
Micropogonias undulatus	S108	0.5	0.5	2.5	1.89	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25	0.1	0.13	0.8	0.51
Myrophis punctatus	S114	0	0	0.8	0.48	0.8	0.48	0.5	0.29	0	0	1.3	0.48	0	0	0.3	0.25	0.2	0.14	0.7	0.20
Menidia beryllina	S110	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0	0	3	3	0.1	0.06	0.8	0.75
Bairdiella chrysoura	S131	0	0	0	0	0	0	0	0	1.8	1.75	0	0	0	0	0	0	0.4	0.44	0	0
Cynoscion nebulosus	S125	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0	0.3	0.22	0	0
Syngnathus louisianae	S146	0	0	0	0	0	0	0	0	1.3	1.25	0	0	0	0	0	0	0.3	0.31	0	0
Elops saurus	S109	0	0	0	0	0	0	0	0	0	0	1	0.58	0	0	0	0	0	0	0.3	0.17
Sphoeroides parvus	S158	0	0	0	0	0.8	0.75	0	0	0	0	0	0	0	0	0	0	0.2	0.19	0	0
Strongylura marina	S168	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.5	0.29	0	0	0.2	0.10	0	0
Adina xenica	S133	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06	0	0
Anguilla rostrata	S169	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Arius felis	S135	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Lepisosteus oculatus	S150	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06
Opsanus beta	S128	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Orthopristis chrysoptera	S123	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Syngnathus floridae	S122	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Cyprinodontidae		10.5	6.3	0	0	0	0	0	0	16	6.92	15.5	9.03	0.3	0.25	0	0	6.7	2.74	3.9	2.66
Gobiidae		0	0	0	0	21	10.98	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89	12.2	5.81	6.9	4.39
Sciaenidae		0.5	0.5	2.8	1.8	3.3	3.25	1	0.58	2.3	1.6	0	0	2.3	1.65	0.3	0.25	2.1	0.93	1	0.51
Bait Fishes		3.3	1.8	2.8	1.11	7	4.67	29.5	23.03	3.8	2.17	61.5	21	56.3	39.15	18.8	2.02	17.6	10.56	28.1	8.92
Commercial Sports Fishes		0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0	0.3	0.22	0	0
FISH TOTALS:		14.8	5.07	7	1.35	35.5	17.39	35.3	22.07	46.3	21.98	86	16.13	74.3	42.82	69.8	39.53	42.7	12.76	49.5	13.35
CRUSTACEANS:																					
Palaemonetes pugio	S403	89	27.7	0.5	0.5	43	14.05	0.3	0.25	67.8	35.79	0.3	0.25	82.8	62.8	0.3	0.25	70.6	18.18	0.31	0.151
Penaeus aztecus	S400	17	3.34	7.8	1.8	28.8	12.54	8.5	3.12	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89	16.4	3.63	8.75	1.296
Callinectes sapidus	S404	1	0.41	0.5	0.5	3.8	0.63	0.3	0.25	5.5	3.84	3	1.58	5.8	3.38	1	0	4.0	1.26	1.19	0.467
Rhithropanopeus harrisii	S445	0	0	0	0	0.5	0.29	0.5	0.5	7.8	7.75	1.5	1.5	0.5	0.5	0	0	2.2	1.93	0.5	0.387
Penaeus setiferus	S401	0.3	0.25	0	0	3.5	3.5	0.5	0.29	0	0	0	0	0	0	0	0	0.9	0.87	0.13	0.085
Neopanope texana	S435	0	0	0	0	0	0	0	0	0	0	0	0	1.3	1.25	1.3	0.95	0.3	0.31	0.31	0.254
Palaemonetes intermedius	S437	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.5	0.5	0	0	0.3	0.17	0	0
Grass Shrimp		89	27.7	0.5	0.5	43	14.05	0.3	0.25	68.3	35.48	0.3	0.25	83.3	62.72	0.3	0.25	70.9	18.14	0.3	0.15
Penaeid Shrimp		17.3	3.15	7.8	1.8	32.3	13.48	9	3.34	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89	17.4	3.99	8.9	1.32
CRUSTACEAN TOTALS:		107.3	30.86	8.8	2.53	79.5	27.33	10	3.74	89.8	46.86	12.5	2.53	102.5	68.1	13.5	4.99	94.8	20.85	11.2	1.68

APPENDIX IV. Means and standard errors of macrofaunal densities before and after flooding in Lavaca River delta marshes during October 1986 (Flood #1), May 1987 (Flood #2), and June 1987 (Flood #3).

LAVACA BAY STUDY FRESHENING EVENT THREE AFTER EVENT Macrofauna/2.8 m sq. (n=4) June 11-12, 1987		LOWER DELTA								UPPER DELTA								OVERALL MEANS & S.E.s (n=16)			
		INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH							
		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	CODE	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																					
Brevoortia patronus	S100	62.8	37.58	42.8	42.08	0.3	0.25	0	0	2.8	2.43	0.3	0.25	428.3	246.0	1132.3	300.06	123.5	72.13	293.8	142.24
Anchoa mitchilli	S120	3	1.08	4	3.34	0	0	20.3	8.92	25.8	8.83	29.8	13.68	44.5	19.4	230.8	102.45	18.3	6.68	71.2	33.32
Gobiosoma bosci	S105	1	1	0	0	4.3	2.53	7.8	4.5	23.3	6.33	6.3	1.65	6.5	3.52	2	1.68	8.8	2.81	4.0	1.39
Bairdiella chrysoura	S131	0	0	0	0	1.3	0.63	0	0	10.5	4.27	0	0	0	0	0	0	2.9	1.49	0	0
Fundulus grandis	S117	2.5	1.5	5.3	5.25	0	0	0	0	1.8	1.18	0	0	0	0	0	0	1.1	0.51	1.3	1.31
Myrophis punctatus	S114	1	0.71	1	0.71	0	0	2.3	0.85	0.5	0.5	1.3	0.75	1.3	1.25	1	0.58	0.7	0.36	1.4	0.35
Leiostomus xanthurus	S101	0	0	2.8	2.75	0	0	0.5	0.29	0	0	0.5	0.5	0	0	0	0	0	0	0.9	0.69
Lagodon rhomboides	S103	0	0	0.8	0.75	1	0.71	0	0	1	0.41	0.3	0.25	0	0	0	0	0.5	0.22	0.3	0.19
Cyprinodon variegatus	S111	2.5	1.19	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.7	0.38	0	0
Mugil cephalus	S106	2	2	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0.3	0.25	0.6	0.50	0.1	0.08
Fundulus pulvereus	S142	1.8	1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.44	0	0
Micropogonias undulatus	S108	0	0	0.5	0.5	0	0	1	0.71	0	0	0.3	0.25	0	0	0	0	0	0	0.4	0.22
Syngnathus scovelli	S137	0	0	0	0	0	0	0.5	0.5	1	0.41	0	0	0	0	0	0	0.3	0.14	0.1	0.13
Menidia beryllina	S110	0	0	0.5	0.5	0	0	0	0	0	0	0.5	0.29	0	0	0	0	0	0	0.3	0.14
Citharicthys spilopterus	S115	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0.3	0.25	0.1	0.13	0.1	0.06
Elops saurus	S109	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0.3	0.25	0.1	0.08	0.1	0.06
Paralichthys lethostigma	S104	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.14
Gobiesox sturmosus	S159	0	0	0	0	0.5	0.29	0	0	0	0	0	0	0	0	0	0	0.1	0.08	0	0
Archosargus probatocephalus	S130	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.1	0.06	0	0
Astroscopus y-graecum	S170	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.1	0.06	0	0
Cyprinodontidae		6.8	2.17	5.3	5.25	0	0	0	0	2	1.41	0	0	0	0	0	0	2.2	0.92	1.3	1.31
Gobiidae		1	1	0	0	4.3	2.53	7.8	4.5	23.3	6.33	6.3	1.65	6.5	3.52	2	1.68	8.8	2.81	4	1.39
Sciaenidae		0	0	3.3	2.63	1.3	0.63	1.5	0.65	10.5	4.27	0.8	0.48	0	0	0	0	2.9	1.49	1.4	0.69
Bait Fishes		5	2.27	5	3.08	1	0.71	20.3	8.92	27	8.5	30	13.56	44.5	19.4	231	102.45	19.4	6.58	71.6	33.3
Commercial Sports Fishes		0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25	0	0	0.2	0.14
FISH TOTALS:		76.8	33.53	57.8	43.3	7.8	2.93	32.8	12	67.3	15.85	39	13.71	481	266.5	1367	369.56	158.2	77.35	374.1	169.86
CRUSTACEANS:																					
Palaemonetes pugio	S403	27.3	9.2	31.5	18.26	18.3	5.81	0	0	98	22.91	3	1.91	43	18.04	1	1	46.6	10.60	8.9	5.32
Penaeus aztecus	S400	6	2.12	3.3	1.65	2.8	0.48	5.5	2.63	13.3	3.22	8.3	2.02	0	0	0	0	5.5	1.55	4.3	1.14
Callinectes sapidus	S404	0.3	0.25	0	0	0.8	0.25	0.8	0.48	3.8	1.18	0.5	0.29	1.3	0.75	0.5	0.29	1.5	0.47	0.4	0.16
Rhithropanopeus harrisii	S445	0	0	0.3	0.25	0.8	0.75	0.3	0.25	3	2.68	0.3	0.25	0	0	1	0.41	0.9	0.70	0.4	0.16
Palaemonetes intermedius	S437	0	0	0	0	0	0	0	0	4.3	3.92	0	0	0	0	0	0	1.1	1.00	0	0
Sesarma reticulatum	S407	0	0	0	0	1	0.58	0	0	0.3	0.25	0	0	0	0	0	0	0.3	0.18	0	0
Penaeus setiferus	S401	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0.1	0.06	0.2	0.14
Palaemonetes vulgaris	S436	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.1	0.13	0	0
Uca longisignalis	S446	0	0	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0.1	0.06
Neopanope texana	S435	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Uca rapax	S447	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0	0
Unknown crustacean species	S431	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.06
Grass Shrimp		27.3	9.2	31.5	18.26	18.3	5.81	0	0	102.3	23.22	3	1.91	43.5	18.44	1	1	47.8	11.01	8.9	5.33
Penaeid Shrimp		6.3	2.25	3.8	1.89	2.8	0.48	5.8	2.87	13.3	3.22	8.3	2.02	0	0	0	0	5.6	1.56	4.4	1.18
CRUSTACEAN TOTALS:		33.8	10.89	36	18.77	24	6.18	7	2.42	122.5	18.83	12	2.45	44.8	18.53	2.5	1.55	56.3	11.99	14.4	5.43



LAVACA BAY STUDY
LAVACA RIVER
LAVACA RIVER DELTA
KELLER BAY
CHOCOLATE BAY
POWDERHORN LAKE
LAVACA BAY
MATAGORDA BAY
GULF OF MEXICO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40
30
20
10
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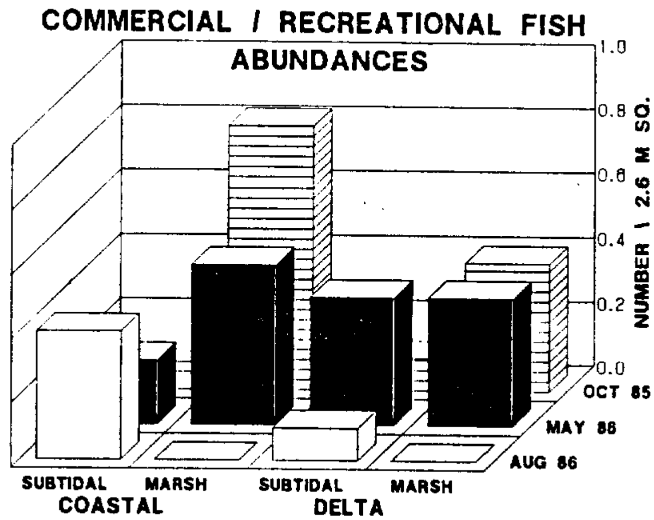
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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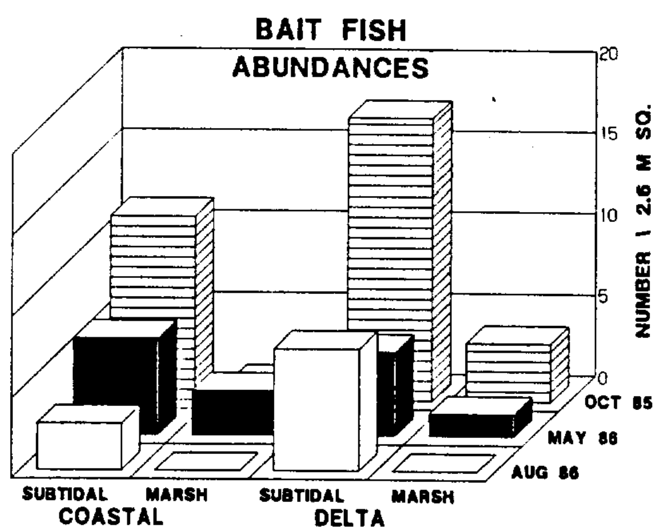
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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15
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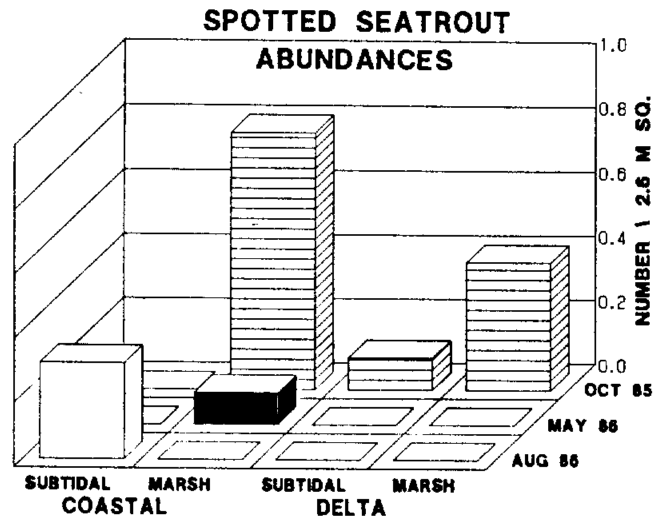
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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AUG 86
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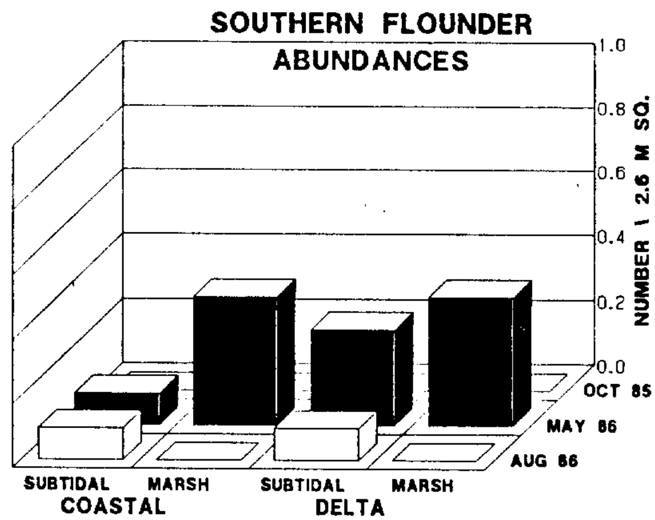
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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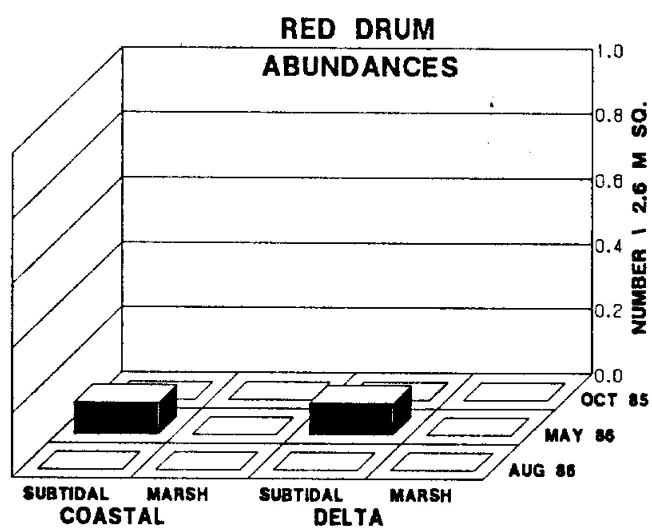
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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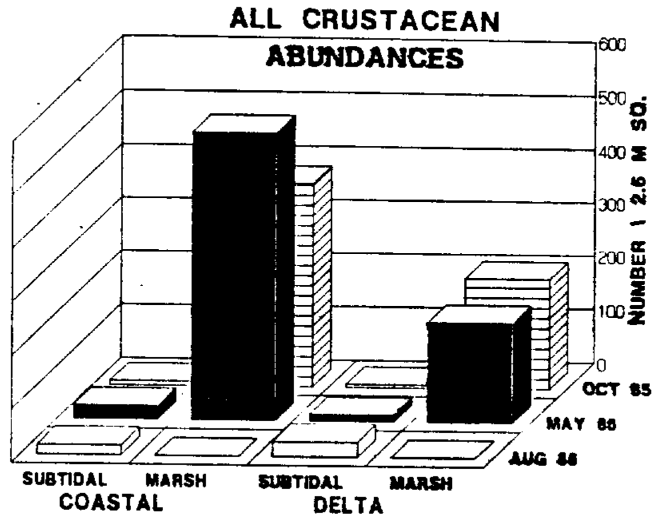
NUMBER / 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA


ALL CRUSTACEAN
ABUNDANCES
NUMBER / 2.6 M SQ.
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300
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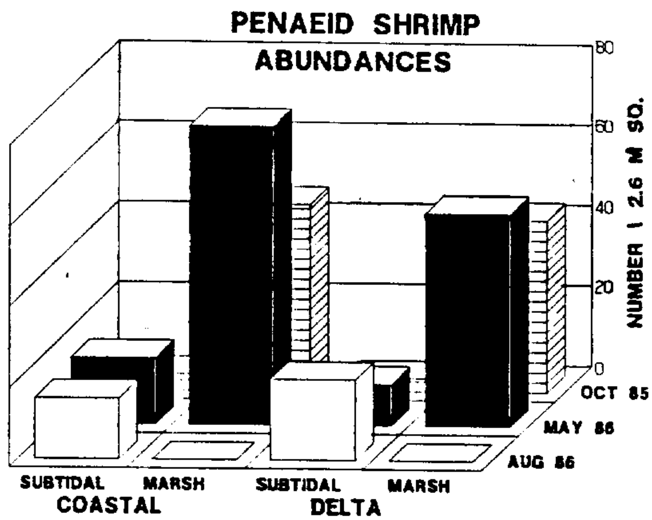
500
600
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA


PENAEID SHRIMP
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NUMBER / 2.6 M SQ.
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AUG 86
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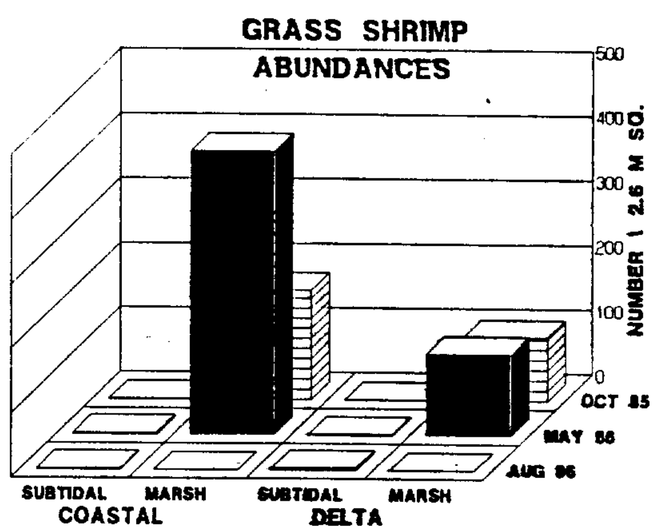
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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ABUNDANCES
NUMBER / 2.6 M SQ.
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300
400
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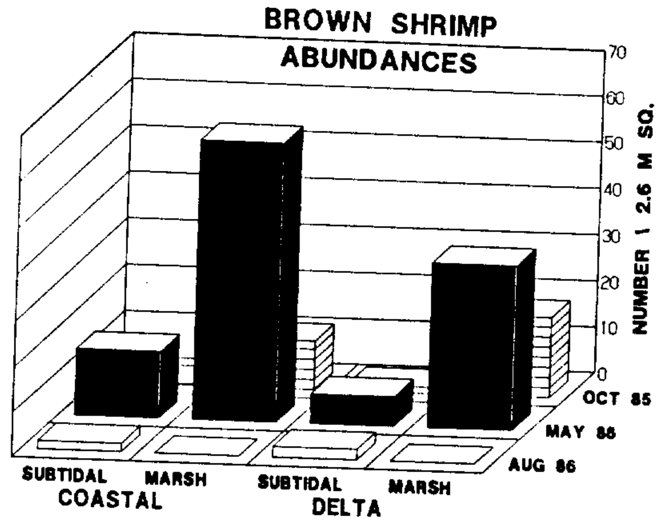
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
SUBTIDAL
MARSH
COASTAL
DELTA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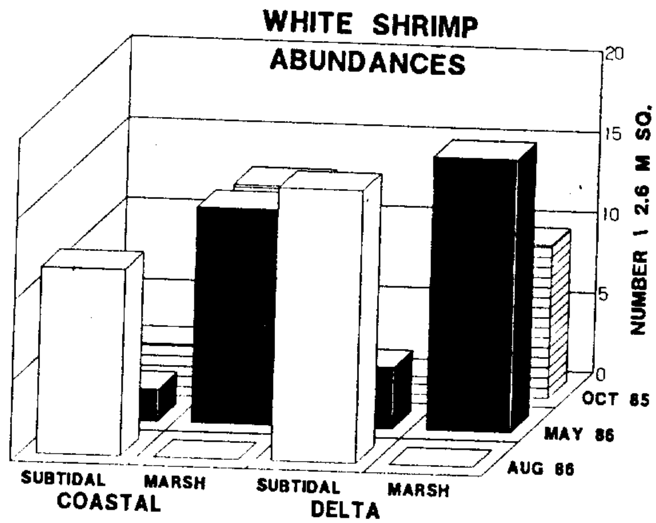
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA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AUG 86
SUBTIDAL
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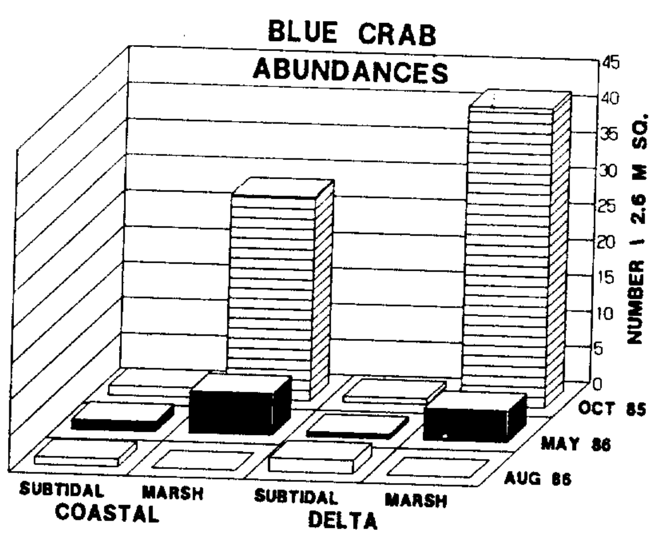
SUBTIDAL
MARSH
DELTA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10
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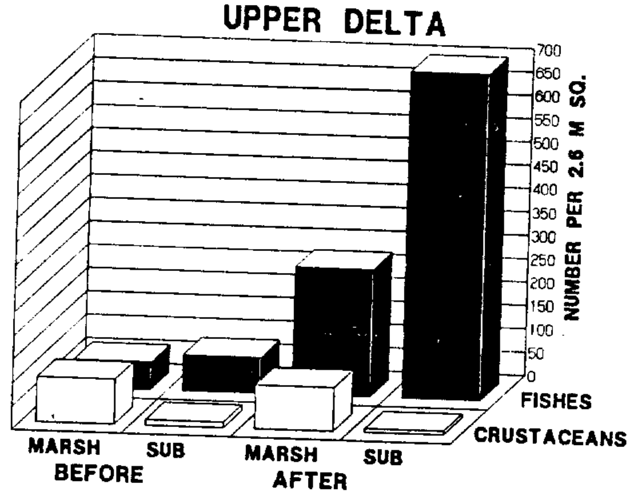
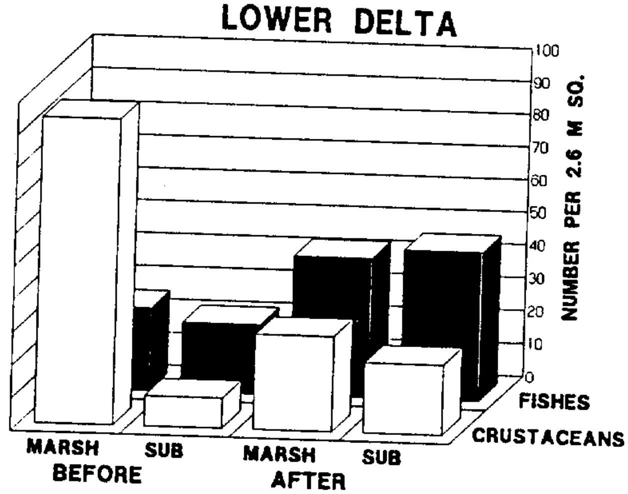
0
NUMBER \ 2.6 M SQ.
OCT 85
MAY 86
AUG 86
SUBTIDAL
MARSH
COASTAL
SUBTIDAL
MARSH
DELTA

FLOOD EFFECTS:
UPPER DELTA

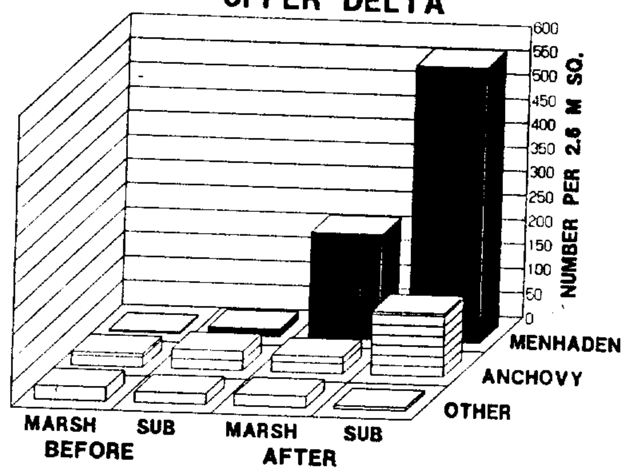


LOWER DELTA

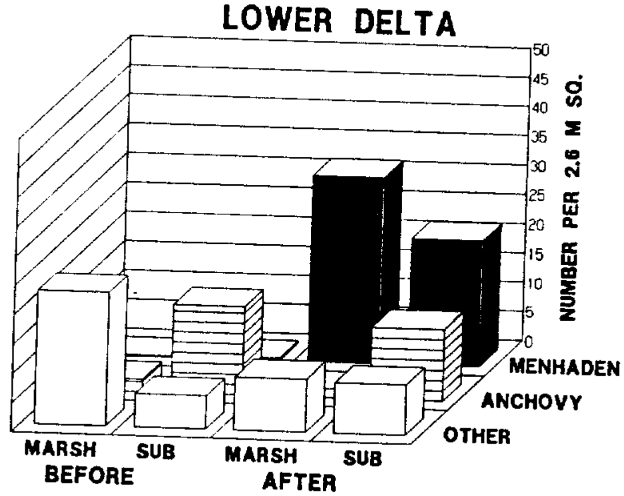


SELECTED FISHES

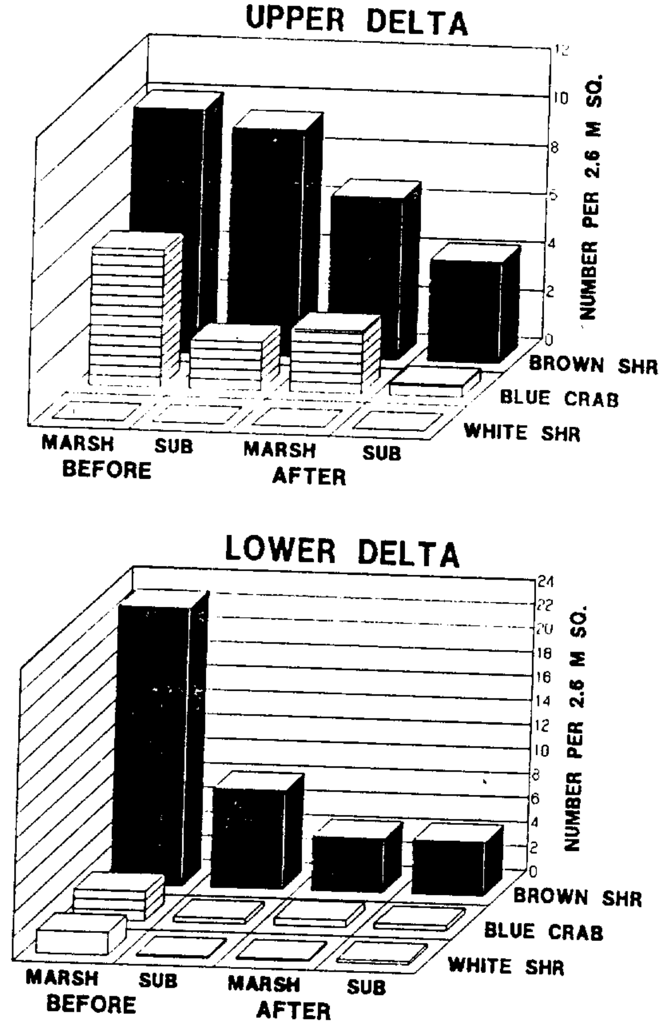
UPPER DELTA

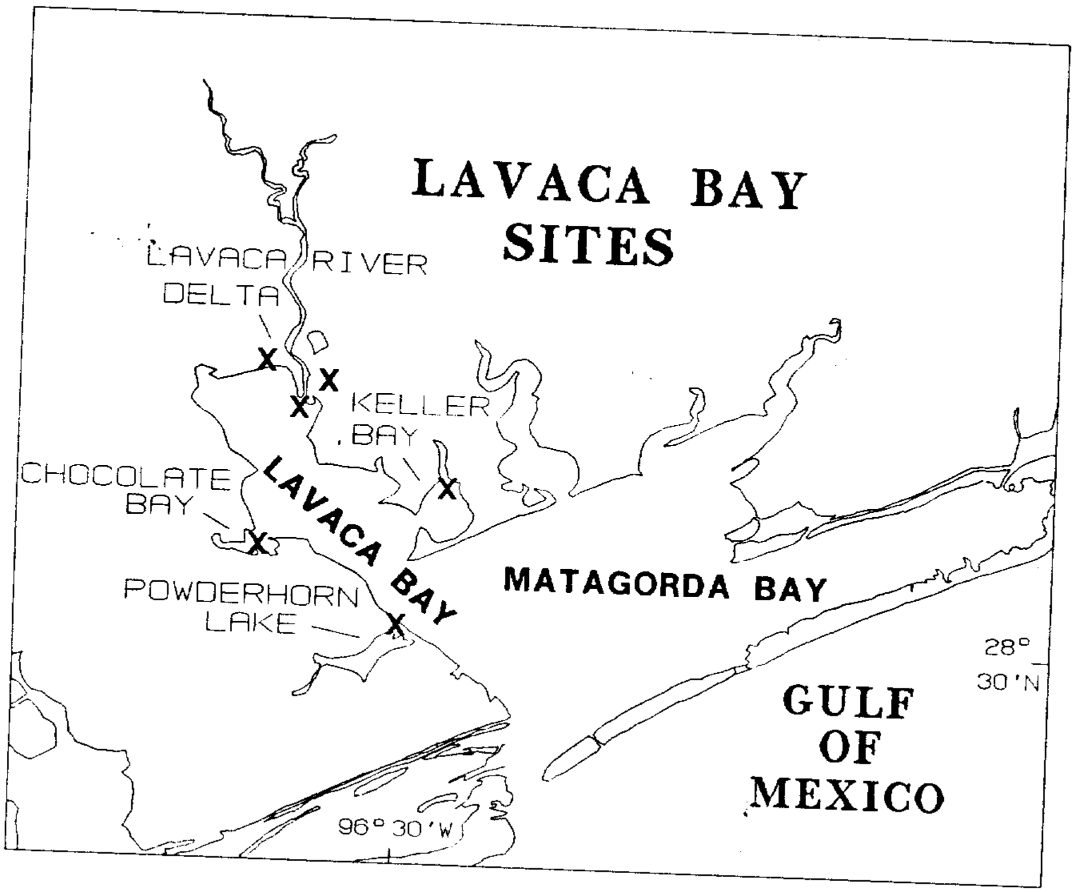


LOWER DELTA



SELECTED CRUSTACEANS





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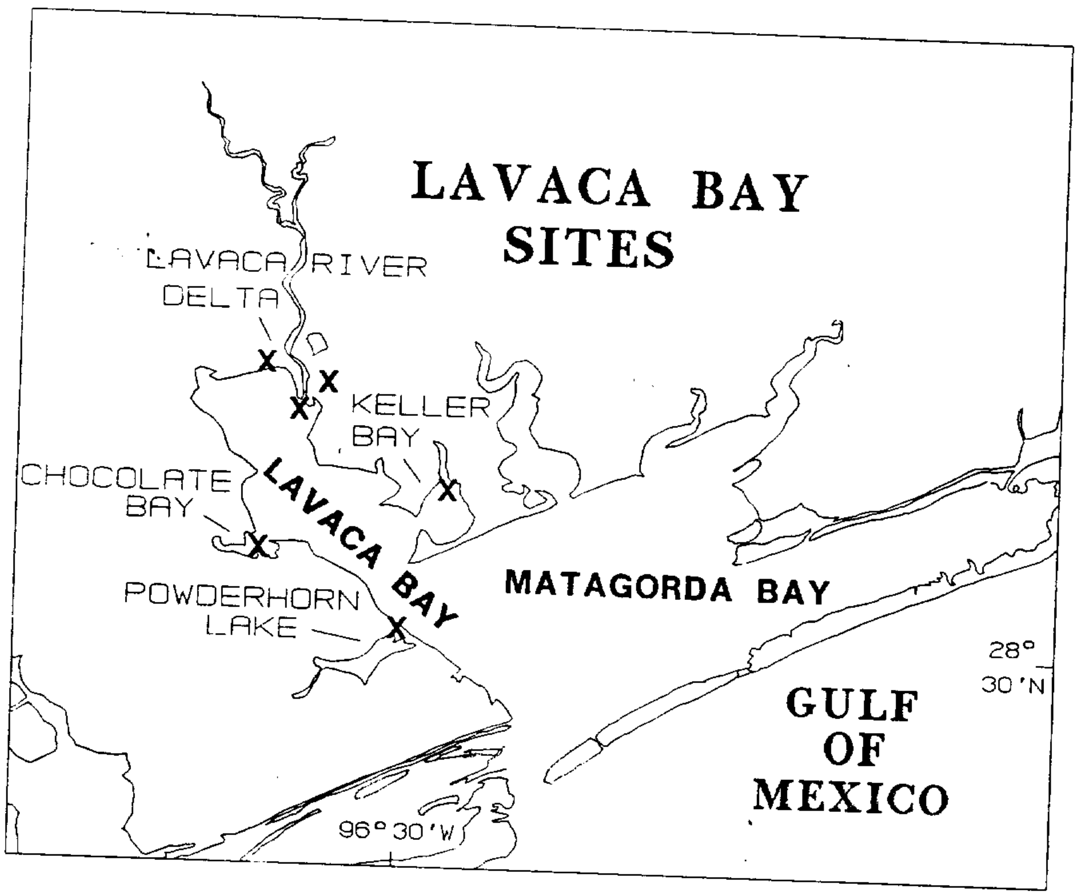

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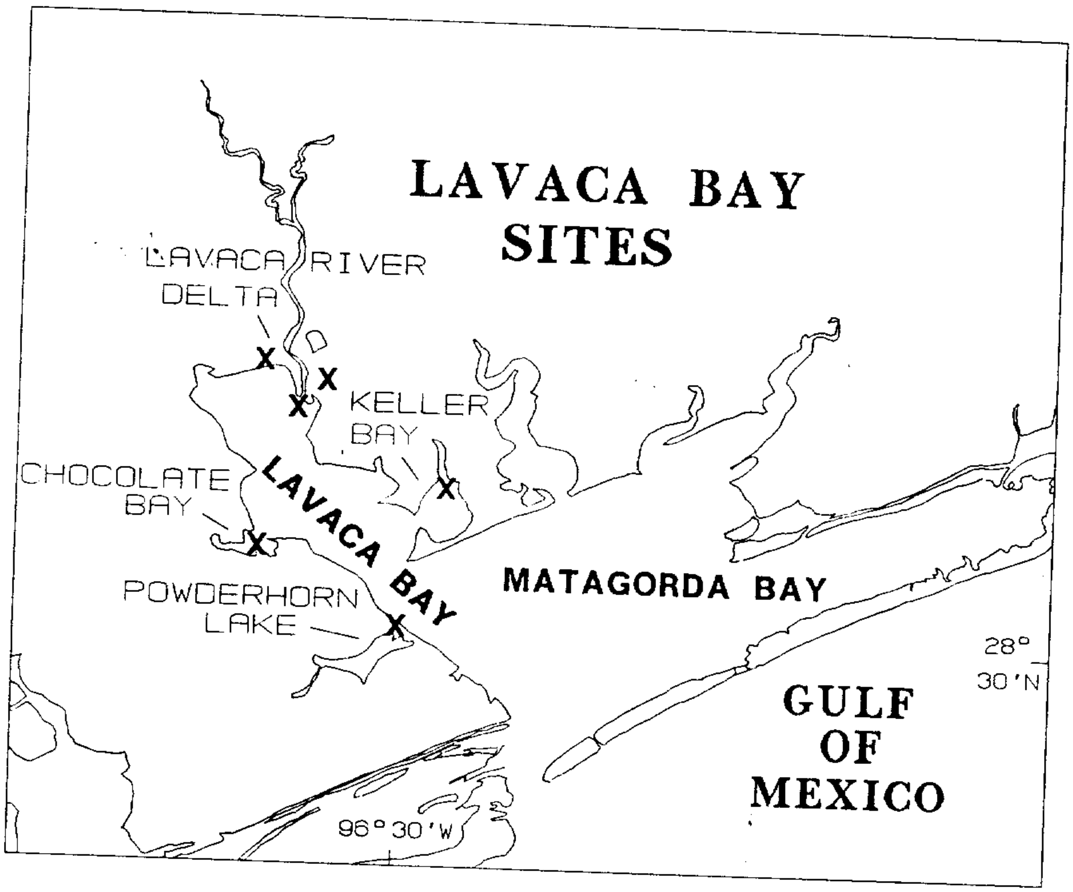

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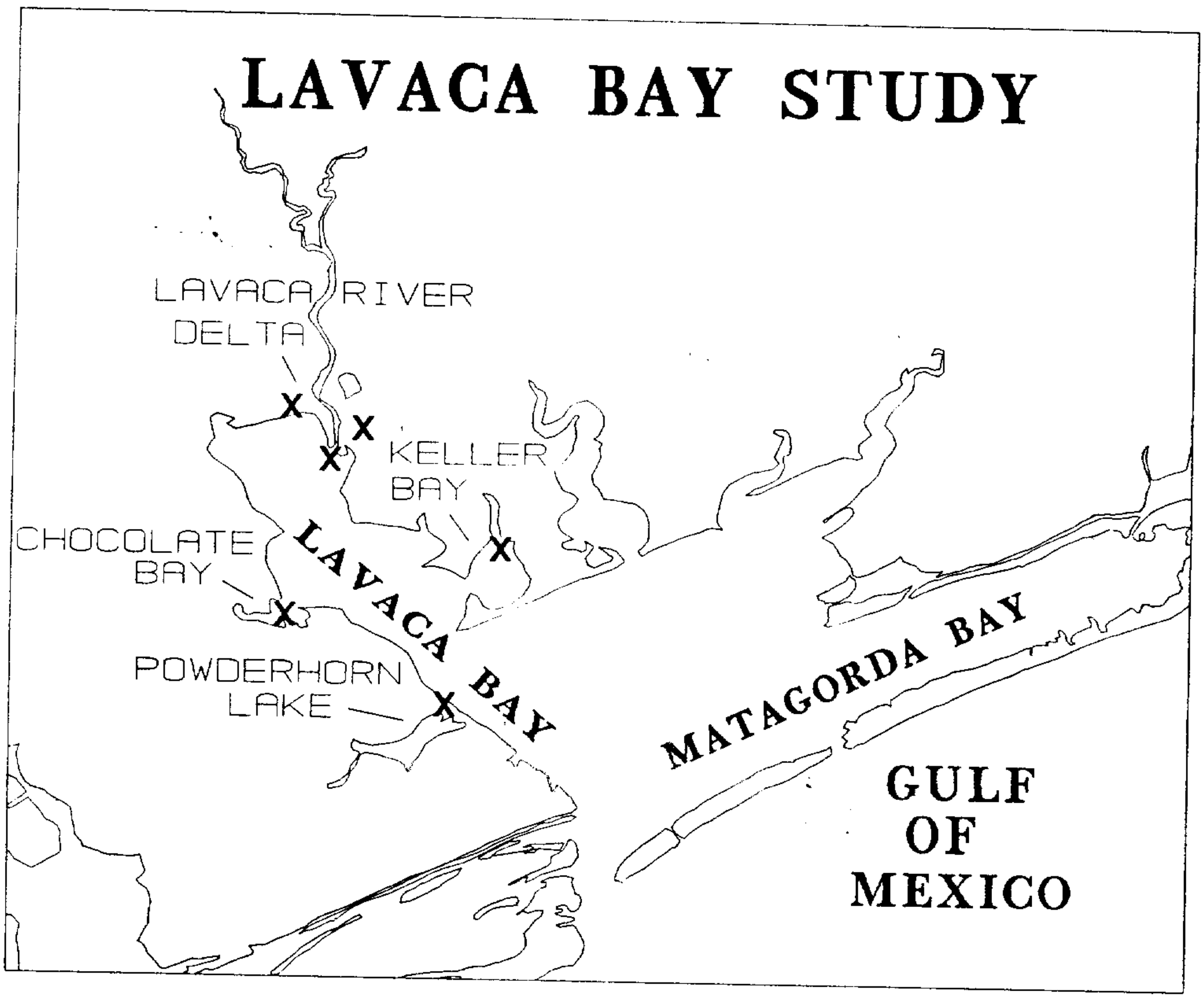

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GULF
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MEXICO

NOAA TECHNICAL MEMORANDUM
NMFS-SEFC-251

The Use of *Juncus* and *Spartina* Marshes by Fisheries Species in Lavaca Bay, Texas, with Reference to Effects of Floods.

BY

Zimmerman, R. J., T. J. Minello,
D. L. Smith and J. Kostera

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Robert Mosbacher, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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NATIONAL MARINE FISHERIES SERVICE
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FEBRUARY 1990

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ABSTRACT

Coastal *Spartina* marshes, deltaic *Juncus* marshes, and subtidal bottom without vegetation in Lavaca Bay were compared for usage by aquatic fauna. Faunal densities were measured using drop trap sampling methodology at coast and delta locations during spring, summer and fall seasons, in salinities that ranged from 13 to 30 ppt (mesohaline and polyhaline regimes). In general, the coast and delta habitats were used similarly. The same species were abundant in both areas. In particular, densities of penaeid shrimps, blue crab and economically important fishes were usually not significantly different between coast and delta habitats. Within locations abundances were usually significantly higher in marsh as compared to bare subtidal habitat. Variations in distributions and abundances were attributed more to seasonal differences in tidal inundation patterns than to coastal or deltaic locations. In a related study, the effect of freshwater flooding on utilization of delta marshes was examined. Animal densities before and after three floods occurring between the fall of 1986 and the spring of 1987 were compared. After the first two floods (October 1986 and May 1987), salinities returned to background levels within a week. After the third flood, in late May and early June 1987, background salinities of 5 to 18 ppt declined to 0 ppt for at least 2 weeks. For the most part, the floods caused no change in densities of decapod crustaceans and fishes in marsh or bare habitats. Where significant changes did occur, the effect was usually negative for decapod crustaceans and positive for fishes. The mere presence of estuarine crustaceans and fishes after Flood 3, when salinities decreased to near zero, suggested a high degree of physiological tolerance to freshwater flooding. These results suggest that short term lowering of salinity does not deter estuarine animals from using deltaic marshes, but rather it may be longer term habitat changes that cause such responses.

INTRODUCTION

Purpose

The purpose of this study was to characterize usage of saline coastal and brackish deltaic habitats by estuarine aquatic species. The focus was estuarine marshes and two objectives were addressed in two separate studies. The first objective was to compare densities of fishes and decapod crustaceans from *Spartina* salt marshes and adjacent nonvegetated bottom with *Juncus* delta marshes and adjacent nonvegetated bottom. This study was conducted in Lavaca Bay, Texas, by comparing coastal locations with upper bay delta locations. The null hypothesis was that coastal and deltaic locations, under mesohaline to polyhaline salinities, would not differ in utilization by estuarine aquatic fauna nor, in particular, by fishery species. The second objective and second study was to characterize the impact of freshwater flooding on utilization of deltaic habitat. This study was conducted in marshes on the lower Lavaca River. The null hypothesis was that densities of estuarine species would not differ after flooding from those present before flooding.

Marsh Utilization

Salt marshes have been long deemed important to estuarine aquatic animals (see general reviews by Teal 1962; Daiber 1977 and 1982; Thayer et al. 1978; Montague et al. 1981). The pervasive view has been that salt marshes are valuable for export of organic matter to fuel estuarine and near shore food chains (Odum 1980). Salt marshes have not been considered particularly important as habitat directly utilized by estuarine aquatic species. This is largely because it is an intertidal habitat with limited aquatic accessibility. But some evidence has supported direct utilization. Aquatic grass shrimps, such as *Palaemonetes pugio*, and killifishes, such as *Fundulus heteroclitus*, are well known associates of salt marshes (Welsh 1975; Morgan 1980; Kneib and Stiven 1982). Moreover, Bell and Coull (1977) and Bell (1980) inferred significant predation by estuarine macrofauna on salt marsh meiofauna. Parker (1970) and Weinstein (1979) showed that shallow waters next to intertidal marshes have large numbers of juveniles of estuarine species. In addition, Turner (1977) demonstrated a relationship between offshore shrimp production and the area of inshore intertidal marsh.

Until recently, the degree of direct utilization of salt marsh surfaces by estuarine aquatic fauna had not been known. Studies of a Texas salt marsh were the first to quantify this utilization (Zimmerman et al. 1984; Zimmerman and Minello 1984). The inundated marsh surface in this investigation was extensively used by juveniles of decapod crustaceans and fishes. Juveniles of brown shrimp (*Penaeus aztecus*), blue crab (*Callinectes sapidus*), red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*) had greater densities on the marsh surface compared to nonvegetated habitat at the marsh edge. In addition, juveniles of white shrimp (*Penaeus setiferus*), southern flounder (*Paralichthys lethostigma*), and Atlantic croaker (*Micropogonias undulatus*) were as abundant on the marsh surface as in nonvegetated open water habitat. Spot (*Leiostomus xanthurus*), bay anchovy (*Anchoa mitchilli*), Gulf menhaden (*Brevoortia patronus*) and striped mullet (*Mugil cephalus*) were the only economically important species that were more abundant in open water habitat.

Use of oligohaline marsh areas by estuarine species has received sparingly little attention. In North Carolina, Rozas and Hackney (1983 and 1984) found that many decapod crustaceans and fishes common in salt marsh creeks were also associated with oligohaline marshes. In Virginia, McIvor and Odum (1986) confirmed that high numbers of estuarine grass shrimp (*P. pugio*), mummichog (*F. heteroclitus*) and blue crab used a freshwater tidal marsh surface. These estuarine species occurred together with a freshwater community that included banded killifish (*F. diaphanus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), mosquitofish (*Gambusia affinis*), tessellated darter (*Etheostoma olmstedi*) and spottail shiner (*Notropis hudsonius*). Among 24 nektonic species, 7 had estuarine affinities. The degree of marsh surface exploitation appeared to partially depend upon the location and quality of nearby subtidal habitats (Rozas and Odum 1987; McIvor and Odum 1988).

Differences in utilization between riverine and saline types of marshes has not been examined previously. One question of economic importance is whether utilization by fishery species differs depending upon marsh type and/or salinity regime. Our study has addressed this question by comparing salt marshes and delta marshes within a bay system.

Influences of freshwater on utilization

Salinity has been identified as a primary factor in determining distributions of estuarine organisms (Remane and Schlieper 1958; Gunter 1961 and 1967). Most of the observed patterns are cited as a response to low salinity limitations. This is because of physiological requirements for accommodating low salinities. Hence, low salinity areas in the upper reaches of estuaries are not considered to be of much direct value for estuarine species. But, it is also known that most estuarine animals tolerate broad ranges of salinity. In addition, distributions observed in nature often conflict with lower tolerance limits reported in the laboratory. This leads to relationships of faunal abundance to salinity that are footnoted with numerous exceptions. It has also led to much confusion in interpreting the value of various salinity conditions for estuarine species (Benson 1981).

Freshwater floods, for example, often have been considered to have negative effects by displacing or causing mortalities in estuarine animals. However, an examination of recent evidence suggests that flooding does not always have such adverse effects. The studies noted earlier (Rozas and Hackney 1983 and 1984; McLvor and Odum 1986 and 1988; Rozas and Odum 1987) show that prominent estuarine animals such as grass shrimp, blue crab and killifishes can exist side-by-side with freshwater species. Moreover, Rogers et al. (1984) reported that abundances of fishes, such as Atlantic croaker, southern flounder, silver perch, spot and Atlantic menhaden, either increased or were unaffected in a Georgia estuary during high river discharges. Furthermore, fishery harvests of estuarine dependent species in the Gulf of Mexico have been positively related to river discharges (Deegan et al. 1986). These investigations indicate an acceptance of low salinity situations by many, if not most, estuarine species. One way of testing acceptance or ability to accommodate low salinities is to compare faunal abundances before and after floods. We have taken this approach as part of our study to examine utilization of marshes.

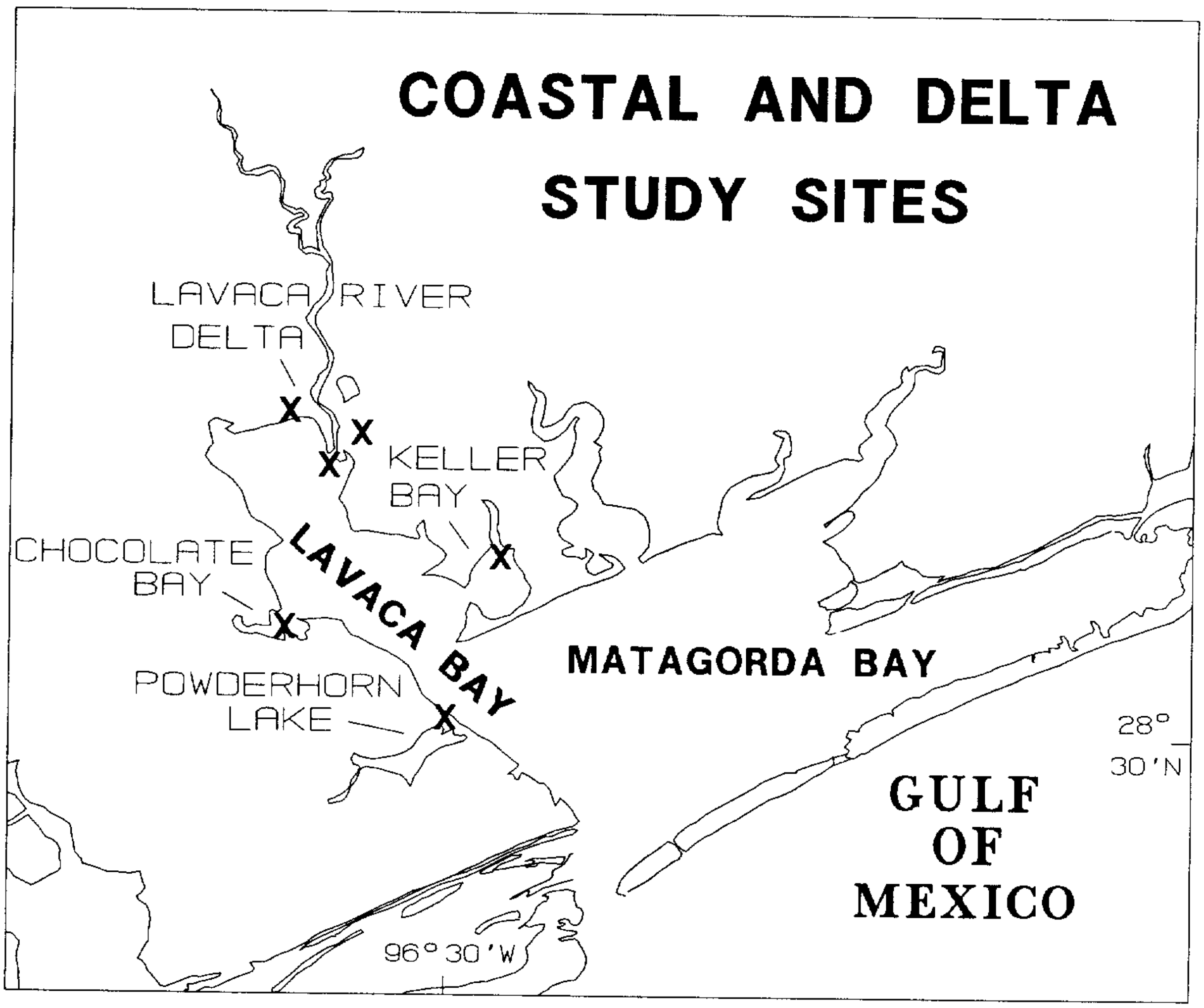


FIGURE 1. Sampling sites in Lavaca Bay, Texas, in coastal *Spartina* marshes and deltaic *Juncus* marshes compared for faunal usage in October 1985, and May and August 1986.

METHODS

Study sites

During 1985 and 1986, densities of aquatic fauna from shallow water habitats were compared between sites at coastal and deltaic locations in Lavaca Bay (Fig. 1). The coastal sites were located in Spartina marshes of three secondary bays, Chocolate Bay, Keller Bay and Powderhorn Lake, each of which opened into the middle part of Lavaca Bay. Conditions at these sites were tidally dominated by seawater entering Caballo Pass from the Gulf of Mexico . Three comparable deltaic sites were located in *Juncus* marshes in the upper bay near the mouth of the Lavaca River. The delta sites were dominated by riverflow of the Lavaca River. However, due to an impoundment about 10 km upstream at Lake Texana, freshwater input to the delta was greatly modified. In both areas, sampling was conducted in intertidal marsh and the adjacent nonvegetated subtidal bottom. These habitats correspondingly were designated coast marsh, coast subtidal bottom, delta marsh and delta subtidal bottom.

During 1986 and 1987, two locations on the Lavaca River delta were studied for the effects of freshwater flooding on habitat utilization (Fig. 2). One location was near the river mouth (designated the lower delta) and the other was about 6 km upriver at Redfish

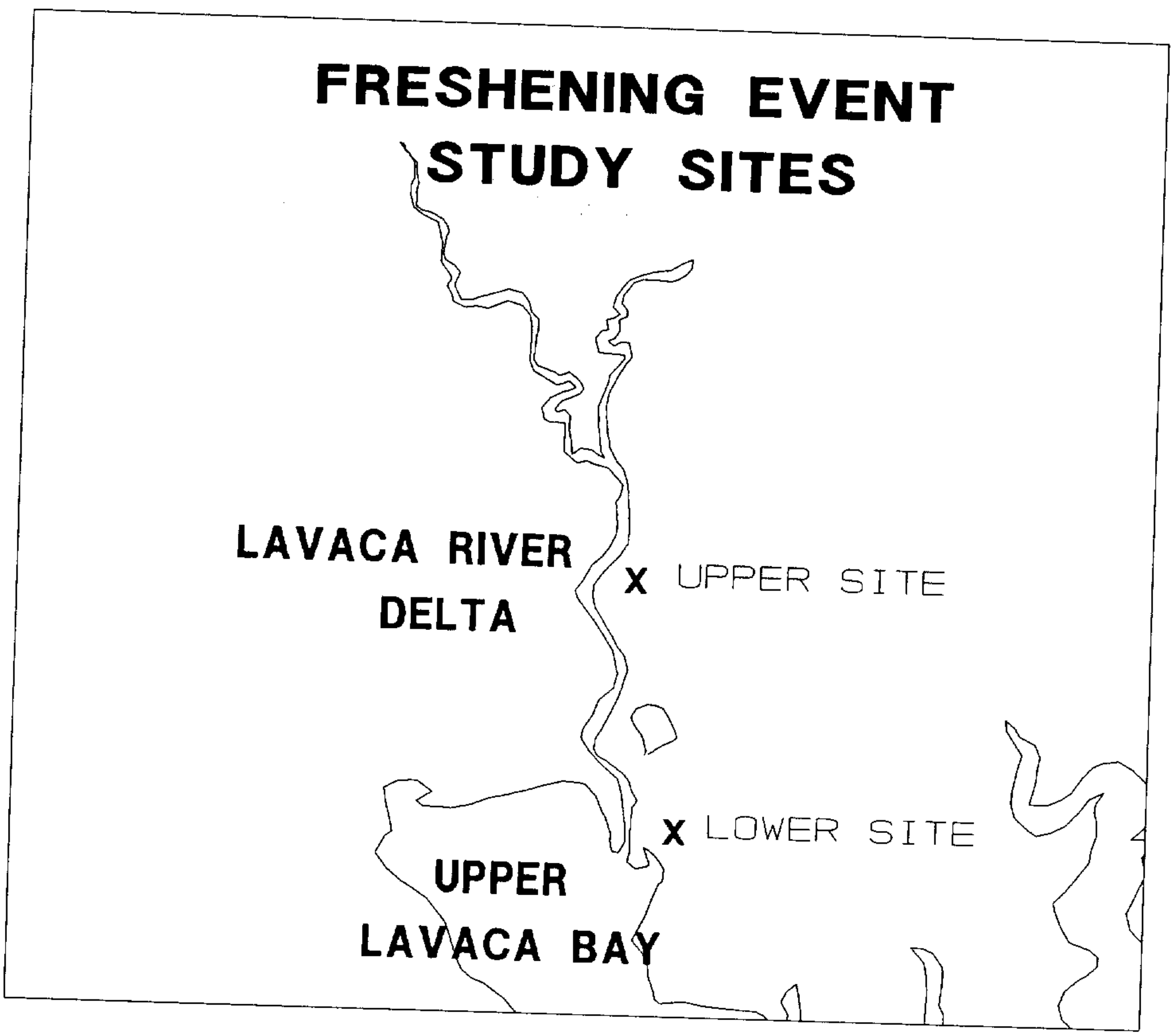


FIGURE 2. Marsh locations at the Lavaca River delta, Texas, compared for faunal usage before and after floods in the fall of 1986 and spring of 1987.

Lake (designated the upper delta). Animal densities were compared at these locations before and after floods. Samples were taken in the marsh and adjacent subtidal bare bottom as in the previous study. These habitats were designated lower delta marsh, lower delta subtidal bottom, upper delta marsh and upper delta subtidal bottom.

Field procedures

Drop trap sampling, described by Zimmerman et al. (1984), was used as to measure animal densities on marsh surfaces and in adjacent subtidal habitat. This method employed a large cylindrical sampler (1.8 m dia.) dropped from a boom on a skiff to entrap organisms in a prescribed 2.6 m^2 area. Most of the fauna were collected in the sampler with dip nets as water was pumped into a 1 mm sq. mesh plankton net. After the sampler was drained, animals remaining on the bottom were picked up by hand. This method was highly effective for sampling decapod crustaceans and small fishes and was especially effective in areas where trawls and seines cannot be used. Moreover, the method measures densities (numbers/unit area) rather than relative abundances of organisms. The technique has been used in water depths of 1 meter or less in marshes, seagrass beds, mangroves, oyster reefs, and bare mud and sand bottoms. In the present studies, four replicates (each enclosing 2.6 m^2) per habitat (marsh and bare bottom) were taken at each site during each sampling period. The samples were preserved in the field using 10% Formalin made up with seawater and Rose Bengal stain.

To compare the coast and delta, a balanced set of 4 samples of each habitat at each site were obtained in the fall (Oct. 1985) and the spring (May 1986) seasons (total of 96 samples). The delta marsh was not inundated during the summer (Aug. 1986), creating an unbalanced data set without delta marsh samples. This summer set was analyzed separately, only using subtidal habitat to compare coast and delta locations. In addition to comparing marsh types between locations, stands of delta *Spartina* and coast *Juncus* were sampled for comparison within locations eg., these subsets consisted of 4 *Spartina* and 4 *Juncus* samples taken within each the Chocolate Bay site (coastal) and the River mouth site (delta). The subsets were acquired only during the fall and spring.

A second study was conducted at the Lavaca River delta to evaluate the effect of floods on utilization. Upper and lower delta sites were sampled, consisting of 8 marsh and 8 nonvegetated habitat samples per site, before and after each flood event. Samples (64 samples/set) were taken regularly until a flood event caused salinities to be significantly lowered in delta marshes. After each flood, additional samples were taken within 10 days. Accordingly, five sets of samples were divided among three high rainfall events, one during the fall of 1986 and two consecutive events during the spring of 1987 (320 samples overall). These floods, each with a "before" and "after" data set, were delineated Flood 1, Flood 2 and Flood 3. The fourth data set (late May 1987) served as the "after" set for Flood 2 and the "before" set for Flood 3. Only during the floods in late May and early June of 1987 (Flood 3), did salinities change significantly between the before and after periods.

Other observations from samples included vegetation density and biomass, maximum and minimum water depth, temperature, salinity, dissolved oxygen and turbidity. Subsamples emergent plants were cut and placed in plastic bags, without preservation, for laboratory processing. Water depth was measured with a meter rule in cm (nearest 0.1). Water temperature was measured to the nearest 0.1 °C and dissolved oxygen to the nearest 0.1 ppm with a YSI Model 51B meter.

Field salinity was measured to the nearest ppt using an American Optical refractometer. Water samples were collected from each drop trap sample in 500 cm^2 bottles to measure turbidity in FTUs with a HR Instruments Model DRT 15 meter and to check salinity with a Hydrolab Data Sonde at the laboratory.

Laboratory procedures

In the laboratory, fishes and crustaceans were sorted to species (using identifications based on taxonomic guides listed in Appendix I), then measured and counted. Fish were counted within 10 mm size intervals (1 to 10, 11 to 20, ...etc.) and decapod crustaceans were counted within 5 mm size intervals (1 to 5, 6 to 10, 11 to 15, ...etc). Marsh plants were identified and wet weights (kg) were taken upon returning to the laboratory. Afterward, plant were air dried for two months and weighed again, dry (kg). In addition, the number of culms in each sample were counted to calculate plant stem densities. The data were written on preprinted standard forms and transcribed to microcomputer files using DBASE III Plus. Faunal samples were stored in 5% Formalin or 70% ETOH to be kept for at least 5 years from the date of collection. All field sheets, laboratory data entry forms and electronic data files will be kept at the NMFS Galveston Laboratory for at least 8 years.

Analytical procedures

We used factorial ANOVAs to test for differences in means between locations in both studies. The main observations were faunal densities. Accordingly, analyses were conducted on selected groups of species eg., all fishes, all decapod crustaceans, economically important fishes, economically important decapod crustaceans and certain families, and on selected abundant species. A 3-way ANOVA was used to test spring and fall data sets for differences in densities attributable to habitat, location, and season. The data were transformed for ANOVA analyses, using log x + 1, to correct for heterogeniety of variances (see means and standard errors in Appendices). ANOVAs were executed on a microcomputer using SAS/STAT programs. Probabilities of 0.05 or less than were deemed significant.

The main test in the first study was to compare of delta and coast locations. In this analysis, sites were considered as replicates (3 at each location) and drop trap samples were considered as subsamples (4 subsamples in each microhabitat at each site). The spring and fall seasons were analyzed together. The summer (August 1986) was analyzed separately because the delta marsh surface was exposed and not available for sampling eg., only subtidal bare habitat was considered.

In the second study, flood events were separately analyzed in 3-way ANOVAs. Flood stage was the main factor (2 periods - before and after each flood), location the second factor (2 locations - upper and lower delta), and habitat the third factor (2 habitats - marsh and subtidal). Eight replicate samples were taken in each habitat.

Untransformed means and standard errors of physical measurements and faunal densities were tabulated by season, site and habitat (given in Appendices). The data have been stored on standard microcomputer 5 1/2 inch floppy disks.

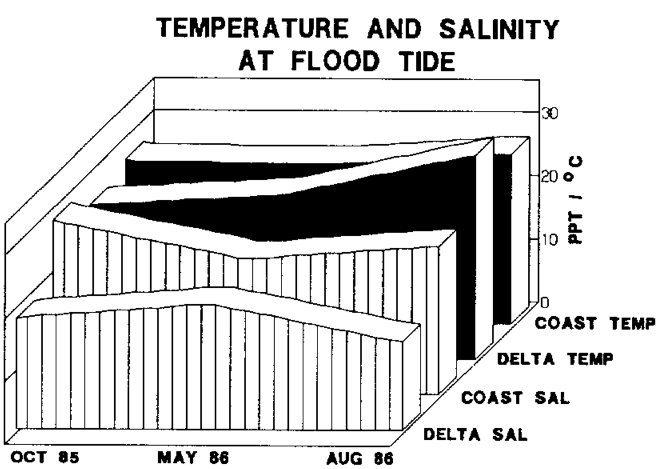
TABLE 1. An analysis of temperature, salinity and water depth means in subtidal habitat, adjacent to marsh, in Lavaca Bay between delta and coastal locations, during spring, summer and fall seasons. P values with significant differences are denoted by asterisks and significant interactions by bold print.

	Temperature	Salinity	Minimum Water Depth
Season	< 0.001**	0.31	0.003*
Location	0.022*	0.002*	0.07
Season x Location	**0.011**	0.14	0.66

RESULTS

Physical Environment

Salinity regimes and floods. During the fall of 1985 and the spring and summer of 1986, salinities in Lavaca Bay marshes ranged from mesohaline to polyhaline (Appendix IIA). Within locations, salinities did not differ significantly over seasons. Between locations salinities were significantly lower at the delta than the coast (Table 1; Fig. 3). Nevertheless, salinities at delta *Juncus* marsh were relatively high, ranging between 13 to 25 ppt and overlapped with 15 to 30 ppt salinities of coastal *Spartina* marshes. The impoundment within 10 km of the mouth of the Lavaca River and low rainfall in 1986 may have promoted the unexpectedly high salinities. As another factor, our sampling was biased to coincide with periods of higher tides, and this may also have contributed to higher values. Withstanding biases, the relatively high salinities in delta marshes did coincide with observations of low river flow (from less than normal rainfall) and were supported by other measurements taken from continuous records of data sondes placed in the upper bay.



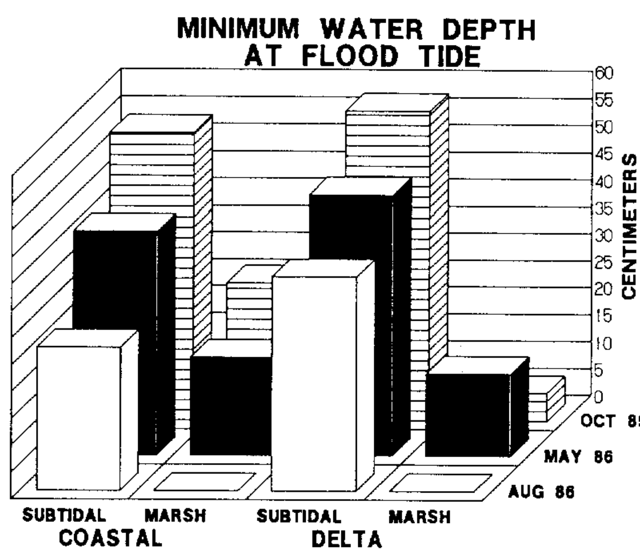


FIGURE 3. Temperature, salinity, and water depth associated with coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

Rainfall did cause general flooding in the Lavaca River watershed during November of 1986, and May and June of 1987. Our data before and after the floods showed that only one of these events (June 1987) was large enough to change salinities over an extended period. Interestingly, during the fall flood (the 1st flood event) 8 inches of rainfall occurred in one day (Oct.23, 1986 at Port Lavaca, Texas) which did not effectively lower salinities. Before the fall event, on October 21 and 22, salinities were 14 to 15 ppt in lower delta marshes and 4 to 5 ppt in upper delta marshes. Following the event, on November 3 and 4, salinities were 12 to 13 ppt at the lower delta and 6 ppt at the upper delta. Similar rains in mid-May of 1986 (the 2nd flood event) also had no effect on lowering of salinities. On May 12 and 13, salinities were 7 to 9 ppt at the lower delta and 1 to 3 ppt at the upper delta. By May 25 and 26, following rains in the area, salinities had actually increased (presumably due the greater effect of high tides over riverflow), so that the lower delta was 14 to 16 ppt and the upper delta was 5 to 10 ppt. However, high rainfall continued into June and flooding (the 3rd flood event) finally was effective and sustained enough to lower salinities in delta marshes (Fig. 4). Accordingly, by June 11 and 12, lower delta salinities were 0.1 to 0.5 ppt and upper delta salinities were 0 to 1.4 ppt.

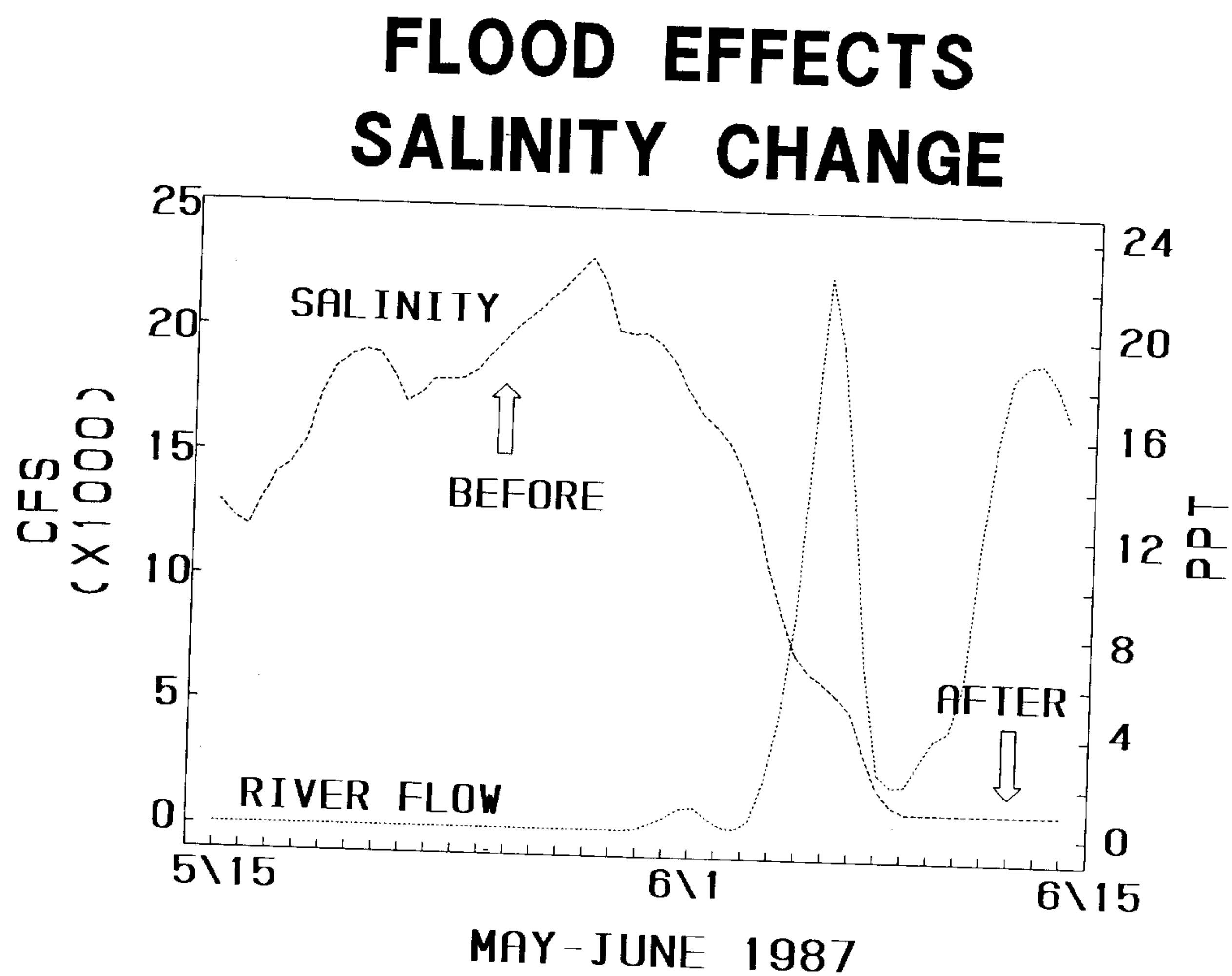


FIGURE 4. Salinity change in upper Lavaca Bay during flooding of the Lavaca River associated with high rainfall in May and June of 1987 (flood # 3).

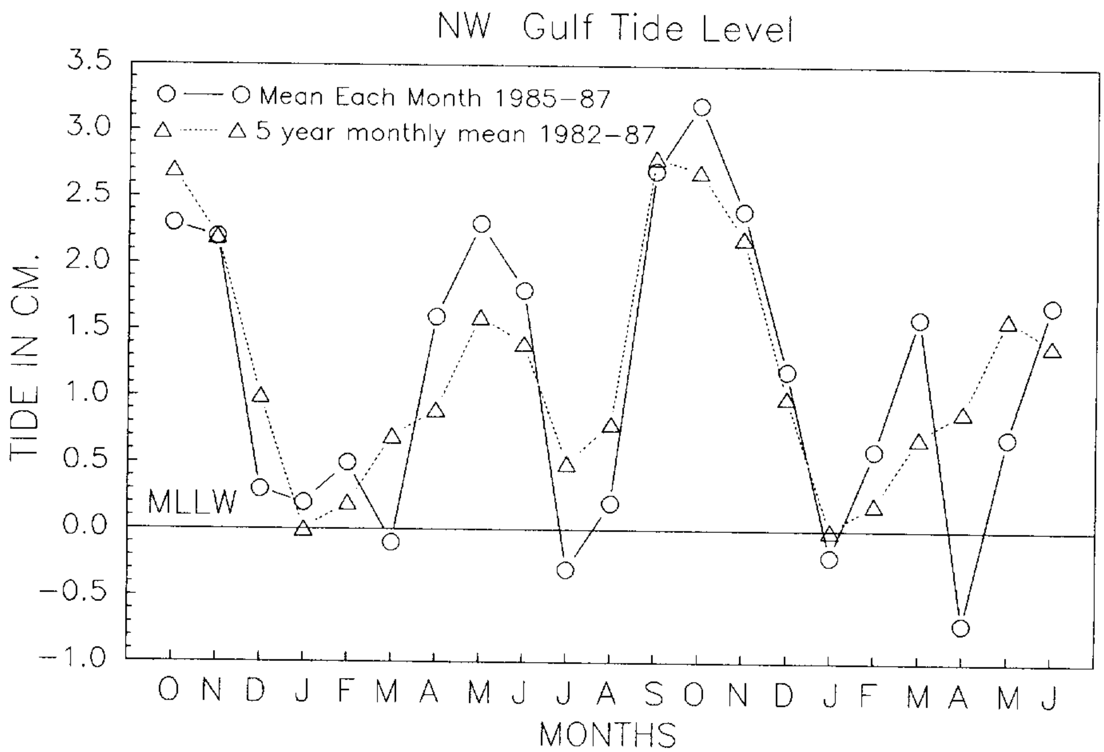


FIGURE 5. The seasonal pattern of tides in the northwestern Gulf of Mexico from records of the NOAA/NOS tide station No. 877-1450 at Galveston Texas.

Water depth and other parameters. Subtidal water depth differed significantly between seasons (lower during the summer period), but not between coast and delta locations (Table 1; Fig. 3). However, it was apparent that coastal *Spartina* was lower than in deltaic *Juncus* (Fig. 3). This was attributed to a characteristic higher elevation of delta marsh environments. As a result, *Juncus* was inundated by tides less frequently, for shorter periods and at shallower depths than *Spartina*. Seasonal periodicity of tidal heights in the northwestern Gulf of Mexico has a large effect on inundation patterns. Seasonal tides are high in the spring and fall and low in the summer and winter (Hicks et al. 1983; and Fig. 5). Under these circumstances, tidal flooding, especially in deltaic *Juncus*, was more frequent in the spring and fall. Low water in the summer and winter causes delta surfaces to be drained for extended periods. The effect of seasonal tides and elevation differences was apparent during our sampling in the summer of 1986. At this time, coast *Spartina* was inundated during the high tide but *Juncus* was not (Fig. 3). Notwithstanding, *Juncus* marshes were inundated by aperiodic river floods that continued for days or weeks depending upon the amount of rainfall. If river flooding coincided with high seasonal tides, as it did during May and June of 1986, inundation was prolonged.

Using subtidal values for spring, summer and fall, water temperatures differed significantly over seasons and between coast and delta locations (Table 1; Fig. 3). The overall range of mean temperatures (daylight hours only) was 24.2 to 28.6 °C in the spring, 25.8 to 33.6 °C in the summer, and 23.4 to 27.9 °C in the fall (Appendix II).

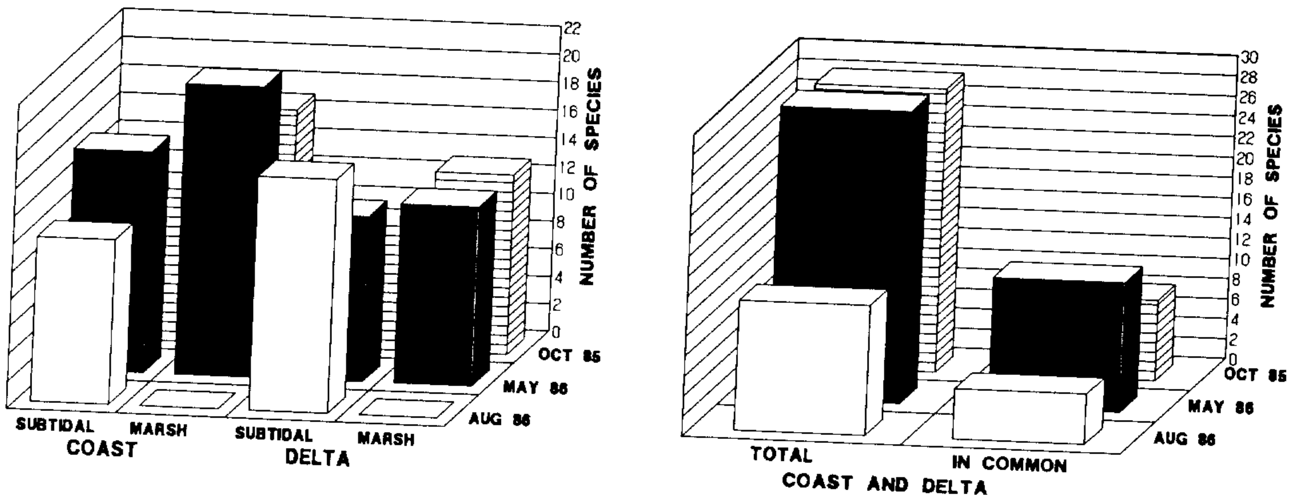


FIGURE 6. Number of fish species between habitats of coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

Utilization Of Coast Versus Delta Habitats

All fishes. During the initial study, 41 species of fishes were collected from *Spartina* and *Juncus* marshes at delta and coastal locations (Appendix III). Of these, 35 species were found at the coast compared to 27 at the delta. It was noteworthy that, although species overlapped extensively between the coast and delta, less than 50% of fish species were found at both locations at any one time (Fig. 6; Appendix III). However, most species commonly found in both areas were abundant in both areas, which included all of the economically important species. Species numbers were always higher in marsh than in adjacent subtidal bare habitat (Fig. 6).

A total of 1291 fishes were caught at the coast compared to 1613 at the delta. Including both habitats across seasons, mean densities were 8.3 fish/m^2 on the coast and 10.3 fish/m^2 at the delta. In the 3-way ANOVA, overall fish abundances had significant interactions between season and location, and between season and habitat (Table 2). In the spring, fish abundances were higher on subtidal bottom and not different between the coast and delta (Fig. 7). During the fall, the reverse occurred, abundances were higher in marsh and higher at the delta. The interaction effects occurred largely due to high goby abundances in the fall (in the marsh) and high menhaden abundances in the spring (in subtidal habitat). Overall abundances of important game fishes did not differ between the coast and the delta, but were significantly more abundant in marsh habitat at both locations (Table 2; Fig. 7). Likewise, abundances of the bay anchovy (a bait fish), were not different between the coast and delta, but, in contrast to game fishes, were significantly greater in subtidal habitat (Table 2; Fig. 7). Likewise, gobies were significantly more abundant in marsh habitat, while Gulf menhaden were more abundant over subtidal habitat (Table 2; Fig. 7). *Juncus* and *Spartina* habitats within locations were not significantly difference in overall fish densities, nor among any of the abundant fish groups.

TABLE 2. An analysis of differences in faunal abundances between marsh and subtidal habitats, at delta and coastal locations, in Lavaca Bay, during spring and fall seasons. P values with significant differences are denoted by asterisks and significant interactions by bold print.

	All Fishes	Game Fishes	Bait Fishes	Naked Gobi	Bay Anchovy	Gulf Menhaden	Spotted Seatrout	Southern Flounder
Season	0.01*	0.7	0.48	0.002**	0.054*	0.009**	<0.001**	0.007**
Location	0.31	0.74	0.82	0.003**	0.7	0.59	0.2	0.68
Season x Loc.	**0.005**	0.46	**0.049**	**0.029**	0.075	0.59	0.52	0.68
Habitat	0.089	0.03*	0.051*	<0.001**	0.005**	0.009**	<0.001**	0.5
Sea. x Hab.	**0.028**	0.1	0.12	**<0.001**	0.54	**0.009**	**0.003**	0.5
Loc. x Hab.	0.42	0.1	0.94	0.22	0.61	0.59	0.06	0.32
S x L x H	0.62	0.98	0.69	0.51	0.48	0.59	0.2	0.32

	Decapod Crust.	Penaeid Shrimps	Brown Shrimp	Grass Shrimps	P. pugio	Blue Crab	White Shrimp	Pink Shrimp
Season	0.12	0.001*	<0.001**	0.06	0.029*	<0.001**	0.81	<0.001*
Location	0.12	0.69	0.23	0.25	0.35	0.56	0.69	0.28
Season x Loc.	0.58	0.55	**0.039**	0.16	0.091	0.26	0.79	0.28
Habitat	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	0.014*	<0.001**
Sea. x Hab.	0.23	**0.055**	0.87	0.49	0.45	**<0.001**	0.47	**<0.001**
Loc. x Hab.	0.36	0.25	0.85	0.71	0.72	0.44	0.84	0.48
S x L x H	0.3	0.9	0.37	0.21	0.18	0.37	0.76	0.48

Game fishes. In order of overall abundance, spotted seatrout, southern flounder and red drum each occurred at coast and delta sites (Fig. 8). Spotted seatrout were significantly more abundant during the fall and in marsh habitat, and did not differ in abundances between coast and delta sites (Table 2; Fig. 8; Appendix III). However, low numbers during the spring caused an interaction between habitat and season, and summer densities were restricted to subtidal bottom (Table 2; Fig. 8). Abundances of spotted seatrout also were not different between *Juncus* and *Spartina* within locations. Southern flounder were significantly more abundant in the spring, and did not differ between coast and delta sites nor between marsh and subtidal habitats. Red drum numbers were considered too low to test, however, highest occurrences were in the spring in subtidal habitat, equally divided between coast and delta sites (Fig. 8).

All decapod crustaceans. Of 23 species of decapod crustaceans, 21 were at the coast compared to 17 at the delta. The most abundant species, including species of grass shrimps, penaeid shrimps, portunid crabs and xanthid crabs, were found in both areas. The number of species were always higher in marsh than in subtidal habitat (Fig. 9).

A total of 13,763 decapod crustaceans were caught at the coastal location compared to 6,627 at the delta. Across seasons and habitats, mean densities were 88.2 decapods/m^2 on the coast and 42.3 decapods/m^2 at the delta. In the 3-way ANOVA, overall decapod abundances, unlike fishes, did not differ significantly between seasons, but did between habitats (higher in marsh). Like fishes, their overall abundances were not different between coast and delta locations (Table 2; Fig. 10; Appendix III). The two most abundant groups, grass shrimps and penaeid shrimps had significantly higher densities in the spring and in marsh habitat, but did not

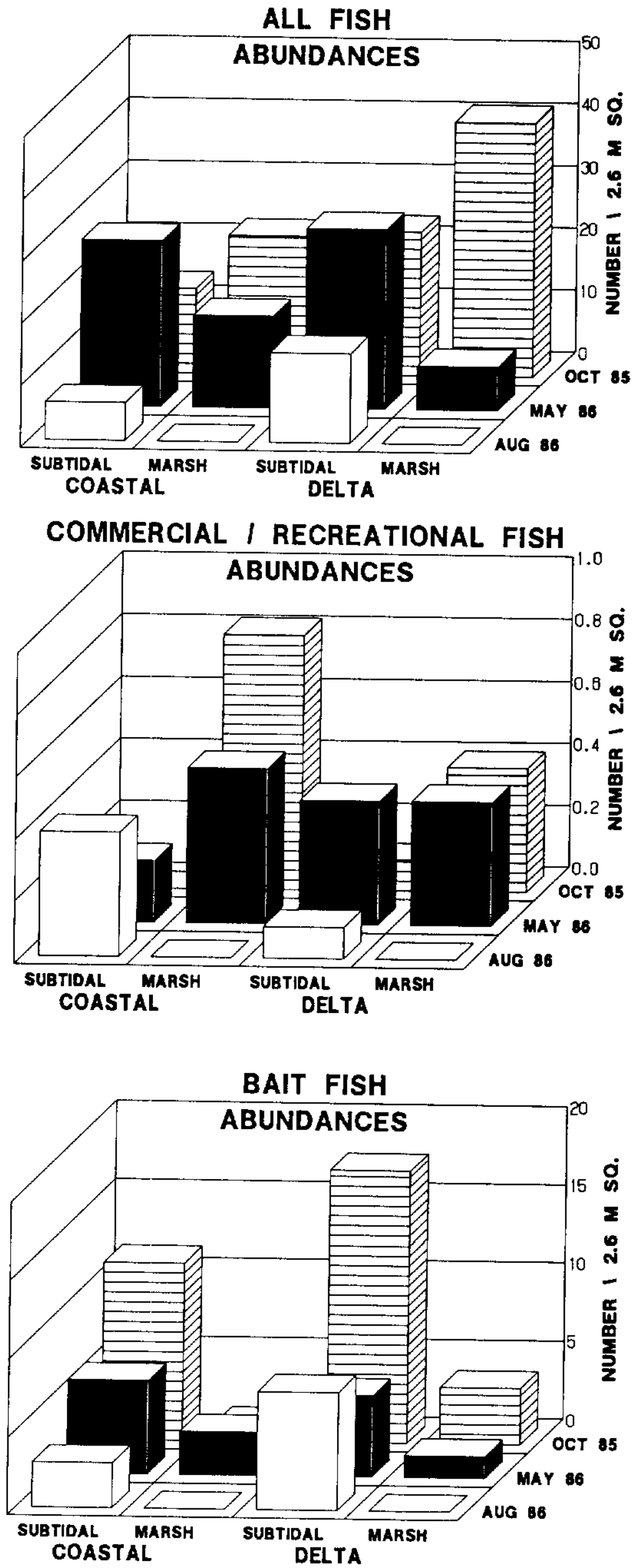


FIGURE 7. Mean abundances of fishes in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

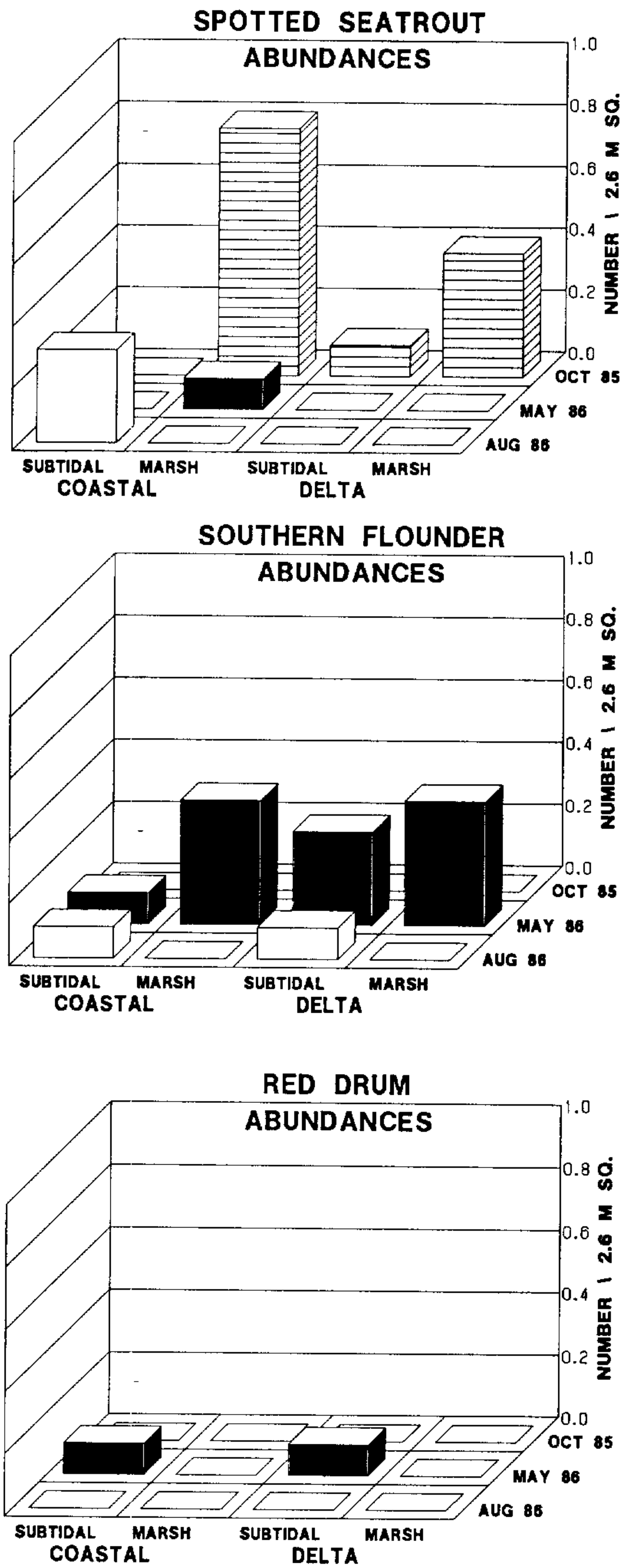


FIGURE 8. Mean abundances of spotted seatrout, southern flounder and red drum in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

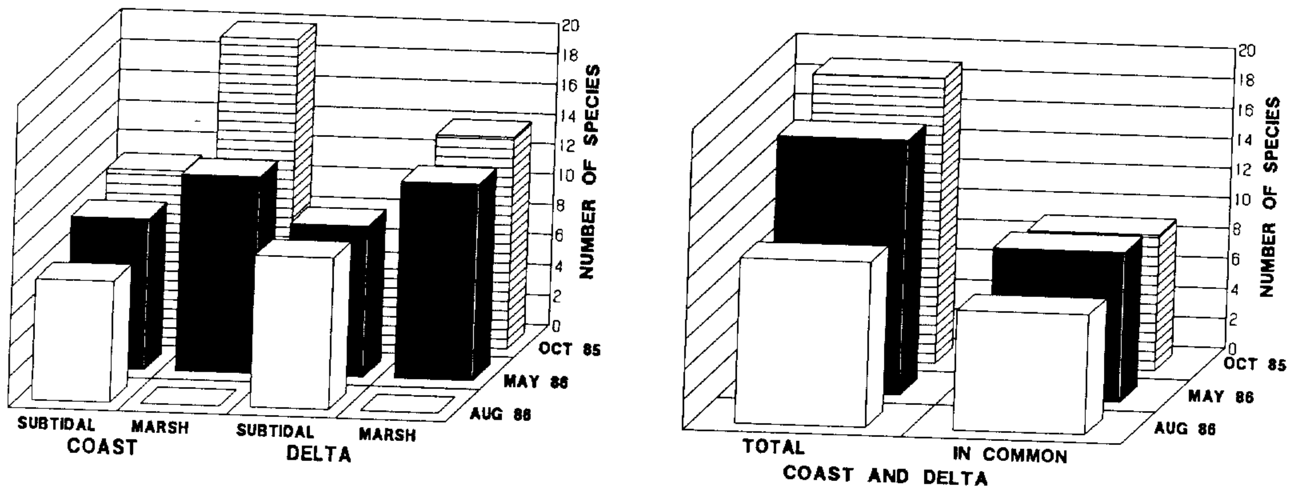


FIGURE 9. Numbers of decapod crustacean species in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

differ between coast and delta sites (Table 2; Fig. 10). Species with significantly higher densities at the coast than the delta were the brokenback shrimp *Hippolyte zostericola*, the arrow shrimp *Tozeuma carolinense* and the grass shrimp *Palaemonetes vulgaris*. The mud crab *Neopanope texana* had significantly higher densities at the delta (Appendix III). In comparing *Juncus* and *Spartina* habitats within locations, densities of most decapod crustaceans were not different. The two exceptions were the blue crab, with significantly higher densities in *Juncus*, and the brokenback shrimp with significantly higher densities in *Spartina* (Appendix III).

Commercial shrimps and crabs. In order of overall abundance, brown shrimp, blue crab, white shrimp and pink shrimp were prominent both on the coast and at the delta (Fig. 11; Appendix III). However, abundances varied significantly between spring and fall seasons for all, except white shrimp (Table 2). Thus, brown shrimp were more abundant in the spring, and blue crab and pink shrimp were more abundant in the fall (Fig. 11). Also, blue crab, white shrimp and pink shrimp abundances were not significantly different between locations. But, brown shrimp abundances had a significant interaction between season and location (Table 2), with more on the coast in the spring and more at the delta in the fall (Fig. 11). All four species were significantly more abundant in the marsh than subtidal microhabitat during the spring and fall (Table 2; Fig. 11). As noted before, marsh was largely unavailable in the summer. Among these important crustaceans, only blue crabs had significantly higher abundances in *Juncus* than *Spartina* habitats within locations; all others did not differ between marsh type.

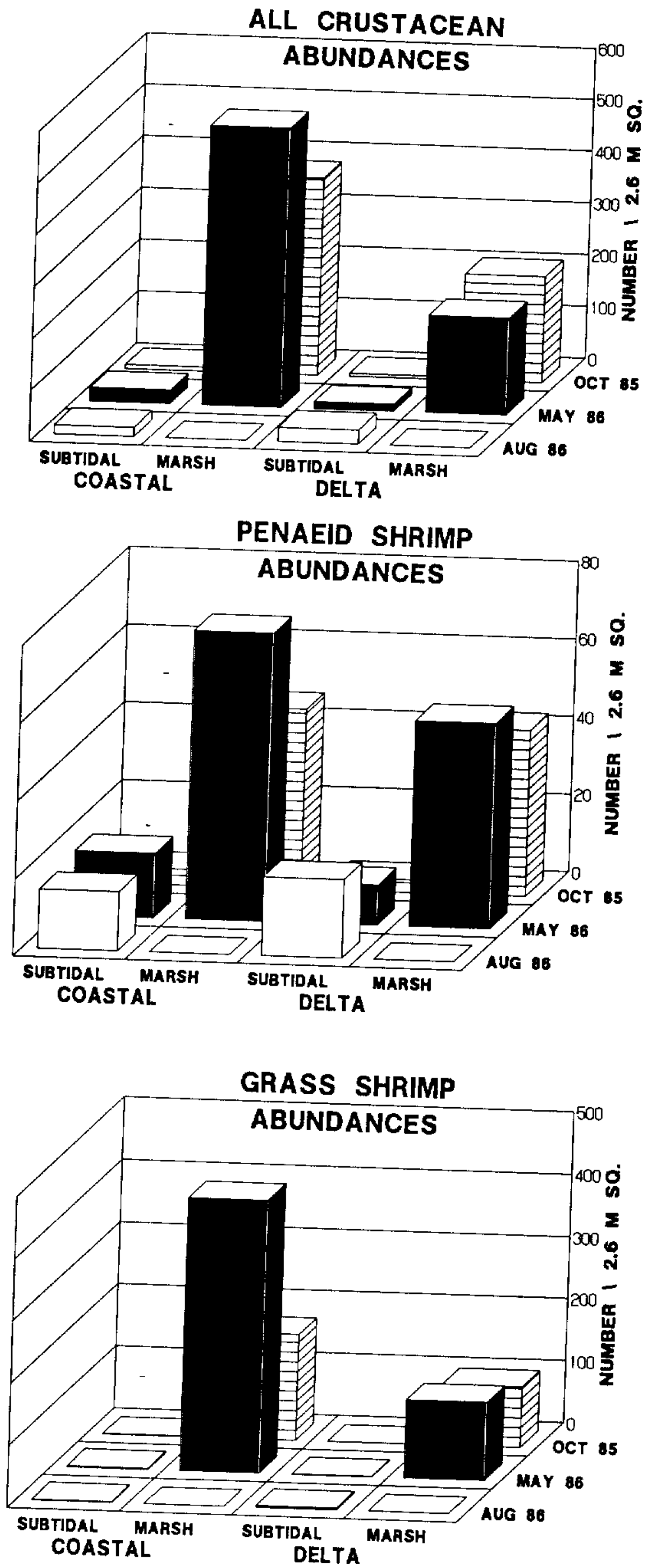


FIGURE 10. Mean abundances of decapod crustaceans in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

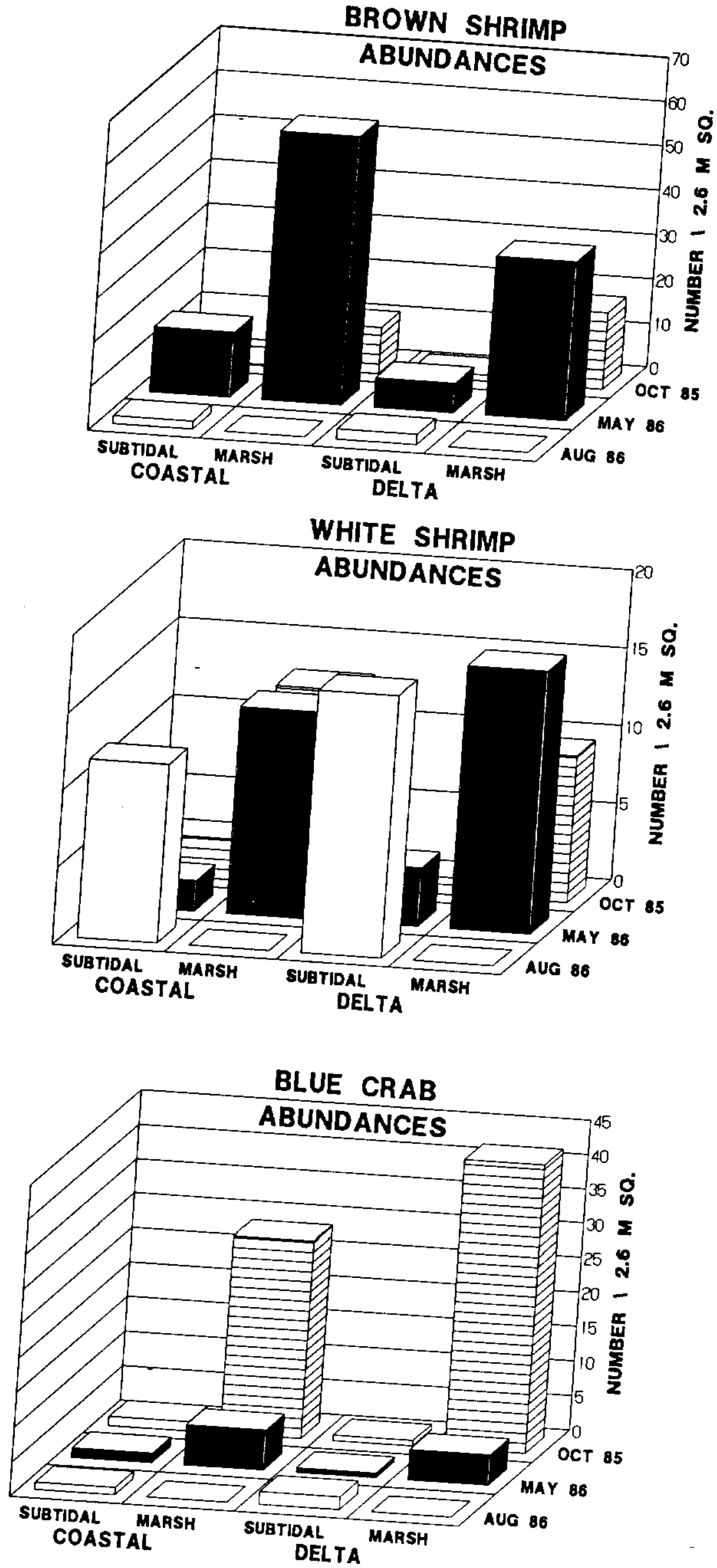


FIGURE 11. Mean abundances of brown shrimp, white shrimp and blue crab in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

TABLE 3. Differences in faunal abundances before and after floods in marshes of the Lavaca River delta, Texas. P values with significant differences are denoted by bold print with + or - indicating the direction of change.

Taxonomic Group	Flood 1 (Oct. 1986)		Flood2 (May 1987)		Flood 3 (June 1987)	
All Fishes	0.45		**0.001**	(+)	**0.017**	(+)
Cyprinodontidae	0.14		0.19		0.21	
Gobiidae	0.19		<**0.001**	(+)	0.67	
Sciaenidae	**0.034**	(+)	0.37		0.64	
Bait Fishes	0.07		0.09		**0.006**	(+)
Commercial/Sports Fishes	0.42		1		0.74	
Anchoa mitchilli	0.06		**0.003**	(+)	0.11	
Bairdiella chrysoura	np		id		**0.035**	(+)
Brevoortia patronus	np		0.31		**0.002**	(+)
Cyprinoson variegatus	0.23		**0.036**	(+)	**0.02**	(-)
Fundulus grandis	0.47		0.31		0.74	
Gobiesox strumosus	np		**0.027**	(+)	**0.044**	(-)
Gobiosoma bosci	0.94		<**0.001**	(+)	0.59	
Lagodon rhonboides	id		0.93		0.25	
Leiostomus xanthurus	id		0.73		0.57	
Micropogonias undulatus	**0.014**	(+)	0.77		0.48	
Menidia berylina	id		0.12		0.63	
Mugil cephalus	id		0.3		0.72	
Muyrophis punctatus	id		0.82		0.09	
All Decapod Crustaceans	0.46		0.18		0.12	
Grass Shrimp	0.67		0.51		0.4	
Penaeid Shrimp	0.17		0.06		<**0.001**	(-)
Xanthid Crabs	0.75		0.49		0.53	
Callinectes sapidus	0.59		0.18		**0.017**	(-)
Neopanope texana	**0.028**	(-)	0.95		id	
Palaemonetes intermedius	0.56		id		0.67	
Palaemonetes pugio	0.78		0.62		0.36	
Penaeus aztecus	0.99		0.07		<**0.001**	(-)
Penaeus duorarum	0.61		np		np	
Penaeus setiferus	**0.044**	(-)	0.1		0.47	
Rhithropanopeus harrissi	**0.006**	(+)	0.42		0.98	

Notations: np = not present; id = insufficient data for ANOVA.

Effects Of Floods On Delta Utilization

All fishes. Overall fish abundances increased significantly in delta habitats after floods on the Lavaca River in May and June of 1987, but not in October of 1986 (Table 3). Salinities did not decline after the October 1986 flood (Flood 1) and densities among prominent fishes, except Atlantic croaker, did not change (Table 3). In May of 1987 (Flood 2), salinities likewise did not change, but fish numbers increased significantly among skilletfish, naked goby, sheepshead minnow and bay anchovy after the flood; all others did not change in densities. The decrease in salinity was precipitous and relatively long lasting during the June 1987 flood (Flood 3; Fig. 4). Fish numbers increased significantly afterward in the marsh and on subtidal bottom in both the upper and the lower delta (Fig. 12). After Flood 3, densities of Gulf menhaden and silver perch increased significantly, skilletfish and sheepshead minnow decreased significantly, and all others remained the same (Table 3). Where changes occurred in fish numbers after floods, abundances usually

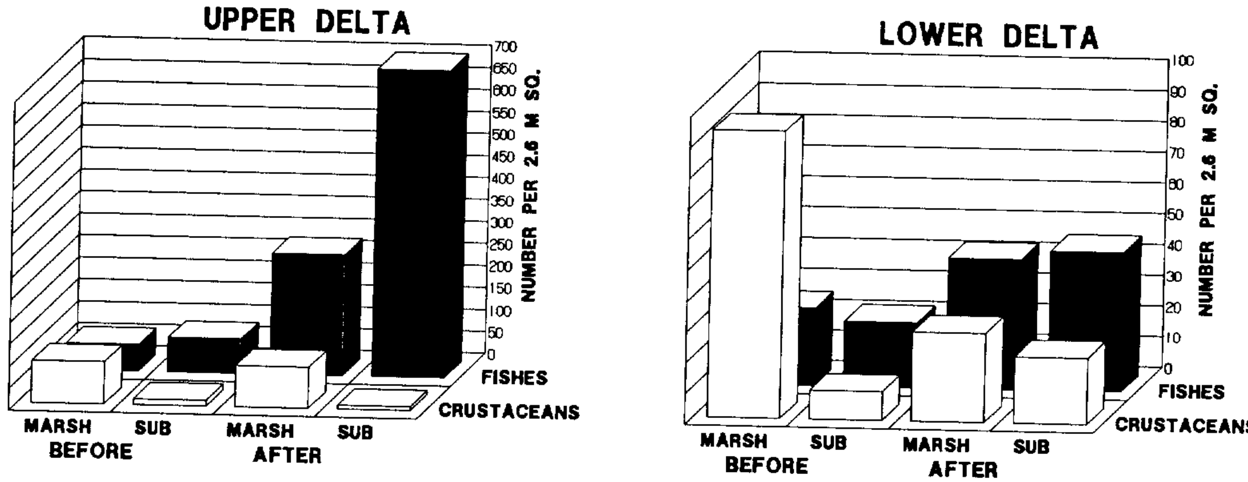


FIGURE 12. Abundances of fishes and decapod crustaceans in Lavaca River delta marshes before and after flooding during May and June of 1987 (flood event # 3).

increased (Table 3). Overall fish abundances were not different between habitats did not occur during Floods 2 and 3, but fishes were significantly more abundant in marsh habitat during Flood 1 (Appendix IV).

Bay anchovy and Gulf menhaden. The bay anchovy and Gulf menhaden were the most abundant of delta fishes and were considered to be especially important for their value as prey (bait fishes). Both species tended to increase after river floods (Appendix IV; Fig. 13). These increases were significant for bay anchovy after Flood 2 and for Gulf menhaden after Flood 3 (Table 3).

The numerical dominance of both species was especially notable at the upper delta location (Fig. 13). Bay anchovy were significantly more abundant in subtidal habitat during Floods 1 and 3, while Gulf menhaden did not differ in abundance between habitats (Appendix IV).

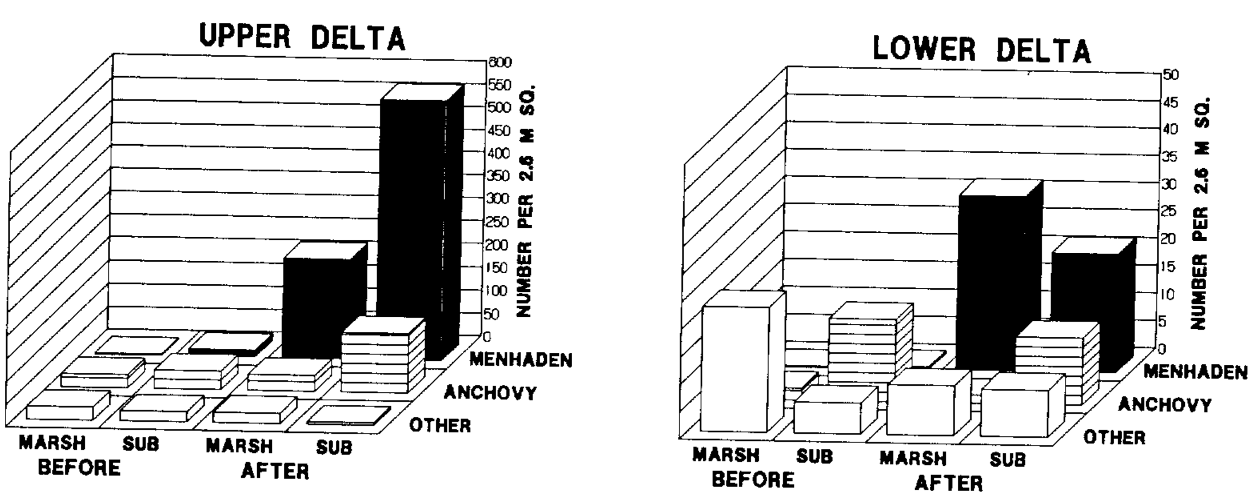


FIGURE 13. Abundances of fishes in Lavaca River delta marshes before and after flooding during May and June of 1987 (flood event # 3).

TABLE 3A. Changes in faunal abundances during flood #3 at the Lavaca River delta, Texas, in marsh and subtidal habitats, and upper and lower delta locations, before and after flooding. P values with significant differences are denoted by asterisks and significant interactions by bold print.

	All Fishes	Game Fishes	Bait Fishes	Sciaenids	Gobiids	Gulf Menhaden	Bay Anchovy
Flood	0.017*	0.74	0.006**	0.64	0.67	0.002**	0.11
Location	<0.001**	0.32	<0.001**	0.83	0.014*	0.004**	<0.001**
Flood x Loc.	0.25	0.17	0.18	0.56	0.67	0.16	0.39
Habitat	0.43	0.74	0.035	0.31	0.2	0.73	<0.001**
Fld. x Hab.	0.67	**0.046**	0.59	0.96	0.98	0.71	0.93
Loc. x Hab.	0.44	0.17	0.37	**0.004**	0.74	0.47	0.48
F x L x H	0.6	0.32	0.53	0.68	0.17	0.86	0.49

	Decapod Crust.	Grass Shrimps	Brown Shrimp	White Shrimp	Blue Crab	Mud Crabs
Flood	0.12	0.4	<0.001**	0.47	0.017*	0.98
Location	0.82	0.99	0.24	0.26	0.008**	0.15
Flood x Loc.	0.57	0.2	0.94	0.47	0.84	0.93
Habitat	<0.001**	<0.001**	0.17	0.77	0.002**	0.59
Fld. x Hab.	0.8	0.15	0.47	0.33	0.45	0.59
Loc. x Hab.	0.52	0.48	0.42	0.77	0.77	0.66
F x L x H	**0.018**	0.071	0.28	0.33	0.14	0.66

All decapod crustaceans. Floods did not significantly change the overall abundances of decapod crustaceans (Table 3; Fig. 12). Among major groups, the abundances of grass shrimps and mud crabs were not significantly different after any of the three floods, and penaeid shrimps and portunid crabs were significantly different only after Flood 3 (Table 3). Moreover, habitat appeared to affect crustacean abundances more than floods. The numbers of decapods were nearly always significantly greater in the marsh as compared to subtidal bottom (Appendix IV; Table 3A). Where changes did occur after floods, decapod abundances were usually reduced (Table 3).

Commercial shrimps and crabs. Brown shrimp and blue crab were significantly fewer in numbers after Flood 3 and white shrimp were significantly fewer after Flood 1 (Table 3 and 3A; Fig 14). Brown shrimp were significantly more abundant in marsh as compared to subtidal habitat in Flood 1 and 2, but not in Flood 3 (Table 3A), while white shrimp did not differ in abundance between habitats in any flood. Blue crab were always significantly more abundant in the marsh (Appendix IV).

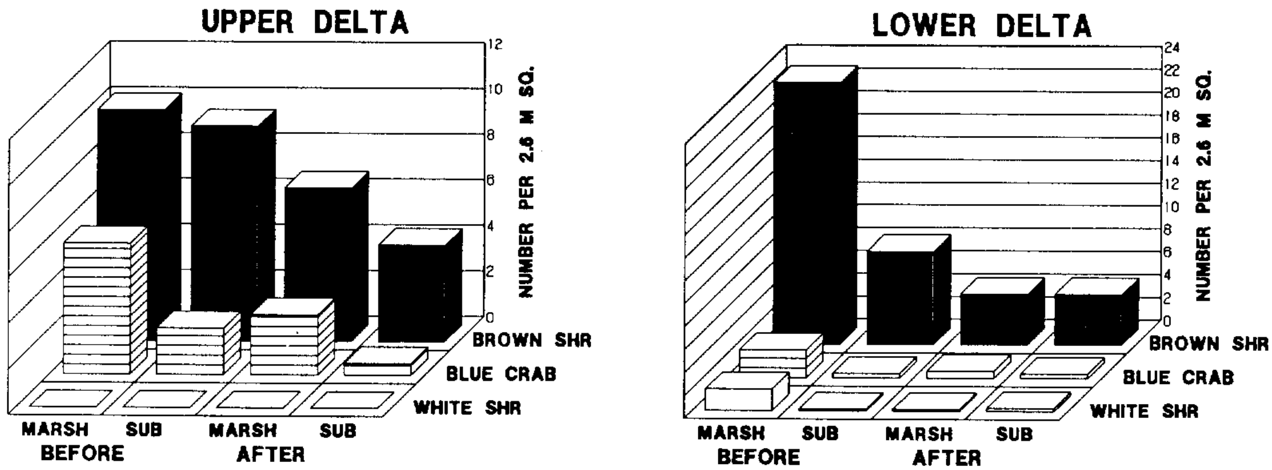


FIGURE 14. Abundances of economically important crustaceans in Lavaca River delta marshes before and after flooding in May and June of 1987 (flood event # 3).

DISCUSSION

Utilization Of Coastal Marshes Versus Deltaic Marshes

The two study areas in Lavaca Bay contrasted in several ways. The marsh plants were different (smooth cordgrass versus black rush), the locations were separated in distance from the coast (lower bay versus upper bay), and the salinity regimes differed (saline versus brackish). Together, the sites potentially represented the range of marsh conditions found in many temperate estuaries, from Texas to New Jersey. Salt marshes in the Gulf of Mexico and southeastern U.S. are usually dominated by smooth cordgrass with black rush as a subdominant (Kurz and Wagner 1957; Charbreck 1972; Gallagher, et al. 1980). Or, in some areas, such as coastal Mississippi, black rush is the dominant (Eleuterius 1980). Both species occur under brackish and saline conditions. In Lavaca Bay, the more saline marshes near the coast were predominately smooth cordgrass but with black rush at the landward edges. Black rush was a progressively greater component of marshes in the upper bay. At the brackish lower delta in the upper bay, black rush was the dominant marsh plant and smooth cordgrass was a subdominant. Thus, Lavaca Bay had tidal marshes ranging from deltaic to lower bay and barrier island types, each distinctly classified (Pethick 1984), and occurring in the same estuary. At the mouth of Lavaca Bay, Caballo Pass transgresses the barrier island (Matagorda Island) and a channel runs directly up the main bay axis to the Lavaca River. This channel appeared to facilitate movement of salt water into and freshwater out of the bay. But during our study, river flow was characteristically low, creating mesohaline to polyhaline conditions (13 to 30 ppt) throughout most of the bay. Oligohaline conditions (> 6 ppt) commenced on the delta about 5 to 10 km upriver. Only once in two years of observation (1985-1987) did these conditions deviate. This occurred temporarily when salinities declined dramatically after floods in May and June of 1987. Thus the estuarine environment of Lavaca Bay was largely mesohaline to polyhaline, and the development of a classical salinity gradient (Prichard 1967) appeared generally weak.

Estuarine fishes and decapod crustaceans used Juncus delta marshes and Spartina coastal marshes similarly and extensively, leading to important implications. First, it showed that most estuarine fauna are able exploit a wide range of habitats available in a mesohaline system. Also , tidal marshes regardless of type are more intensively utilized by estuarine fauna than subtidal bottom. One reason for this habitat selection appears to be that tidal marshes provide more food (Rader 1984; Fleeger 1985; Zimmerman, Minello and Dent 1990) and protection (Minello and Zimmerman 1983; McIvor and Odum 1988) for certain predators. Juveniles of fishery species are among the most prominent of these predators.

Juveniles of fishery species in Lavaca Bay used marsh surfaces as extensively as in Galveston and Barataria Bays (Zimmerman and Minello 1984; Zimmerman, Minello, Smith and Castiglione 1990a and b; Zimmerman 1989). All were mesohaline and polyhaline marshes and all of the estuarine dependent fishery of the NW Gulf used them. Furthermore, juveniles of brown shrimp, blue crab and spotted seatrout were always significantly more dense on marsh surfaces than bare subtidal bottom. Such high abundances suggest a relationship between the nursery function of marshes and fishery yields. Accordingly, tidally flooded marshes in the NW Gulf appear to function similar to seagrass beds as high quality nursery habitat. In Christmas Bay, Thomas et al.(1990) reported that densities of small blue crabs did not differ between salt marshes and seagrasses. Seagrass and salt marsh habitats provided equivalent food and protective qualities that were far superior to bottom without vegetation (Thomas 1989). In West Bay, small brown shrimp grew faster, because of higher densities of food, (Zimmerman, Minello and Dent 1989) and survived better, due to structural protection (Minello and Zimmerman 1983), in salt marsh as compared to nonvegetated bottom. Nonetheless, salt marshes on the east coast of the U. S. did not function like those in Texas. Orth et al. (1984) and Wilson et al.(1989) have found that blue crabs in New Jersey and Virginia use seagrasses but not salt marshes as nurseries. Likewise, young brown shrimp in South Carolina use subtidal bottoms more extensively than tidal marshes (E. Wenner, personal communication). The difference appears to be one of degree in duration of marsh flooding. Because of subsidence, NW Gulf marshes are flooded more frequently and for longer periods than east coast marshes (Baumann 1987). This allows tidal marshes to develop ecological characteristics that are like subtidal seagrasses. Since the NW Gulf has extensive tidal marshes, but few seagrass beds, the nursery function of these marshes is unusually important.

The salinity regimes of tidal marshes modify their nursery value. For example, faunal usage of marshes in Galveston Bay and San Antonio Bay (Zimmerman, Minello, Castiglione and Smith 1989 a, b and c), varied in relation to long term salinity characteristics. Species numbers at oligohaline and polyhaline ends of the gradient were generally higher than the mesohaline middle, reflecting incursions of freshwater and marine species, respectively. However, abundances were highest in mesohaline areas. This was particularly true of juveniles of estuarine dependent fishery species. Delta marshes became especially depauperate in abundances of estuarine species when exposed to salinities below 2 ppt for periods longer than one month. This occurred in association with high river flows, over extended periods, in Galveston Bay at the Trinity Delta and in upper San Antonio Bay near the Guadelupe Delta (Zimmerman, Minello, Castiglione and Smith 1989c). Changes in usage under oligohaline conditions in Galveston Bay were attributed to reductions in small epibenthic fauna useful as food (Zimmerman, Minello, Castiglione and Smith 1989b).

Thus, accessibility and area surfaces as well as quality of marsh surface may greatly affect the outcome of secondary productivity. An estuary with a large mesohaline area and highly accessible marsh surfaces stimulates faunal production. This appears to have been the case for Lavaca Bay. Relatively low river flow promoted mesohaline to polyhaline conditions. As a result, faunal utilization of marshes was high throughout the bay. These conditions, especially in delta marshes, expanded the estuarine system. Gulf fisheries are highly estuarine dependent (Gunter 1961). Does this estuarine expansion translate to larger offshore yields? The implications of these findings to NW Gulf fisheries are further discussed below.

The Effects Of Freshwater Flooding

Freshwater floods, both with and without precipitous decline in salinity, had relatively little effect on short term (days to weeks) utilization of marshes. Most estuarine species were similar in abundance levels before and after floods. Accommodation to flooding among estuarine fishes is supported by Rogers et al. (1984). Sciaenids including, Atlantic croaker, silver perch, and spot, as well as menhaden and southern flounder were not deterred by freshwater conditions up to 100 days from flooding of a Georgia salt marsh (Rogers et al. 1984). In Calcasieu estuary, Louisiana, Felley (1987) reported that juveniles of Gulf menhaden, southern flounder, Atlantic croaker, spot and bay anchovy were attracted to freshwater and oligohaline areas. In our study of Lavaca River delta marshes, Gulf menhaden and bay anchovy increased in abundances after floods. Floods may also generate longer term beneficial effects. Red drum, known to use low salinity waters as early juveniles (Peters and McMichael 1987), had high recruitment success during a year of reduced salinities, caused by flooding following a hurricane, in the Laguna Madre of Texas (Matlock 1987). High rainfall patterns and freshwater inflow have also been associated with increased production of white shrimp (Gunter and Hildebrand 1954; Mueller and Matthews 1987). In Louisiana, white shrimp occurrences are often cited under oligohaline and freshwater circumstances (Felley, 1987). In Lavaca Bay marshes, white shrimp were seasonally abundant and not affected by salinity changes. Other decapod crustaceans responded to floods with lower abundances, but even they demonstrated a high degree of apparent tolerance to freshening conditions. Distribution patterns in estuaries have long been based on salinities (Hedgepeth 1953; Gunter 1961) and changes in community structure have been related to freshwater inflow changes (Hoese 1960; Copeland 1966). But, we still do not understand the cause-effect relationships between salinity and occurrences of estuarine animals. This is clear from observations in Lavaca Bay where fauna were relatively unaffected by short-term extreme changes in salinity due to floods.

Habitat Relationships To Fishery Productivity

Analyses of NMFS landing records for the Gulf indicate that fishery landings and recruitment have increased even though marsh habitat is being severely lost in both Texas and Louisiana (Zimmerman, Klima and Minello 1989). Since 1960, it is estimated that brown shrimp and white shrimp recruitment have increased by 50 % and menhaden recruitment is up by 100 %. In response, the fishing effort and dockside landing have increased without diminishing catch per unit effort.

The answer to the paradox is in understanding what is happening to tidal marshes of the NW Gulf. In NW Gulf tidal marshes, high and low, fresh and salt, inundation is occurring for unusually long periods because of accelerating subsidence and sea-level rise. One result is that low marshes (mostly salt marshes) are drowning and breaking up into ever smaller but increasingly numerous islands in ever expanding areas of open water. In the process of deterioration, the marshes offer an ideal environment for food organisms foraged by shrimp, blue crabs and small commercial and sports fishes such as flounder, spotted seatrout and red drum. The multitudes of small marsh islands have more edge than large unbroken expanses of marsh and are more readily accessible from surrounding the open water. As both high and low marshes become progressively lower relative to sea level, the duration of intertidal flooding and saltiness increases, which makes most NW Gulf marshes more favorable to exploitation by estuarine fauna. These conditions appear to have stimulated fishery production over the last few decades and have engendered the paradox; but, this is occurring at the expense of marsh area loss.

Impounding our rivers and reducing freshwater inflow, as in the case of Lavaca Bay, may be one of the factors increasing our fishery productivity. This is possible because deltas are normally low salinity environments, that without optimal freshwater input function as highly exploitable mesohaline environments. The effect expands usable nursery area especially for fishery species. But, deltas are built by river borne sedimentation that comes from freshwater inflow. Active delta building is our major source of wetland creation, and, at present, the only means to offset other causes of wetland losses. Thus, if we do not maintain delta building processes, high quality nursery areas in future systems will not exist. And, the eventual effects of continuing wetland losses will assure future declines in fishery production.

LITERATURE CITED

Baumann, R. H. 1987. Chapter 2. Physical Variables. pp. 8-17. In: W. H. Conner and J. W. Day, Jr. (eds.) The Ecology of Barataria Basin, Louisiana: An Estuarine Profile. U. S. Fish. Wildl. Serv. Biol. Rep. 85 (7.13).

Bell, S. S. 1980. Meiofauna-macrofauna interactions in a high salt marsh habitat. Ecol. Monogr. 50:487-505.

Bell, S. S. and B. C. Coull 1978. Field evidence that shrimp predation regulates meiofauna. Oecologia 35:141-148.

Benson, N. G. 1981. The freshwater-inflow-to estuaries issue. Fisheries 6 (5):8-10.

Borey, R. B., P. A. Harcombe and F. M. Fisher 1983. Water and organic fluxes from an irregularly flooded brackish marsh on the upper Texas coast, U.S.A. Estuar. Coast Shelf Sci. 16:379-402.

Charbreck, R. H. 1972. Vegetation, water, soil characteristics of the Louisiana coastal region. Bull. Louisiana State Univ. Agri. Exp. Sta. 664. Baton Rouge. 72 pp.

Copeland, B. J. 1966. Effects of decreased river flow on estuarine ecology. J. Water Pollut. Control Fed. 38:1831-1839.

Daiber, F. C. 1977. Salt-marsh animals: distributions related to tidal flooding, salinity and vegetation. pp. 79-108. In: V. J. Chapman (ed.) Ecosystems of the World: I, Wet Coastal Ecosystems. Elsevier Scientific Publ. Co., Amsterdam, Netherlands.

Deegan, L. A., J. W. Day, Jr., J. G. Gosselink, A. Yanez-Arancibia, G. Soberon Chavez and P. Sanchez-Gil 1986. Relationships among physical characteristics, vegetation distribution and fisheries yield in the Gulf of Mexico estuaries. pp. 83-100. In: D. A. Wolfe (ed.) Estuarine Variability. Acad. Press, Inc. New York, N. Y.

Eleuterius, L. N. 1980. Tidal marsh plants of Mississippi and adjacent states. Mississippi-Alabama Sea Grant Consortium, Pub. No. MASGP-77-039, Gulf Coast Res. Lab., Ocean Springs, Mississippi 39564

Felley, J. D. 1987. Nekton assemblages of three tributaries to the Calcasieu estuary, Louisiana. Estuaries 10:321-329.

Fleeger, J. W. 1985. Meiofaunal densities and copepod species composition in a Louisiana, U.S.A., estuary. Trans. Am. Microsc. Soc. 104:321-332.

Gallagher, J. L., R. J. Reimold, R. A. Linthurst and W. J. Pfeiffer 1980. Aerial production, mortality, and mineral accumulation-export dynamics in *Spartina alterniflora* and *Juncus roemerianus* plant stands in a Georgia salt marsh. Ecology 61:303-312.

Gunter, G. 1961. Some relations of estuarine organisms to salinity. Limnol. Oceanogr. 6:182-190.

Gunter, G. 1967. Some relationships of estuaries to fisheries of the Gulf of Mexico. pp. 621-637. In: G.H. Lauff (ed). Estuaries. Amer. Assoc. Adv. Sci. Publ. No. 83.

Gunter, G. and H. H. Hildebrand 1954. The relationship of rainfall of the state and catch of the marine shrimp (*Penaeus setiferus*) in Texas waters. Bull. Mar. Sci. Gulf Carib. 4:95-103.

Hedgpeth, J. W. 1953. An Introduction to the zoogeography of the northwestern Gulf of Mexico with reference to invertebrate fauna. Publ. Inst. Mar. Sci. Texas 3:107-224.

Hicks, S. D., H. A. Debaugh Jr. and L. E. Hickman 1983. Sea level variations for the United States 1855-1980. NOAA/NOS Rpt., National Ocean Survey, Tides and Water Levels Branch, Rockville, MD. 170 pp.

Hoese, H. D. 1960. Biotic changes in a bay associated with the end of a drought. Limnol. Oceanogr. 5:326-336.

Kneib, R. T. and A. E. Stiven 1982. Benthic invertebrate responses to size and density manipulations of the common mummichog, *Fundulus heteroclitus*, in an intertidal salt marsh. Ecology 63:1518-1532.

Kurz, H. and K. Wagner 1957. Tidal marshes of the Gulf and Atlantic coasts of northern Florida and Charleston, South Carolina. Fla. St. Univ. Stud. 24:1-168. Tallahassee, Florida.

Matlock, G. C. 1987. The role of hurricanes in determining year-class strength of red drum. Contrib. Mar. Sci. 30:39-47.

McIvor, C. C. and W. E. Odum 1986. The flume net: a quantative method for sampling fishes and macrocrustaceans on tidal marsh surfaces. Estuaries 9:219-224.

McIvor, C. C. and W. E. Odum 1988. Food, predation risk, and microhabitat selection in a marsh fish assemblage. Ecology 69: 1341-1351.

Minello, T. J., and R. J. Zimmerman 1983. Fish predation on juvenile brown shrimp, *Penaeus aztecus* Ives: the effect of simulated *Spartina* structure on predation rates. J. Exp. Mar. Biol. Ecol. 72:211-231.

Morgan, M. D. 1980. Grazing and predation of the grass shrimp *Palaemonetes pugio*. Limnol. Oceanogr. 25:896-902.

Montague, c. L., S. M. Bunker, E. B. Haines, M. L. Pace and R. L. Wetzel 1981. Aquatic macro-consumers. pp. 69-85.In: L. R. Pomeroy and R. G. Wiegert (eds.), The Ecology of a Salt Marsh. Springer-Verlag, New York, N. Y.

Mueller, A. J. and G. A. Matthews 1987. Freshwater inflow needs of the Matagorda Bay system with focus on penaeid shrimp. NOAA Tech. Memo. NMFS-SEFC-189, 97 pp.

Odum, E. P. 1980. The status of three ecosystem-level hypotheses regarding salt marsh estuaries: tidal subsidy, outwelling, and detritus-based food chains. pp. 485-495. In: V. S. Kennedy (ed.), Estuarine Perspectives. Academic Press, New York,N.Y.

Orth, R. J. and J. van Monfrans 1989. Factors affecting settlement, survival and utilization in marsh and seagrass systems by post-larval and early juvenile stages of *Callinectes sapidus* along latitudinal gradients. Bull. Mar. Sci. (in press).

Parker, J. C. 1970. Distribution of juvenile brown shrimp (*Penaeus aztecus* Ives) in Galveston Bay, Texas, as related to certain hydrographic features and salinity. Contrib. Mar. Sci. 15:1-12.

Peters, K. M. and R. H. McMichael, Jr. 1987. Early life history of the red drum, *Sciaenops ocellatus* (Pisces: Sciaenidae), in Tampa Bay, Florida. Estuaries 10:92-107.

Pethick, J. 1984. An Introduction to Coastal Geomorphology. Edward Arnold, Ltd., London. 260 pp.

Pritchard, D. W. 1967. What is an estuary: physical viewpoint. pp.3-8. In: G. H. Lauff (ed.) Estuaries. Pub. No. 83, Am. Assoc. Adv. Sci., Wash., D. C.

Rader, D. N. 1984. Salt-marsh benthic invertebrates: small-scale patterns of distribution and abundance. Estuaries 7:413-420.

Remane, A. and C. Schlieper 1958 (translated 1971). The biology of brackish water. Wiley-Interscience, New York, N.Y. 372 pp.

Rogers, G. S., T. E. Targett and S. B. Van Sant 1984. Fish-nursery use in Georgia salt-marsh estuaries: the influence of springtime freshwater conditions. Trans. Am. Fish. Soc. 113:595-606.

Rozas, L. P. and C. T. Hachney 1983. The importance of oligohaline estuarine wetland habitats to fisheries resources. Wetlands 3:77-89.

Rozas, L. P. and C. T. Hackney 1984. Use of oligohaline marshes by fishes and macrofaunal crustaceans in North Carolina. Estuaries 7:213-224.

Rozas, L. P. and W. E. Odum 1987. Use of tidal freshwater marshes by fishes and macrofaunal crustaceans along a marsh stream-order gradient. Estuaries 10:36-43.

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology 43:614-624.

Thayer, G. W., H. H. Stuart, W. J. Kenworthy, J. F. Ustach and A. B. Hall 1978. Habitat values of salt marshes, mangroves, and seagrasses for aquatic organisms. pp. 235-247. In: Greeson, P. E., J. R. Clark and J. E. Clark (eds.), Wetland functions and values: the state of our understanding. Proc. National Sym. Wetlands, Am. Water Res. Assoc., Minneapolis.

Thomas, J. 1989. A comparative evaluation of *Halodule wrightii, Spartina alterniflora* and bare sand as nursery habitats for juvenile *Callinectes sapidus*. M.S. Thesis. Biology Department, Texas A&M University. 119 pp.

Thomas, J., R. J. Zimmerman, and T. J. Minello 1990. Abundance patterns of juvenile blue crabs (*Callinectes sapidus*) in nursery habitats of two Texas bays. Bull. Mar. Sci. Vol. 46 No. 1 (in press).

Turner, R. E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Trans. Am. Fish. Soc. 106: 411-416.

Weinstein, M. P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, North Carolina. Fish. Bull. 77:339-357.

Welsh, B. L. 1975. The role of grass shrimp, *Palaemonetes pugio*, in a tidal marsh system. Ecology 56:513-530.

Williams, A.B. 1984. Shrimps, lobsters and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press. Washington, D.C. 550 pp.

Wilson, K. A., K. W. Able and K. L. Heck, Jr. 1989. Habitat use by juvenile blue crabs: a comparison among habitats in southern New Jersey. Bull. Mar. Sci. (in press).

Zimmerman, R. J. 1989. An assessment of salt marsh usage by estuarine aquatic fauna at Grande Isle, Louisiana. NMFS/SEC Rep. to EPA Region IV (Dallas). NMFS Galveston Lab., Galveston, Tex., 27 pp.

Zimmerman, R. J., E. F. Klima and T. J. Minello 1989. Problems Associated with Determining Effects of Nursery Habitat Loss on Offshore Fishery Production. Annual Meeting Am. Fish. Soc., Anchorage, Alaska., 1 p.(Abst.).

Zimmerman, R. J. and T. J. Minello 1984. Densities of *Penaeus aztecus, Penaeus setiferus*, and other natant macrofauna in a Texas salt marsh. Estuaries 7:421-433.

Zimmerman, R. J., T. J. Minello and G. Zamora 1984. Selectionof vegetated habitat by *Penaeus aztecus* in a Galveston Bay salt marsh. Fish. Bull. 82:325-336.

Zimmerman, R. J., T. J. Minello and S. Dent. Habitat-related growth and resource partitioning of penaeid shrimp in a salt marsh. Mar. Ecol. Prog. Ser. (conditionally accepted).

Zimmerman, R. J., T. J. Minello, M. C. Castiglione and D. L. Smith 1989. Implications of Riverflow to Utilization of Estuarine Marshes by Fishery Species. International Meeting Assoc. State Wetland Managers, Charleston, S. C., July 6-9, 1989. 1 p.(Abst.).

Zimmerman, R. J., T. J. Minello, M. C. Castiglione and T. J. Baumer 1990. Freshwater inflow effects on marsh utilization in San Antonio Bay. NMFS/SEC Rep. to Tex. Parks Wildl. Dept. and Tex. Water Development Bd., NMFS Galveston Lab., Galveston Tex.

Zimmerman, R. J., T.J. Minello, M. C. Castiglione and D. L. Smith 1990. Utilization of marsh and associated habitats along a salinity gradient in Galveston Bay. NOAA Technical Memorandum NMFS-SEFC-250, 68 pp.

APPENDIX I: Principal Keys and References Used to Identify Lavaca Bay Aquatic Fauna.

Fishes:

Hoese, H.D. and R.H. Moore 1977. Fishes of the Gulf of Mexico, Texas, Louisiana, and adjacent waters. Texas A&M Press, College Station, Texas. 327 pp.

Murdy, E.O. 1983. Saltwater fishes of Texas: a dichotomous key. Texas A&M Sea Grant College Program TAMU-SG-83-607, College Station.

U.S. Fish and Wildlife Service 1978. Development of fishes of the Mid-Atlantic Bight: an atlas of egg, larval and juvenile stages. Volumes I-VII. U.S. Fish Wildl. Serv., Biol. Serv. Program, FWS/OBS-78/12.

Crustaceans:

Bousfield, E.L. 1973. Shallow-water gammaridean Amphipoda of New England. Cornell University Press, Ithaca, New York. 312 pp.

Chaney, A.H. 1983. Key to the common inshore crabs of Texas. pp. 1-30 In: A.H. Chaney, Keys to selected marine invertebrates of Texas. Caesar Kleberg Wildlife Research Institute Tech. Bull. No. 4, Kingsville, Texas. 86 pp.

Felder, D.L. 1973. An annotated key to crabs and lobsters (Decapoda, Reptantia) from coastal waters of the northwestern Gulf of Mexico. Center for Wetland Resources, Louisiana State University. LSU-SG-73-02. Baton Rouge, Louisana. 103 pp.

Heard, R.W. 1982. Guide to common tidal marsh invertebrates of the northeastern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium. MASGP-79-004. Ocean Springs, Mississippi. 82 pp.

Schultz, G.A. 1969. The marine isopod crustaceans. William C. Brown Co. Publ., Dubuque, Iowa. 359 pp.

Williams, A.B. 1984. Shrimps, lobsters and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press. Washington, D.C. 550pp.

Molluscs:

Andrews, J. 1981. Texas shells. University of Texas Press. Austin, Texas. 175 pp.

Annelids:

Fauchald, K. 1977. The polychaete worms. Definitions and keys to the orders, families and genera. Natural History Museum of Los Angeles County in conjunction with the Allan Hancock Foundation. Science Series 28, University of Southern California, Los Angeles, California. 188 pp.

Uebelacker, J.M. and P.G. Johnson (eds.) 1984. Taxonomic guide to the polychaetes of the northern Gulf of Mexico. Vol. I - VI. Minerals Management Service, U.S. Dept. Interior, Gulf of Mexico Regional Office, Metaire, Louisiana.

Plants:

Charbreck, R.H. and R.E. Condrey 1979. Common vascular plants of the Louisiana marsh. Sea Grant Pub.No. LSU-T-79-003. Louisiana State Center for Wetland Resources, Baton Rouge, Louisiana. 116 pp.

Edwards, P. 1976. Illustrated guide to the seaweeds and seagrasses in the vicinity of Port Aransas, Texas. Univ. Texas Press, Austin, Texas. 126 pp.

Eleuterius, L.N. 1980. Tidal marsh plants of Mississippi and adjacent states. Mississippi-Alabama Sea Grant Consortium Pub. No. MASGP-77-039. Gulf Coast Research Laboratory, Ocean Springs, Mississippi. 130 pp.

Tarver, D.P., J.A. Rodgers, M.J. Mahler and R. L. Lazor 1986. Aquatic and wetland plants of Florida. Published by the Bureau of Aquatic Plant Research and Control, Florida Department of Natural Resources, Tallahassee, Florida. 127pp.

APPENDIX II. FISH AND DECAPOD CRUSTACEAN DENSITIES IN COASTAL SPARTINA MARSHES AND NONVEGETATED OPEN WATER IN LAVACA BAY, FALL 1985.

LAVACA BAY STUDY COASTAL LOCATIONS October 15-18, 1985 Macrofauna/2.6 m sq. (n=4) Samples not paired	CHOCOLATE BAY				KELLER BAY				POWDERHORN LAKE			
	Spartina		Non-vegetated		*Spartina*		Non-vegetated		*Spartina*		Non-vegetated	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:												
Anchoa mitchilli	1.3	0.75	28.8	20.33	0.3	0.25	2.8	2.43	0.3	0.25	2.3	1.65
Gobiosoma bosci	15.5	5.42	0	0	3.8	2.59	0.3	0.25	10.5	4.98	0	0
Gobionellus boleosoma	6	1.68	0	0	2.8	0.85	0	0	14	3.67	0.8	0.75
Symphurus plagiusa	1.3	0.25	0.3	0.25	1.8	1.03	0.3	0.25	0.5	0.29	0.3	0.25
Microgobius gulosus	0	0	1.5	0.5	0	0	0.5	0.5	0	0	1	0.71
Cynoscion nebulosus	0.8	0.48	0	0	0.5	0.29	0	0	1	0.41	0	0
Syngnathus louisianae	0.5	0.29	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0
Mugil cephalus	0.5	0.29	0	0	0	0	0	0	0.5	0.29	0.3	0.25
Eucinostomus argenteus	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0.5	0.5
Menidia beryllina	0.3	0.25	0	0	0	0	0	0	0	0	0.5	0.5
Syngnathus scovelli	0	0	0	0	0.8	0.48	0	0	0	0	0	0
Bathygobius soporator	0	0	0	0	0	0	0	0	0.5	0.29	0	0
Sygnathus scovelli	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0
Bathygobius soporator	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0
Leiostomus xanthurus	0	0	0	0	0	0	0.5	0.5	0	0	0	0
Micropogonias undulatus	0	0	0	0	0.5	0.5	0	0	0	0	0	0
Achirus lineatus	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Archosargus probatocephalus	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Sphoeroides parvus	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Syngnathus floridae	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Cyprinodontidae	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0
Gobiidae	21.5	6.9	1.5	0.5	6.5	3.43	0.8	0.48	25	8.58	1.8	1.03
Sciaenidae	0.8	0.48	0	0	1	0.41	0.5	0.5	1	0.41	0	0
Bait Fishes	2	1.08	28.8	20.33	0.3	0.25	2.8	2.43	1	0.71	2.5	1.55
Commercial/Sports Fishes	0.8	0.48	0	0	0.5	0.29	0	0	1	0.41	0	0
TOTAL FISHES:	27	7.74	30.8	19.71	10.8	4.21	4.3	2.29	28.8	9.28	5.8	2.39
CRUSTACEANS:												
Palaemonetes pugio	8.3	1.65	0	0	172.8	110.6	0	0	210.5	45.95	0.3	0.25
Hippolyte zostericola	4.3	1.55	0	0	96.3	36.97	1	0.41	106.5	67.59	0	0
Tozeuma carolinesis	2	0.82	0	0	80.8	19.41	0.8	0.75	93.3	77.09	0	0
Palaemonetes vulgaris	0.5	0.29	0	0	45.3	35.67	0	0	54.8	14.41	2.5	2.5
Callinectes sapidus	13.8	4.55	1.5	0.87	43.3	15.82	2.5	0.65	28.5	7.09	0	0
Penaeus duorarum	30.8	6.76	2.5	0.87	21.3	7.20	0.3	0.25	17	2.68	0.5	0.5
Penaeus setiferus	11.3	3.71	2.8	2.10	11.8	6.03	0.3	0.25	15	8.07	4.8	4.75
Penaeus aztecus	3.5	1.04	0.3	0.25	2.3	0.75	0.5	0.29	25.8	11.65	0.3	0.25
Palaemonetes intermedius	0.5	0.5	0	0	6.5	6.17	0	0	9.5	5.85	0	0
Neopanope texana	0	0	0	0	1.8	1.44	0	0	6.5	1.94	0	0
Alphaeus heterochaelis	0	0	0	0	1.3	1.25	0	0	4.3	2.84	0	0
Clibanarius vittatus	0	0	0	0	2.0	1.23	0.3	0.25	1.5	1.5	0.3	0.25
Uca pugnax	0	0	0	0	0	0	0	0	3.5	3.5	0	0
Pagurus spp.	0	0	0	0	0.3	0.25	1.8	1.75	0	0	0	0
Libinia dubia	0	0	0	0	0.5	0.29	0	0	0.3	0.25	0	0
Eurypanopeus depressus	0	0	0	0	0	0	0	0	0.5	0.29	0	0
Unknown crustacean species	0	0	0.5	0.5	0	0	0	0	0	0	0	0
Latreutes parvulus	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Panopeus herbstii	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Petrolisthes galathinus	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Sesarma reticulatum	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Grass Shrimp	9.3	1.89	0	0	224.5	150.9	0	0	274.8	39.25	2.8	2.75
Penaeid Shrimp	45.5	9.84	5.5	2.33	35.3	11.41	1	0.41	57.8	17.56	5.5	4.56
TOTAL CRUSTACEANS:	74.8	13.49	7.5	1.85	486	217.0	7.3	2.36	578	112.5	8.5	4.17

APPENDIX II. FISH AND DECAPOD CRUSTACEAN DENSITIES IN DELTA JUNCUS MARSHES AND NONVEGETATED OPEN WATER IN LAVACA BAY, FALL 1985.

LAVACA BAY STUDY DELTA LOCATIONS October 15-18, 1985 Macrofauna/2.6 m sq. (n=4) Samples not paired	LAVACA DELTA EAST				LAVACA DELTA RIVER				LAVACA DELTA WEST			
	Juncus		Non-vegetated		*Juncus*		Non-vegetated		*Juncus*		Non-vegetated	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:												
Gobiosoma bosci	45.8	10.09	2.8	1.89	25.8	5.78	0.5	0.29	16.8	4.21	3	1.78
Anchoa mitchilli	9.3	2.18	15	14.02	0	0	20.5	14.06	1.5	1.5	16.8	5.25
Fundulus grandis	1	0.71	0	0	8	7.67	0	0	0.3	0.25	0	0
Symphurus plagiusa	0.3	0.25	0	0	1.8	1.44	2.3	0.95	1	0.71	1.3	0.75
Microgobius gulosus	0	0	3	0.82	0	0	2.5	0.87	0	0	0.3	0.25
Adina xenica	0	0	0	0	4.8	4.42	0	0	0	0	0	0
Gobionellus boleosoma	0.3	0.25	0	0	1.5	0.87	0	0	0.3	0.25	0	0
Cynoscion nebulosus	0.8	0.48	0	0	0	0	0.3	0.25	0.5	0.5	0	0
Myrophis punctatus	0.3	0.25	0	0	0.3	0.25	0.3	0.25	0	0	0.3	0.25
Fundulus pulvereus	0	0	0	0	1	1	0	0	0	0	0	0
Fundulus similis	0	0	0	0	1	1	0	0	0	0	0	0
Gobiesox strumosus	0	0	0	0	0	0	0	0	0.5	0.5	0	0
Arius felis	0.3	0.25	0	0	0	0	0	0	0	0	0.3	0.25
Citharicthys spilopterus	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Cyprinodon variegatus	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Sphoeroides parvus	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Cyprinodontidae	1	0.71	0	0	15	13.02	0	0	0.3	0.25	0	0
Gobiidae	46	9.86	5.8	1.8	27.3	5.62	3	0.58	17	4.18	3.3	2.02
Sciaenidae	0.8	0.48	0	0	0	0	0.3	0.25	0.5	0.5	0	0
Bait Fishes	9.3	2.17	15	14.02	0	0	20.5	14.06	1.5	1.5	16.8	5.25
Commercial/Sports Fishes	0.8	0.48	0	0	0	0	0.3	0.25	0.5	0.5	0	0
TOTAL FISHES:	57.8	9.89	20.8	15.79	44.3	10.14	26.5	12.74	20.8	4.37	22.0	3.39
CRUSTACEANS:												
Palaemonetes pugio	96	22.47	0	0	59.8	17.96	0	0	127.3	49.08	0	0
Callinectes sapidus	35	11.97	0.3	0.25	56.8	9.74	1	1	33.8	9.46	1.3	0.63
Neopanope texana	25.5	8.25	0.3	0.25	7.8	4.37	1.3	0.48	33	15.24	1.8	1.75
Penaeus aztecus	25.8	6.05	1.5	0.29	12	4.55	2	0.91	14.5	4.41	0.8	0.48
Penaeus duorarum	18.8	4.31	0.5	0.29	19	5.92	0.5	0.5	9.5	3.4	1.5	0.96
Penaeus setiferus	13.5	4.91	0.8	0.48	2	1.08	0.8	0.48	13	10.16	1.8	1.03
Palaemonetes intermedius	0.8	0.75	0	0	0	0	0	0	2.5	1.66	0	0
Palaemonetes vulgaris	1.5	1.5	0	0	0	0	0	0	1.8	1.03	0	0
Clibanarius vittatus	0	0	0	0	1.3	0.48	0	0	1.3	1.25	0	0
Sesarma reticulatum	0	0	0	0	0	0	0	0	1	0.58	0	0
Petrolisthes galathinus	0	0	0	0	0	0	0	0	0.5	0.5	0	0
Uca pugnax	0	0	0	0	0	0	0	0	0.5	0.29	0	0
Panopeus herbstii	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Grass Shrimp	98.3	23.01	0	0	59.8	17.96	0	0	131.5	49	0	0
Penaeid Shrimp	58	14.26	2.8	0.48	33	9.51	3.3	1.11	37	17.02	4	1.63
TOTAL CRUSTACEANS:	216.8	30.17	3.3	0.48	158.5	27.31	5.5	0.87	238.8	55.54	7.0	3.34

APPENDIX II. FISH AND DECAPOD CRUSTACEAN DENSITIES IN COASTAL *SPARTINA* MARSHES AND NONVEGETATED OPEN WATER IN LAVACA BAY, SPRING 1986.

LAVACA BAY STUDY COASTAL LOCATIONS May 26-30, 1986 Macrofauna/2.6 m sq. (n=4) Paired samples	CHOCOLATE BAY				KELLER BAY				POWDERHORN LAKE			
	Spartina		Non-vegetated		*Spartina*		Non-vegetated		*Spartina*		Non-vegetated	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:												
Brevoortia patronus	0	0	44.5	44.17	0	0	0.5	0.5	0	0	0.8	0.75
Anchoa mitchilli	1.8	1.03	4.5	1.94	0	0	10.5	7.01	0	0	2	2
Bairdiella chrysoura	1.8	1.18	0	0	9.5	7.92	2.3	2.25	2.8	2.14	0	0
Gobiosoma bosci	1	0.71	0	0	4.3	2.63	5.3	4.31	1.5	0.65	1	0.71
Lagodon rhomboides	1	0.41	0	0	1.5	0.5	0.3	0.25	3.8	1.44	0.8	0.25
Fundulus grandis	2.3	1.32	0	0	2.3	1.93	0	0	0	0	0	0
Menidia beryllina	0	0	1.3	0.75	1.3	1.25	0.5	0.5	0	0	1	0.71
Gobionellus boleosoma	0	0	0	0	0	0	0	0	2	0.41	1	0.41
Leiostomus xanthurus	0.3	0.25	0.8	0.48	0	0	0	0	0	0	0.5	0.5
Orthopristis chrysoptera	0	0	0	0	0	0	0.3	0.25	1	0.71	0.3	0.25
Paralichthys lethostigma	0.5	0.29	0	0	0.8	0.48	0	0	0	0	0.3	0.25
Syngnathus scovelli	0	0	0	0	0.5	0.5	0	0	1	0.71	0	0
Arius felis	0	0	0.3	0.25	0.5	0.5	0.3	0.25	0	0	0	0
Cyprinodon variegatus	0	0	0.3	0.25	0.5	0.5	0	0	0	0	0	0
Gobiesox strumosus	0	0	0	0	0.3	0.25	0	0	0.5	0.5	0	0
Archosargus probatocephalus	0.3	0.25	0	0	0	0	0	0	0.3	0.25	0	0
Citharicthys spilopterus	0	0	0	0	0	0	0	0	0	0	0.5	0.5
Mugil cephalus	0.3	0.25	0	0	0.3	0.25	0	0	0	0	0	0
Symphurus plagiusa	0	0	0	0	0	0	0.3	0.25	0.3	0.25	0	0
Adina xenica	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Chaetodipterus faber	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Cynoscion arenarius	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Cynoscion nebulosus	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Sciaenops ocellatus	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Syngnathus louisianae	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Unknown fish species	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Cyprinodontidae	2.3	1.31	0.3	0.25	2.8	2.43	0	0	0.3	0.25	0	0
Gobiidae	1	0.71	0	0	4.3	2.63	5.3	4.31	3.5	0.5	2	0.82
Sciaenidae	2	1.41	1	0.71	9.8	8.17	2.3	2.25	2.8	2.14	0.8	0.48
Bait Fishes	3	1.22	4.5	1.94	1.8	0.25	10.8	7.25	3.8	1.44	2.8	2.1
Commercial/Sports Fishes	0.5	0.29	0	0	1	0.58	0	0	0	0	0.5	0.29
TOTAL FISHES:	9.3	0.75	51.8	45.46	22	11.37	20.3	9.76	13.3	5.25	8.3	3.12
CRUSTACEANS:												
Palaemonetes pugio	224	61.56	1	0.58	380.5	206.2	4.8	4.11	619.3	187.5	1	0.71
Penaeus aztecus	58.8	14.33	5.8	1.38	51	15.91	16	13.39	72.8	24	22.8	19.75
Palaemonetes vulgaris	0	0	0	0	0.8	0.75	0	0	55.3	30.03	0	0
Penaeus setiferus	34	15.48	4.3	1.03	6.3	2.18	1	0.71	0	0	0.8	0.75
Hippolyte zostericola	0	0	0	0	2.3	2.25	6	6	36	24.04	0	0
Palaemonetes intermedius	1.3	1.25	0	0	2.5	2.5	0.8	0.75	34.3	19.78	0	0
Callinectes sapidus	3.3	0.48	0.3	0.25	5.8	2.25	1.5	0.65	8.3	2.32	2.5	1.56
Clibanarius vittatus	1.3	0.63	0	0	3	1.16	0.3	0.25	8	3.51	2.5	1.66
Tozeuma carolinesis	0	0	0	0	0	0	9.8	9.42	0	0	0	0
Alphaeus heterochaelis	0.3	0.25	0	0	4.8	4.75	0	0	4	0.91	0	0
Neopanope texana	0	0	0	0	0.3	0.25	0	0	1.5	1.19	0	0
Sesarma reticulatum	0	0	0	0	0	0	0	0	1	1	0	0
Pagurus spp.	0	0	0	0	0.3	0.25	0	0	0	0	0.5	0.29
Unknown crustacean species	0	0	0	0	0	0	0.8	0.48	0	0	0	0
Panopeus herbstii	0	0	0	0	0	0	0	0	0.5	0.29	0	0
Eurypanopeus depressus	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Grass Shrimp	225.3	61.74	1	0.58	383.8	205.8	5.5	4.86	708.8	231	1	0.71
Penaeid Shrimp	92.8	25.52	10	0.71	57.3	15.5	17	14.04	72.8	24	23.5	20.5
TOTAL CRUSTACEANS:	322.8	86.32	11.3	1.31	457.3	224.6	40.8	35.48	841	255.8	30	24

APPENDIX II. FISH AND DECAPOD CRUSTACEAN DENSITIES IN DELTA JUNCUS MARSHES AND NONVEGETATED OPEN WATER IN LAVACA BAY, SPRING 1986.

LAVACA BAY STUDY DELTA LOCATIONS May 26-30, 1986	LAVACA DELTA EAST				LAVACA DELTA RIVER				LAVACA DELTA WEST			
Macrofauna/2.6 m sq. (n=4) Paired samples	*Juncus*		Non-vegetated		*Juncus*		Non-vegetated		*Juncus*		Non-vegetated	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:												
Brevoortia patronus	0	0	0.3	0.25	0	0	46.5	46.5	0	0	10.5	6.06
Anchoa mitchilli	0	0	0	0	0.3	0.25	4.3	4.25	0.8	0.75	10.5	10.5
Gobiosoma bosci	4	0.71	2.5	1.89	2.3	0.85	1.3	0.95	3	1.78	0.8	0.48
Menidia beryllina	1.5	1.5	1.3	0.75	0	0	0.3	0.25	0	0	1.3	1.25
Lagodon rhomboides	1.5	0.65	0.3	0.25	1.5	0.65	0	0	0.3	0.25	0.5	0.29
Opsanus beta	0.3	0.25	2.8	2.43	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0.3	0.25	0.8	0.25	1	1	0.3	0.25	0	0	0	0
Fundulus grandis	0.3	0.25	0	0	1	0.41	0	0	0.8	0.75	0	0
Sphoeroides parvus	0	0	0.8	0.48	0	0	1	0.41	0	0	0	0
Bairdiella chrysoura	0.8	0.75	0	0	0	0	0	0	0.5	0.5	0	0
Leiostomus xanthurus	0.3	0.25	0	0	0	0	0.8	0.48	0	0	0	0
Cyprinodon variegatus	0	0	0	0	0.8	0.48	0	0	0	0	0	0
Arius felis	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Gobiosoma robustum	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Myrophis punctatus	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Sciaenops ocellatus	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Syngnathus louisianae	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Cyprinodontidae	0.3	0.25	0	0	1.8	0.48	0	0	0.8	0.75	0	0
Gobiidae	4.3	0.75	2.5	1.89	2.3	0.85	1.3	0.95	3	1.78	0.8	0.48
Sciaenidae	1	0.71	0	0	0	0	1	0.41	0.5	0.5	0	0
Bait Fishes	1.5	0.65	0.3	0.25	1.8	0.75	4.3	4.25	1	1	11	10.34
Commercial/Sports Fishes	0.3	0.25	0.8	0.25	1	1	0.5	0.29	0	0	0	0
TOTAL FISHES:	9.3	1.93	8.8	4.09	6.8	2.66	54.5	45.69	5.3	2.39	23.8	16.51
CRUSTACEANS:												
Palaemonetes pugio	165	29.93	1	0.41	168.3	55.84	0.3	0.25	37.3	30.92	0.5	0.29
Penaeus aztecus	42.8	5.04	8.8	2.32	39.3	6.13	4.8	1.11	26.3	5.76	6.8	1.25
Penaeus setiferus	47.3	30.33	11	5.8	3.5	2.18	0.5	0.5	0.3	0.25	0	0
Callinectes sapidus	3.5	1.32	1.3	0.75	7.8	3.12	0.3	0.25	2	1	0.5	0.5
Neopanope texana	6	3.24	3.3	3.25	2.8	0.95	0	0	2.3	1.03	0.3	0.25
Palaemonetes intermedius	2.8	1.03	0	0	1.3	1.25	0	0	1	1	0	0
Rhithropanopeus harrisii	0.5	0.5	2	2	0	0	0	0	0	0	0	0
Alphaeus heterochaelis	0	0	1.5	0.96	0.3	0.25	0	0	0	0	0	0
Palaemonetes vulgaris	0	0	0	0	1.3	1.25	0	0	0.3	0.25	0	0
Sesarma reticulatum	0	0	0	0	0.5	0.5	0	0	0.8	0.75	0	0
Eurypanopeus depressus	0	0	0	0	0	0	1	1	0	0	0	0
Hippolyte zostericola	0.8	0.75	0	0	0	0	0	0	0.3	0.25	0	0
Clibanarius vittatus	0	0	0	0	0.5	0.29	0.3	0.25	0	0	0	0
Menippe mercenaria	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Grass Shrimp	167.8	29.53	1	0.41	170.8	57.22	0.3	0.25	38.5	31.84	0.5	0.29
Penaeid Shrimp	90	34.21	19.8	5.76	42.8	7.49	5.3	1.49	26.5	5.85	6.8	1.25
TOTAL CRUSTACEANS:	268.5	14.1	28.8	6.79	225.5	60.73	7	2.65	70.3	34.78	8	1

APPENDIX II. FISH AND DECAPOD CRUSTCEAN DENSITIES IN COASTAL AND DELTA NOVEGETATED OPEN WATER HABITAT IN LAVACA BAY, SUMMER 1986.

LAVACA BAY STUDY NON-VEGETATED SAMPLES COASTAL VS. DELTA LOCATIONS August 19-20, 1986 Macrofauna/2.6 m sq. (n=4) Samples not paired	COASTAL AL SITE S						DELTA SITES					
	Chocolate Bay		Keller Bay		Powderhorn Lake		Lavaca Delta East		Lavaca Delta River		Lavaca Delta West	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:												
Anchoa mitchilli	0.8	0.48	0	0	0.5	0.5	1.3	0.95	4.5	2.22	17	17
Gobiosoma bosci	0	0	0.3	0.25	0	0	2.3	1.93	1	0.71	10	8.12
Mugil cephalus	0	0	0	0	7.5	4.35	0	0	0	0	0	0
Menidia beryllina	0	0	0	0	0.5	0.5	5.5	5.17	0.3	0.25	0	0
Gobionellus boleosoma	0	0	0	0	3.25	2.63	0	0	0	0	0	0
Symphurus plagiusa	0	0	1	1	0.5	0.5	0	0	0.3	0.25	0.3	0.25
Cynoscion nebulosus	0.3	0.25	0	0	0.75	0.48	0	0	0	0	0	0
Achirus lineatus	0	0	0.3	0.25	0.5	0.5	0	0	0	0	0	0
Myrophis punctatus	0	0	0	0	0	0	0.3	0.25	0	0	0.5	0.5
Leiostomus xanthurus	0	0	0	0	0.5	0.29	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0.25	0.25	0.3	0.25	0	0	0	0
Cynoscion nothus	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Orthopristis chrysoptera	0	0	0	0	0.25	0.25	0	0	0	0	0	0
Cyprinodontidae	0	0	0	0	0	0	0	0	0	0	0	0
Gobiidae	0	0	0.3	0.25	4.3	2.39	2.3	1.93	1	0.71	10	8.12
Sciaenidae	0.5	0.5	0	0	1.3	0.63	0	0	0	0	0	0
Bait Fishes	0.8	0.48	0	0	8	4.62	1.3	0.95	4.5	2.22	17	17
Commercial/Sports Fishes	0.3	0.25	0	0	1	0.58	0.3	0.25	0	0	0	0
TOTAL FISHES:	1.3	0.48	1.5	1.19	15.5	8.67	9.8	5.53	6	2.12	27.8	16.02
CRUSTACEANS:												
Penaeus setiferus	16.8	12.01	0.5	0.5	17.5	15.19	29.5	24.97	1	0.71	20.5	17.86
Palaemonetes pugio	5	3.14	0	0	0.5	0.29	8.3	8.25	0.3	0.25	0.8	0.48
Penaeus aztecus	1.3	1.25	3.8	2.25	0.75	0.25	1.5	0.96	2.8	1.6	3	1.08
Penaeus duorarum	1	0.58	2	1.16	3	3	1.8	1.44	0.8	0.25	0.8	0.75
Callinectes sapidus	0.3	0.25	0.8	0.75	2.25	1.03	0	0	4.8	4.75	1	0.71
Neopanope texana	0	0	0	0	0.25	0.25	1.3	0.75	0.5	0.5	4.3	2.21
Panopeus herbstii	0	0	0	0	0	0	0	0	0	0	0.8	0.48
Eurypanopeus depressus	0	0	0	0	0	0	0	0	0	0	0.5	0.5
Clibanarius vittatus	0	0	0	0	0.25	0.25	0	0	0	0	0.3	0.25
Alphaeus heterochaelis	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Tozeuma carolinesis	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Grass Shrimp	5	3.14	0	0	0.5	0.29	8.3	8.25	0.3	0.25	0.8	0.48
Penaeid Shrimp	19	11.68	6.3	3.61	21.3	14.61	32.8	27.28	4.5	2.33	24.3	18.06
TOTAL CRUSTACEANS:	24.3	13.81	7.3	3.99	24.5	15.82	42.3	36.11	10	7.22	32	17.55

APPENDIX III. DENSITIES OF FISHES AND DECAPOD CRUSTACEANS IN SPARTINA AND JUNCUS HABITAT WITHIN SITES, FALL 1985.

LAVACA BAY STUDY *Juncus vs. Spartina* October 15-18, 1985 Macrofauna/2.6 m sq. (n=4) Samples not paired	Chocolate Bay Site				Lavaca Delta Site			
	Juncus		*Spartina*		*Juncus*		*Spartina*	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:								
Gobiosoma bosci	16.3	5.95	15.5	5.42	25.8	5.78	23.5	8.82
Fundulus grandis	0	0	0.3	0.25	8	7.67	12.3	5.36
Gobionellus boleosoma	0.8	0.75	6	1.68	1.5	0.87	2.8	1.8
Anchoa mitchilli	7.5	3.66	1.3	0.75	0	0	0	0
Symphurus plagiusa	0	0	1.3	0.25	1.8	1.44	3	1.47
Adina xenica	0	0	0	0	4.8	4.42	0	0
Cynoscion nebulosus	1.5	0.87	0.8	0.48	0	0	0.5	0.5
Fundulus pulvereus	0	0	0	0	1	1	0	0
Fundulus similis	0	0	0	0	1	1	0	0
Gobiesox strumosus	0	0	0	0	0	0	1	0.41
Sphoeroides parvus	0.3	0.25	0.3	0.25	0	0	0.3	0.25
Syngnathus louisianae	0	0	0.5	0.29	0	0	0.3	0.25
Cyprinodon variegatus	0	0	0	0	0.3	0.25	0.3	0.25
Microgobius gulosus	0.5	0.5	0	0	0	0	0	0
Mugil cephalus	0	0	0.5	0.29	0	0	0	0
Eucinostomus argenteus	0	0	0.3	0.25	0	0	0	0
Lagodon rhomboides	0	0	0.3	0.25	0	0	0	0
Menidia beryllina	0	0	0.3	0.25	0	0	0	0
Monacanthus hispidus	0	0	0	0	0	0	0.3	0.25
Myrophis punctatus	0	0	0	0	0.3	0.25	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0.3	0.25
Poecilia latipinna	0.3	0.25	0	0	0	0	0	0
Syngnathus scovelli	0.3	0.25	0	0	0	0	0	0
Cyprinodontidae	0	0	0.3	0.25	15	13.02	12.5	5.3
Gobiidae	17.5	5.56	21.5	6.9	27.3	5.62	26.3	10.36
Sciaenidae	1.5	0.87	0.8	0.48	0	0	0.5	0.5
Bait Fishes	7.5	3.66	2	1.08	0	0	0	0
Commercial Sports Fishes	1.5	0.87	0.8	0.48	0	0	0.8	0.48
TOTAL FISHES:	27.3	3.54	27	7.74	44.3	10.14	44.3	11.24
CRUSTACEANS:								
Palaemonetes pugio	24.5	8.26	8.3	1.65	59.8	17.96	120.8	15.41
Callinectes sapidus	29.8	7.54	13.8	4.55	56.8	9.74	35	15.98
Penaeus duorarum	18.5	6.7	30.8	6.76	19	5.92	17	3.39
Penaeus aztecus	7	3.24	3.5	1.04	12	4.55	28.8	9.99
Penaeus setiferus	6.5	3.66	11.3	3.71	2	1.08	2	2
Neopanope texana	1	0.58	0	0	7.8	4.37	6	2.48
Palaemonetes vulgaris	0.3	0.25	0.5	0.29	0	0	5.5	3.28
Hippolyte zostericola	0	0	4.3	1.55	0	0	0	0
Palaemonetes intermedius	0.3	0.25	0.5	0.5	0	0	2	0.71
Clibanarius vittatus	0	0	0	0	1.3	0.48	1	0.41
Tozeuma carolinesis	0.3	0.25	2	0.82	0	0	0	0
Eurypanopeus depressus	0	0	0	0	0	0	0.5	0.5
Alphaeus heterochaelis	0.3	0.25	0	0	0	0	0	0
Grass Shrimp	25	8.24	9.3	1.89	59.8	17.96	128.3	16.39
Penaeid Shrimp	32	7.94	45.5	9.84	33	9.51	47.8	13.83
TOTAL CRUSTACEANS:	88.3	9.91	74.8	13.49	158.5	27.31	218.5	9.46

APPENDIX III. DENSITIES OF FISHES AND DECAPOD CRUSTACEANS IN SPARTINA AND JUNCUS HABITAT WITHIN SITES, SPRING 1986.

LAVACA BAY STUDY *Spartina vs. Juncus* May 28-29, 1986	Chocolate Bay Site				Lavaca Delta Site			
Macrofauna/2.6 m sq. (n=4) Paired Samples	*Juncus*		*Spartina*		*Juncus*		*Spartina*	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:								
Lagodon rhomboides	0.5	0.29	1	0.41	1.5	0.65	10.5	6.04
Gobiosoma bosci	6.3	3.88	1	0.71	2.3	0.85	1	0.71
Fundulus grandis	3	2.68	2.3	1.32	1	0.41	1	0.71
Anchoa mitchilli	3	3	1.8	1.03	0.3	0.25	0	0
Paralichthys lethostigma	0.5	0.29	0.5	0.29	1	1	1.3	0.63
Bairdiella chrysoura	0	0	1.8	1.18	0	0	0	0
Cyprinodon variegatus	0	0	0	0	0.8	0.48	0.5	0.5
Brevoortia patronus	0.5	0.5	0	0	0	0	0.3	0.25
Mugil cephalus	0.5	0.29	0.3	0.25	0	0	0	0
Orthopristis chrysoptera	0	0	0	0	0	0	0.8	0.48
Archosargus probatocephalus	0	0	0.3	0.25	0	0	0	0
Leiostomus xanthurus	0	0	0.3	0.25	0	0	0	0
Menidia beryllina	0.3	0.25	0	0	0	0	0	0
Syngnathus louisianae	0	0	0.3	0.25	0	0	0	0
Cyprinodontidae	3	2.68	2.3	1.31	1.8	0.48	1.5	0.65
Gobiidae	6.3	3.88	1	0.71	2.3	0.85	1	0.71
Sciaenidae	0	0	2	1.41	0	0	0	0
Bait Fishes	4	3.03	3	1.22	1.8	0.75	10.5	6.03
Commercial Sports Fishes	0.5	0.29	0.5	0.29	1	1	1.3	0.63
TOTAL FISHES:	14.5	3.5	9.3	0.75	6.8	2.66	15.3	6.57
CRUSTACEANS:								
Palaemonetes pugio	357.5	148.7	224	61.56	168.3	55.84	84.8	13.12
Penaeus aztecus	32.8	13.55	58.8	14.33	39.3	6.13	19.8	7.66
Penaeus setiferus	16.8	8.89	34	15.48	3.5	2.18	0.8	0.75
Callinectes sapidus	7	2.04	3.3	0.48	7.8	3.12	3.3	1.03
Neopanope texana	1.3	0.75	0	0	2.8	0.95	3.5	2.60
Palaemonetes intermedius	0.5	0.5	1.3	1.25	1.3	1.25	0.5	0.5
Clibanarius vittatus	0	0	1.3	0.63	0.5	0.29	0.5	0.29
Panopeus herbstii	0	0	0	0	0	0	2	2
Eurypanopeus depressus	0	0	0	0	0	0	1.3	1.25
Palaemonetes vulgaris	0	0	0	0	1.3	1.25	0	0
Alphaeus heterochaelis	0	0	0.3	0.25	0.3	0.25	0	0
Sesarma reticulatum	0	0	0	0	0.5	0.5	0	0
Menippe mercenaria	0	0	0	0	0.3	0.25	0	0
Grass Shrimp	358	148.28	225.3	61.74	170.8	57.22	85.3	12.69
Penaeid Shrimp	49.5	15.97	92.8	25.52	42.8	7.49	20.5	7.8
TOTAL CRUSTACEANS:	415.8	156.24	322.8	86.32	225.5	60.73	116.3	19.56

APPENDIX IV. FISH AND DECAPOD CRUSTACEAN DENSITIES BEFORE FLOODING IN LAVACA RIVER DELTA MARSHES DURING OCTOBER 1986 (FLOOD #1).

LAVACA BAY STUDY FRESHENING EVENT ONE BEFORE EVENT Macrofauna/2.6 m sq. (n=4) October 21-22, 1986	LOWER DELTA								UPPER DELTA							
	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
	VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																
Gobiosoma bosci	13.5	8.45	4	3.08	59.8	31.91	14.5	6.81	31	7.49	9.5	7.01	36.3	12.64	8.3	3.94
Anchoa mitchilli	0	0	5	4.06	0	0	0	0	0.5	0.5	68	61.71	2.5	2.18	1.5	1.19
Cyprinodon variegatus	13.8	8.51	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Fundulus grandis	6	4.71	0	0	1.8	1.44	0	0	0	0	0	0	0	0	0	0
Menidia beryllina	1.5	1.5	0.3	0.25	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Microgobius gulosus	0	0	0	0	0	0	1.3	1.25	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0.8	0.48	0.3	0.25	0	0	0	0
Symphurus plagiusa	0	0	0	0	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0	0
Cynoscion nebulosus	0	0	0	0	0.5	0.29	0	0	0	0	0.3	0.25	0	0	0	0
Gobionellus boleosoma	0	0	0	0	0.5	0.29	0.3	0.25	0	0	0	0	0	0	0	0
Syngnathus scovelli	0	0	0	0	0.3	0.25	0	0	0.5	0.29	0	0	0	0	0	0
Achirus lineatus	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0.3	0.25
Fundulus pulvereus	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0
Syngnathus floridae	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.29	0	0
Citharicthys spilopterus	0	0	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Gobiosoma robustum	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Leiostomus xanthurus	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Micropogonias undulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Cyprinodontidae	19.8	10.31	0	0	1.8	1.44	0	0	0.5	0.5	0	0	0.3	0.25	0	0
Gobiidae	13.5	8.45	4	3.08	60.3	32.2	16.3	8.23	31	7.49	9.5	7.01	36.3	12.64	8.3	3.94
Sciaenidae	0	0	0	0	0.5	0.29	0	0	0	0	0.5	0.5	0	0	0.3	0.25
Bait Fishes	0	0	5	4.06	0	0	0.3	0.25	0.5	0.5	68	61.71	2.5	2.18	1.5	1.19
Commercial Sports Fishes	0	0	0	0	0.5	0.29	0	0	0.8	0.48	0.5	0.29	0	0	0	0
TOTAL FISHES:	34.8	5.6	9.5	6.86	63.3	32.21	17.3	8.56	33.3	8.62	78.5	69.28	39.8	13.86	10.3	4.77
CRUSTACEANS:																
Palaemonetes pugio	51	17.57	0.5	0.5	65.8	5.81	0	0	16	8.38	0	0	140.5	56.82	0.3	0.25
Penaeus setiferus	5	2.2	6.5	2.47	6.3	6.25	2	0.71	2.8	0.75	0.8	0.75	5.5	1.44	1.8	0.63
Callinectes sapidus	3	1	0	0	3.5	2.22	0.3	0.25	4.8	0.63	0.3	0.25	7.3	2.87	0.5	0.29
Penaeus aztecus	1	0.41	0	0	2.3	1.65	0	0	3.8	2.25	0	0	4	1.35	0.3	0.25
Neopanope texana	0	0	0	0	2.5	1.89	1.3	1.25	1	0.58	0.3	0.25	0.3	0.25	0.3	0.25
Penaeus duorarum	0.5	0.5	0	0	0.5	0.5	0	0	0.8	0.75	0	0	0.3	0.25	0.3	0.25
Palaemonetes intermedius	0	0	0	0	0.3	0.25	0.8	0.75	0.5	0.29	0	0	0.5	0.5	0	0
Panopeus herbstii	0	0	0	0	0	0	1.8	1.44	0	0	0.3	0.25	0	0	0	0
Palaemonetes vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0
Sesarma reticulatum	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0
Rhithropanopeus harrisii	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Uca minax	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Xanthidae, unknown species	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Grass Shrimp	51	17.57	0.5	0.5	66	5.96	0.8	0.75	16.5	8.37	0	0	141.5	56.35	0.3	0.25
Penaeid Shrimp	6.5	2.53	6.5	2.47	9	8.35	2	0.71	7.3	2.5	0.8	0.75	9.8	1.93	2.3	0.85
TOTAL CRUSTACEANS:	60.5	18.98	7	2.86	82	10.52	6	1.22	29.5	9.94	1.5	0.5	159	52.57	3.25	0.85

APPENDIX IV. FISH AND DECAPOD CRUSTACEAN DENSITIES AFTER FLOODING IN LAVACA RIVER DELTA MARSHES DURING OCTOBER 1986 (FLOOD #1).

LAVACA BAY STUDY
FRESHENING EVENT ONE
AFTER EVENT
Macrofauna/2.6 m sq. (n=4)
November 3-6, 1986

	LOWER DELTA								UPPER DELTA							
	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
	VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																
Gobiosoma bosci	50	11.2	2	0.82	21.3	8.5	6	3.24	37.3	5.07	3.5	1.32	39.8	10.13	2	0.71
Anchoa mitchilli	1	0.71	67.8	52.8	0	0	0.5	0.29	10.5	10.5	16	7.72	10.8	6.97	7	3
Micropogonias undulatus	0	0	13	6.42	0.8	0.75	0.8	0.75	0	0	0	0	0.5	0.5	0	0
Syngnathus scovelli	0	0	0.3	0.25	0.3	0.25	0	0	1.8	1.18	0.3	0.25	1.5	0.96	0	0
Fundulus grandis	2.5	1.66	0	0	0	0	0	0	0.3	0.25	0	0	0.3	0.25	0	0
Menidia beryllina	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0.8	0.75	0.3	0.25
Gobionellus boleosoma	0.5	0.5	0.3	0.25	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Cyprinodon variegatus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cynoscion nebulosus	0.3	0.25	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25
Unknown fish species	0	0	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Fundulus pulvereus	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0
Symphurus plagiusa	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0
Microgobius gulosus	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Cyprinodontidae	3.5	2.6	0	0	0	0	0	0	0.8	0.75	0	0	0.3	0.25	0	0
Gobiidae	50.5	11.43	2.5	0.87	21.3	8.5	6.3	3.47	37.3	5.07	3.5	1.32	25.5	11.91	2	0.71
Sciaenidae	0.3	0.25	13.3	6.57	1	0.71	0.8	0.75	0	0	0	0	0.5	0.5	0	0
Bait Fishes	1	0.71	68	52.7	0	0	0.5	0.29	10.5	10.5	16	7.72	10.8	6.97	7	3
Commercial Sports Fishes	0.3	0.25	0.3	0.25	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0	0
FISH TOTALS:	55.3	13.14	84.8	54.64	22.5	9.44	8.5	4.27	50.3	12.09	19.8	8.86	54	16.14	9.5	3.43
CRUSTACEANS:																
Palaemonetes pugio	153	49.12	0.3	0.25	36.5	26.75	0	0	47.5	26.78	0	0	115.5	63.09	0	0
Callinectes sapidus	4.3	0.85	0	0	5	3.19	1.3	0.48	2.5	1.32	0.3	0.25	103.8	97.78	0	0
Penaeus setiferus	1.3	0.48	1.8	1.75	8	5.66	0.8	0.48	1.3	0.95	0.3	0.25	2.5	0.65	2	1.41
Penaeus aztecus	2.3	0.85	0.8	0.48	0.3	0.25	0.3	0.25	1.5	0.65	0.3	0.25	2.5	0.65	0.3	0.25
Rhithropanopeus harrisii	0.5	0.5	0	0	3.8	2.17	0.3	0.25	1.3	0.75	0	0	0.3	0.25	0	0
Palaemonetes intermedius	0	0	0	0	0	0	0	0	2.5	1.04	0	0	2	2	0	0
Penaeus duorarum	0.3	0.25	0	0	1.3	1.25	0.8	0.75	0.5	0.5	0	0	0.8	0.48	0	0
Sesarma reticulatum	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Neopanope texana	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0.3	0.25	0	0
Xanthidae, unknown species	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0.3	0.25
Grass Shrimp	153	49.12	0.3	0.25	36.5	26.75	0	0	50	26.03	0	0	117.5	63.26	0	0
Penaeid Shrimp	3.8	1.31	2.5	1.89	9.5	5.85	1.8	1.18	3.3	1.18	0.5	0.5	5.8	0.75	2.3	1.31
CRUSTACEAN TOTALS:	161.5	48.74	2.8	2.14	55.8	31.86	3.5	0.65	57	26.59	0.8	0.75	227.8	78.27	2.5	1.32

APPENDIX IV. FISH AND DECAPOD CRUSTACEAN DENSITIES BEFORE FLOODING IN LAVACA RIVER DELTA MARSHES DURING MAY 1987 (FLOOD #2).

LAVACA BAY STUDY FRESHENING EVENT TWO BEFORE EVENT	LOWER DELTA								UPPER DELTA							
Macrofauna/2.6 m sq. (n=4)	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
May 12-13, 1987	VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																
Brevoortia patronus	10.3	10.25	23.3	15.4	9.3	7.11	21	21	1	0.71	0.5	0.5	0	0	5.5	5.5
Anchoa mitchilli	1.3	0.95	1	0.71	2	1.35	1	0.71	1.5	0.87	0.5	0.5	18.8	15.85	14	13.67
Cyprinodon variegatus	7.8	7.42	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0
Lagodon rhomboides	0.8	0.75	0	0	6.3	2.32	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0
Menidia beryllina	1	0.71	0	0	0	0	0	0	0	0	2.5	1.44	1	0.71	3.3	2.93
Myrophis punctatus	0.8	0.75	0.3	0.25	3	2.68	0.5	0.29	0.8	0.75	0.5	0.29	0	0	0	0
Mugil cephalus	3.8	2.17	0.5	0.29	0	0	0	0	0.3	0.25	0	0	0	0	0.3	0.25
Fundulus grandis	0.5	0.29	0	0	0	0	0	0	0.8	0.75	1.5	0.87	0.3	0.25	0	0
Leiostomus xanthurus	0.5	0.29	2	1.15	0	0	0.8	0.75	0	0	0	0	0	0	0	0
Adinia xenica	2	2	0	0	0	0	0	0	0.8	0.75	0	0	0	0	0	0
Gobiosoma bosci	0	0	0	0	0.8	0.48	0.8	0.75	0	0	0.3	0.25	0.3	0.25	0	0
Gobiosoma robustum	0	0	0	0	2.5	2.5	0	0	0	0	0	0	0	0	0	0
Micropogonias undulatus	0	0	0	0	0	0	0.5	0.29	0.5	0.5	0.3	0.25	0.3	0.25	0.5	0.29
Arius felis	0	0	0	0	0	0	1	1	0	0	0	0	0.3	0.25	0	0
Membras martinica	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	0	0	0
Sciaenops ocellatus	0	0	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Stellifer lanceolatus	0	0	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Gobiesox strumosus	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Hyporhamphus unifasciatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Ictalurus furcatus	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Paralichthys lethostigma	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0
Sphoeroides parvus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Syngnathus louisianae	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Syngnathus scovelli	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Synodus foetens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25
Unknown fish species	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprinodontidae	10.3	7.11	0	0	0	0	0	0	1.5	1.5	1.5	0.87	0.8	0.75	0	0
Gobiidae	0	0	0	0	3.3	2.29	0.8	0.75	0	0	0.3	0.25	0.3	0.25	0	0
Sciaenidae	0.5	0.29	2.8	1.6	0	0	1.5	0.65	0.8	0.75	0.3	0.25	0.3	0.25	0.5	0.29
Bait Fishes	5.8	2.66	1.5	0.65	8.3	2.78	1.3	0.63	2.3	0.85	0.5	0.5	19	15.8	14.3	13.59
Commercial Sports Fishes	0	0	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0
FISH TOTALS:	29	12.56	27.8	16.68	26.3	5.72	26	22.7	6.5	1.44	6	2.68	21.8	15.88	24.3	18.59
CRUSTACEANS:																
Palaemonetes pugio	52	17.65	0.5	0.29	112.8	38.54	0	0	30.3	16.98	0.3	0.25	26.3	18.39	0.5	0.5
Penaeus aztecus	20	5.93	5.8	3.75	64	15.31	13.5	2.36	9.3	3.2	7.8	3.2	1.3	1.25	0.8	0.75
Callinectes sapidus	2.5	0.87	0	0	8.8	1.75	0.3	0.25	5	2.08	3.8	1.44	4.5	1.66	2	0.91
Rhithropanopeus harrissi	0.5	0.29	0	0	1.8	1.11	0.3	0.25	0	0	0	0	0	0	0	0
Neopanope texana	0	0	0	0	0.5	0.5	0.3	0.25	0.5	0.5	0.3	0.25	0	0	0.3	0.25
Clibanarius vittatus	0	0	0	0	0.8	0.48	0	0	0	0	0	0	0	0	0	0
Palaemonetes intermedius	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0
Penaeidae	52	17.65	0.5	0.29	112.8	38.54	0	0	30.8	16.99	0.3	0.25	26.3	18.39	0.5	0.5
Palaemonidae	20	5.93	5.8	3.75	64	15.31	13.5	2.36	9.3	3.2	7.8	3.2	1.3	1.25	0.8	0.75
CRUSTACEAN TOTALS:	75	19.99	6.3	3.59	188.5	49.84	14.3	2.84	45.5	22.03	12	5.02	32	19.97	3.5	2.25

APPENDIX IV. FISH AND DECAPOD CRUSTACEAN DENSITIES AFTER FLOODING IN LAVACA RIVER DELTA MARSHES DURING MAY 1987 (FLOOD #2).

LAVACA BAY STUDY
FRESHENING EVENT TWO
AFTER EVENT
Macrofauna/2.6 m sq. (n=4)
May 25-26, 1987

	LOWER DELTA								UPPER DELTA							
	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
	VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																
Anchoa mitchilli	0.8	0.75	0.5	0.29	3.5	3.18	29.5	23.03	2.3	1.31	61.3	21.13	55.5	39.38	18.5	2.1
Gobiosoma bosci	0	0	0	0	15.5	8.97	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89
Brevoortia patronus	0	0	0.8	0.75	0.3	0.25	0	0	1.8	1.44	3	2.68	2.3	2.25	27	24.09
Cyprinodon variegatus	6	4.34	0	0	0	0	0	0	9.3	3.52	15.3	8.86	0.3	0.25	0	0
Fundulus grandis	4.5	2.18	0	0	0	0	0	0	6.5	4.27	0.3	0.25	0	0	0	0
Gobiesox strumosus	0	0	0	0	1.8	1.44	0.3	0.25	0	0	0	0	6	3.46	0	0
Mugil cephalus	2.3	1.03	2	1.08	0.8	0.75	0	0	0.5	0.29	0.3	0.25	0.3	0.25	0	0
Leiostomus xanthurus	0	0	0.3	0.25	3.3	3.25	0.5	0.5	0.5	0.29	0	0	1	1	0	0
Bathygobius soporator	0	0	0	0	5.3	5.25	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0.3	0.25	0.3	0.25	2.8	0.75	0	0	1	0.58	0	0	0.5	0.29	0.3	0.25
Micropogonias undulatus	0.5	0.5	2.5	1.89	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25
Myrophis punctatus	0	0	0.8	0.48	0.8	0.48	0.5	0.29	0	0	1.3	0.48	0	0	0.3	0.25
Menidia beryllina	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0	0	3	3
Bairdiella chrysoura	0	0	0	0	0	0	0	0	1.8	1.75	0	0	0	0	0	0
Cynoscion nebulosus	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0
Syngnathus louisianae	0	0	0	0	0	0	0	0	1.3	1.25	0	0	0	0	0	0
Elops saurus	0	0	0	0	0	0	0	0	0	0	1	0.58	0	0	0	0
Sphoeroides parvus	0	0	0	0	0.8	0.75	0	0	0	0	0	0	0	0	0	0
Strongylura marina	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.5	0.29	0	0
Adina xenica	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Anguilla rostrata	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Arius felis	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Lepisosteus oculatus	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Opsanus beta	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Orthopristis chrysoptera	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syngnathus floridae	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Cyprinodontidae	10.5	6.3	0	0	0	0	0	0	16	6.92	15.5	9.03	0.3	0.25	0	0
Gobiidae	0	0	0	0	21	10.98	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89
Sciaenidae	0.5	0.5	2.8	1.8	3.3	3.25	1	0.58	2.3	1.6	0	0	2.3	1.65	0.3	0.25
Bait Fishes	3.3	1.8	2.8	1.11	7	4.67	29.5	23.03	3.8	2.17	61.5	21	56.3	39.15	18.8	2.02
Commercial Sports Fishes	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0
FISH TOTALS:	14.8	5.07	7	1.35	35.5	17.39	35.3	22.07	46.3	21.98	86	16.13	74.3	42.82	69.8	39.53
CRUSTACEANS:																
Palaemonetes pugio	89	27.7	0.5	0.5	43	14.05	0.3	0.25	67.8	35.79	0.3	0.25	82.8	62.8	0.3	0.25
Penaeus aztecus	17	3.34	7.8	1.8	28.8	12.54	8.5	3.12	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89
Callinectes sapidus	1	0.41	0.5	0.5	3.8	0.63	0.3	0.25	5.5	3.84	3	1.58	5.8	3.38	1	0
Rhithropanopeus harrisii	0	0	0	0	0.5	0.29	0.5	0.5	7.8	7.75	1.5	1.5	0.5	0.5	0	0
Penaeus setiferus	0.3	0.25	0	0	3.5	3.5	0.5	0.29	0	0	0	0	0	0	0	0
Neopanope texana	0	0	0	0	0	0	0	0	0	0	0	0	1.3	1.25	1.3	0.95
Palaemonetes intermedius	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.5	0.5	0	0
Grass Shrimp	89	27.7	0.5	0.5	43	14.05	0.3	0.25	68.3	35.48	0.3	0.25	83.3	62.72	0.3	0.25
Penaeid Shrimp	17.3	3.15	7.8	1.8	32.3	13.48	9	3.34	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89
CRUSTACEAN TOTALS:	107.3	30.86	8.8	2.53	79.5	27.33	10	3.74	89.8	46.86	12.5	2.53	102.5	68.1	13.5	4.99

APPENDIX IV. FISH AND DECAPOD CRUSTACEAN DENSITIES BEFORE FLOODING IN LAVACA RIVER DELTA MARSHES DURING MAY-JUNE 1987 (FLOOD #3).

LAVACA BAY STUDY FRESHENING EVENT THREE BEFORE EVENT	LOWER DELTA								UPPER DELTA							
Macrofauna/2.6 m sq. (n=4)	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
May 25-26, 1987	VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																
Anchoa mitchilli	0.8	0.75	0.5	0.29	3.5	3.18	29.5	23.03	2.3	1.31	61.3	21.13	55.5	39.38	18.5	2.1
Gobiosoma bosci	0	0	0	0	15.5	8.97	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89
Brevoortia patronus	0	0	0.8	0.75	0.3	0.25	0	0	1.8	1.44	3	2.68	2.3	2.25	27	24.09
Cyprinodon variegatus	6	4.34	0	0	0	0	0	0	9.3	3.52	15.3	8.86	0.3	0.25	0	0
Fun[illegible] grand.	4.5	2.18	0	0	0	0	0	0	6.5	4.27	0.3	0.25	0	0	0	0
Gobie[illegible] strumosus	0	0	0	0	1.8	1.44	0.3	0.25	0	0	0	0	6	3.46	0	0
Mugil cephalus	2.3	1.03	2	1.08	0.8	0.75	0	0	0.5	0.29	0.3	0.25	0.3	0.25	0	0
Leiostomus xanthurus	0	0	0.3	0.25	3.3	3.25	0.5	0.5	0.5	0.29	0	0	1	1	0	0
Bathygobius soporator	0	0	0	0	5.3	5.25	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0.3	0.25	0.3	0.25	2.8	0.75	0	0	1	0.58	0	0	0.5	0.29	0.3	0.25
Micropogonias undulatus	0.5	0.5	2.5	1.89	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25
Myrophis punctatus	0	0	0.8	0.48	0.8	0.48	0.5	0.29	0	0	1.3	0.48	0	0	0.3	0.25
Menidia beryllina	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0	0	3	3
Bairdiella chrysoura	0	0	0	0	0	0	0	0	1.8	1.75	0	0	0	0	0	0
Cynoscion nebulosus	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0
Syngnathus louisianae	0	0	0	0	0	0	0	0	1.3	1.25	0	0	0	0	0	0
Elops saurus	0	0	0	0	0	0	0	0	0	0	1	0.58	0	0	0	0
Sphoeroides parvus	0	0	0	0	0.8	0.75	0	0	0	0	0	0	0	0	0	0
Strongylura marina	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0.5	0.29	0	0
Adina xenica	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Anguilla rostrata	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Arius felis	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Lepisosteus oculatus	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0
Opsanus beta	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Orthopristis chrysoptera	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syngnathus floridae	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Cyprinodontidae	10.5	6.3	0	0	0	0	0	0	16	6.92	15.5	9.03	0.3	0.25	0	0
Gobiidae	0	0	0	0	21	10.98	3.5	2.87	21	21	3.5	2.6	6.8	1.65	20.5	16.89
Sciaenidae	0.5	0.5	2.8	1.8	3.3	3.25	1	0.58	2.3	1.6	0	0	2.3	1.65	0.3	0.25
Bait Fishes	3.3	1.8	2.8	1.11	7	4.67	29.5	23.03	3.8	2.17	61.5	21	56.3	39.15	18.8	2.02
Commercial Sports Fishes	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.75	0	0
FISH TOTALS:	14.8	5.07	7	1.35	35.5	17.39	35.3	22.07	46.3	21.98	86	16.13	74.3	42.82	69.8	39.53
CRUSTACEANS:																
Palaemonetes pugio	89	27.7	0.5	0.5	43	14.05	0.3	0.25	67.8	35.79	0.3	0.25	82.8	62.8	0.3	0.25
Penaeus aztecus	17	3.34	7.8	1.8	28.8	12.54	8.5	3.12	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89
Callinectes sapidus	1	0.41	0.5	0.5	3.8	0.63	0.3	0.25	5.5	3.84	3	1.58	5.8	3.38	1	0
Rhithropanopeus harrisii	0	0	0	0	0.5	0.29	0.5	0.5	7.8	7.75	1.5	1.5	0.5	0.5	0	0
Penaeus setiferus	0.3	0.25	0	0	3.5	3.5	0.5	0.29	0	0	0	0	0	0	0	0
Neopanope texana	0	0	0	0	0	0	0	0	0	0	0	0	1.3	1.25	1.3	0.95
Palaemonetes intermedius	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0.5	0.5	0	0
Grass Shrimp	89	27.7	0.5	0.5	43	14.05	0.3	0.25	68.3	35.48	0.3	0.25	83.3	62.72	0.3	0.25
Penaeid Shrimp	17.3	3.15	7.8	1.8	32.3	13.48	9	3.34	8.3	2.39	7.8	1.75	11.8	3.09	11	3.89
CRUSTACEAN TOTALS:	107.3	30.86	8.8	2.53	79.5	27.33	10	3.74	89.8	46.86	12.5	2.53	102.5	68.1	13.5	4.99

APPENDIX IV. FISH AND DECAPOD CRUSTACEAN DENSITIES AFTER FLOODING IN LAVACA RIVER DELTA MARSHES DURING MAY-JUNE 1987 (FLOOD #3).

LAVACA BAY STUDY
FRESHENING EVENT THREE
AFTER EVENT
Macrofauna/2.6 m sq. (n=4)
June 11-12, 1987

	LOWER DELTA								UPPER DELTA							
	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
	VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG		VEGETATED		NON-VEG	
SPECIES	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.	MEAN	S.E.
FISHES:																
Brevoortia patronus	62.8	37.58	42.8	42.08	0.3	0.25	0	0	2.8	2.43	0.3	0.25	428.3	246	1132.3	300.1
Anchoa mitchilli	3	1.08	4	3.34	0	0	20.3	8.92	25.8	8.83	29.8	13.68	44.5	19.4	230.8	102.5
Gobiosoma bosci	1	1	0	0	4.3	2.53	7.8	4.5	23.3	6.33	6.3	1.65	6.5	3.52	2	1.68
Bairdiella chrysoura	0	0	0	0	1.3	0.63	0	0	10.5	4.27	0	0	0	0	0	0
Fundulus grandis	2.5	1.5	5.3	5.25	0	0	0	0	1.8	1.18	0	0	0	0	0	0
Myrophis punctatus	1	0.71	1	0.71	0	0	2.3	0.85	0.5	0.5	1.3	0.75	1.3	1.25	1	0.58
Leiostomus xanthurus	0	0	2.8	2.75	0	0	0.5	0.29	0	0	0.5	0.5	0	0	0	0
Lagodon rhomboides	0	0	0.8	0.75	1	0.71	0	0	1	0.41	0.3	0.25	0	0	0	0
Cyprinodon variegatus	2.5	1.19	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Mugil cephalus	2	2	0.3	0.25	0	0	0	0	0.3	0.25	0	0	0	0	0.3	0.25
Fundulus pulvereus	1.8	1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropogonias undulatus	0	0	0.5	0.5	0	0	1	0.71	0	0	0.3	0.25	0	0	0	0
Syngnathus scovelli	0	0	0	0	0	0	0.5	0.5	1	0.41	0	0	0	0	0	0
Menidia beryllina	0	0	0.5	0.5	0	0	0	0	0	0	0.5	0.29	0	0	0	0
Citharichthys spilopterus	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0.3	0.25
Elops saurus	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0.3	0.25
Paralichthys lethostigma	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25
Gobiesox strumosus	0	0	0	0	0.5	0.29	0	0	0	0	0	0	0	0	0	0
Archosargus probatocephalus	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.25	0	0
Astroscopus y-graecum	0	0	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0
Cyprinodontidae	6.8	2.17	5.3	5.25	0	0	0	0	2	1.41	0	0	0	0	0	0
Gobiidae	1	1	0	0	4.3	2.53	7.8	4.5	23.3	6.33	6.3	1.65	6.5	3.52	2	1.68
Sciaenidae	0	0	3.3	2.63	1.3	0.63	1.5	0.65	10.5	4.27	0.8	0.48	0	0	0	0
Bait Fishes	5	2.27	5	3.08	1	0.71	20.3	8.92	27	8.5	30	13.56	44.5	19.4	231	102.5
Commercial Sports Fishes	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0.3	0.25
FISH TOTALS:	76.8	33.53	57.8	43.3	7.8	2.93	32.8	12	67.3	15.85	39	13.71	481	266.5	1367	369.6
CRUSTACEANS:																
Palaemonetes pugio	27.3	9.2	31.5	18.26	18.3	5.81	0	0	98	22.91	3	1.91	43	18.04	1	1
Penaeus aztecus	6	2.12	3.3	1.65	2.8	0.48	5.5	2.63	13.3	3.22	8.3	2.02	0	0	0	0
Callinectes sapidus	0.3	0.25	0	0	0.8	0.25	0.8	0.48	3.8	1.18	0.5	0.29	1.3	0.75	0.5	0.29
Rhithropanopeus harrisii	0	0	0.3	0.25	0.8	0.75	0.3	0.25	3	2.68	0.3	0.25	0	0	1	0.41
Palaemonetes intermedius	0	0	0	0	0	0	0	0	4.3	3.92	0	0	0	0	0	0
Sesarma reticulatum	0	0	0	0	1	0.58	0	0	0.3	0.25	0	0	0	0	0	0
Penaeus setiferus	0.3	0.25	0.5	0.5	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Palaemonetes vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uca longisignalis	0	0	0.3	0.25	0.3	0.25	0	0	0	0	0	0	0.5	0.5	0	0
Neopanope texana	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0
Uca rapax	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0
Unknown crustacean species	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0
Grass Shrimp	27.3	9.2	31.5	18.26	18.3	5.81	0	0	102.3	23.22	3	1.91	43.5	18.44	1	1
Penaeid Shrimp	6.3	2.25	3.8	1.89	2.8	0.48	5.8	2.87	13.3	3.22	8.3	2.02	0	0	0	0
CRUSTACEAN TOTALS:	33.8	10.89	36	18.77	24	6.18	7	2.42	122.5	18.83	12	2.45	44.8	18.53	2.5	1.55