NOAA Technical Memorandum
NMFS - SEFC - 251

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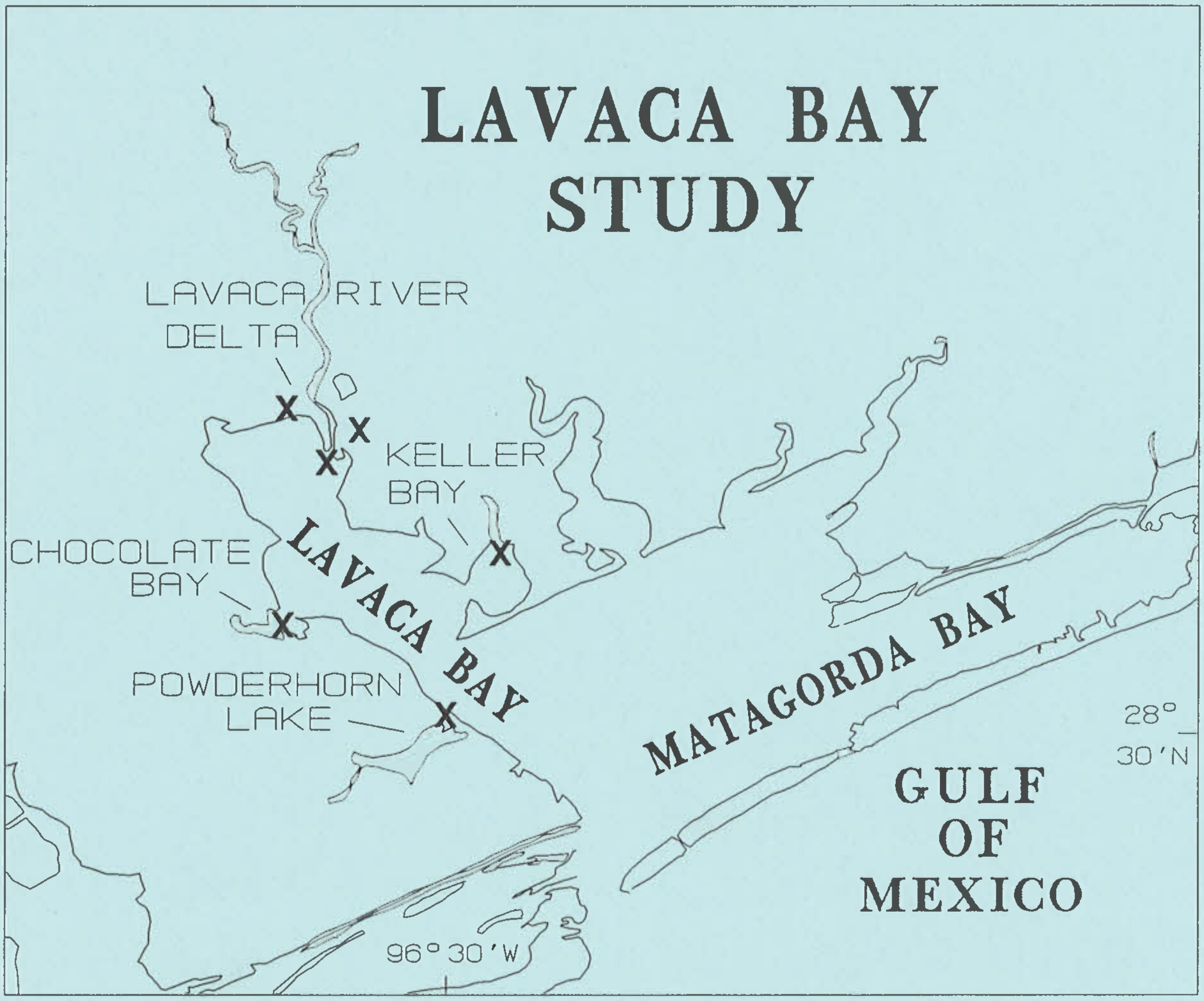

GALVESTON LABORATORY

SOUTHEAST FISHERIES CENTER

NATIONAL MARINE FISHERIES SERVICE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

DEPARTMENT OF COMMERCE

FEBRUARY 1990

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The Use of *Juncus* and *Spartina* Marshes by Fisheries 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 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.

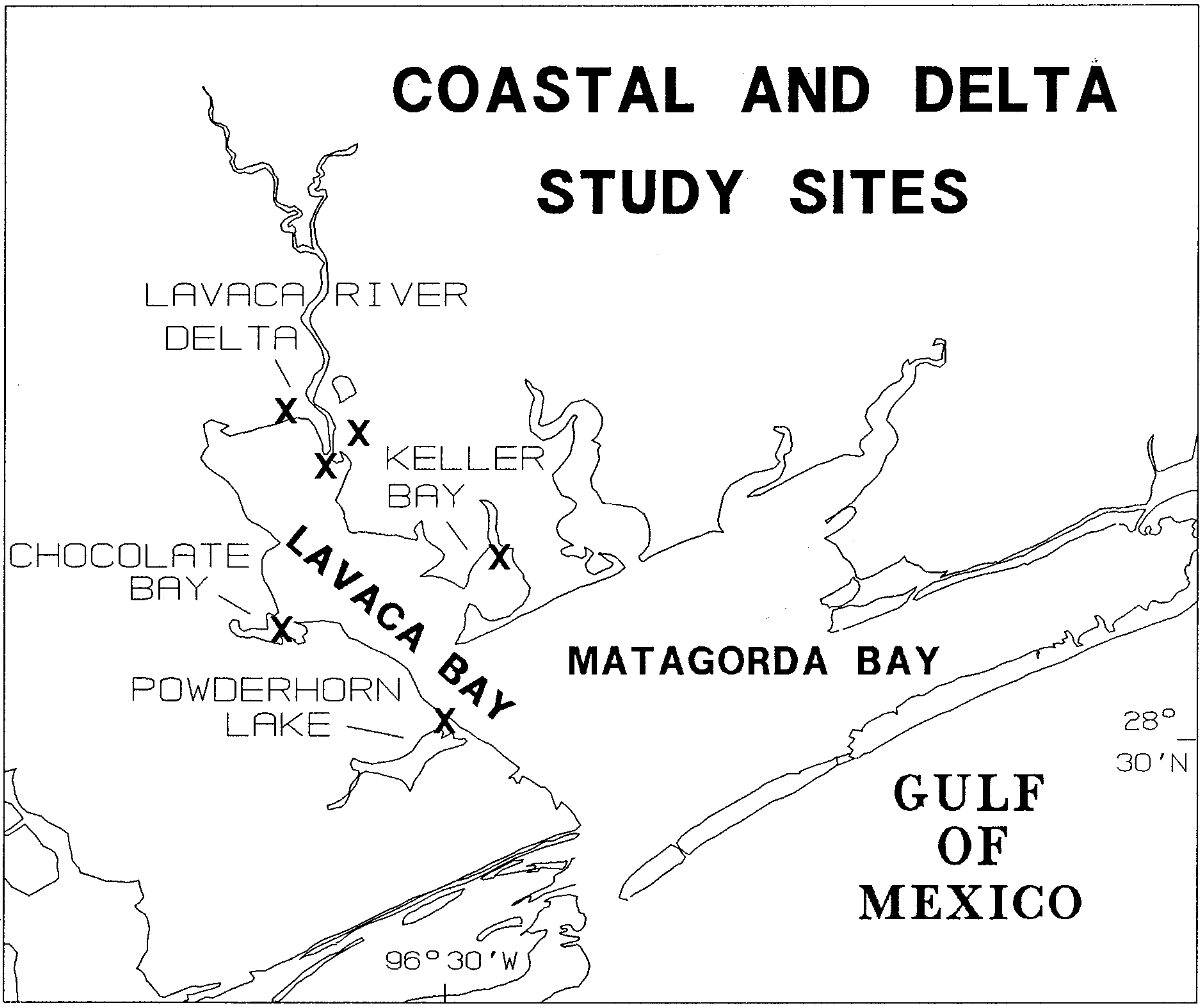

FIGURE 1. Sampling sites in Lavaca Bay, Texas, in coastal *Spartina* marshes and deltaic *Juncus* marshes compared for faunal usage in October 1985, and May and August 1986.

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

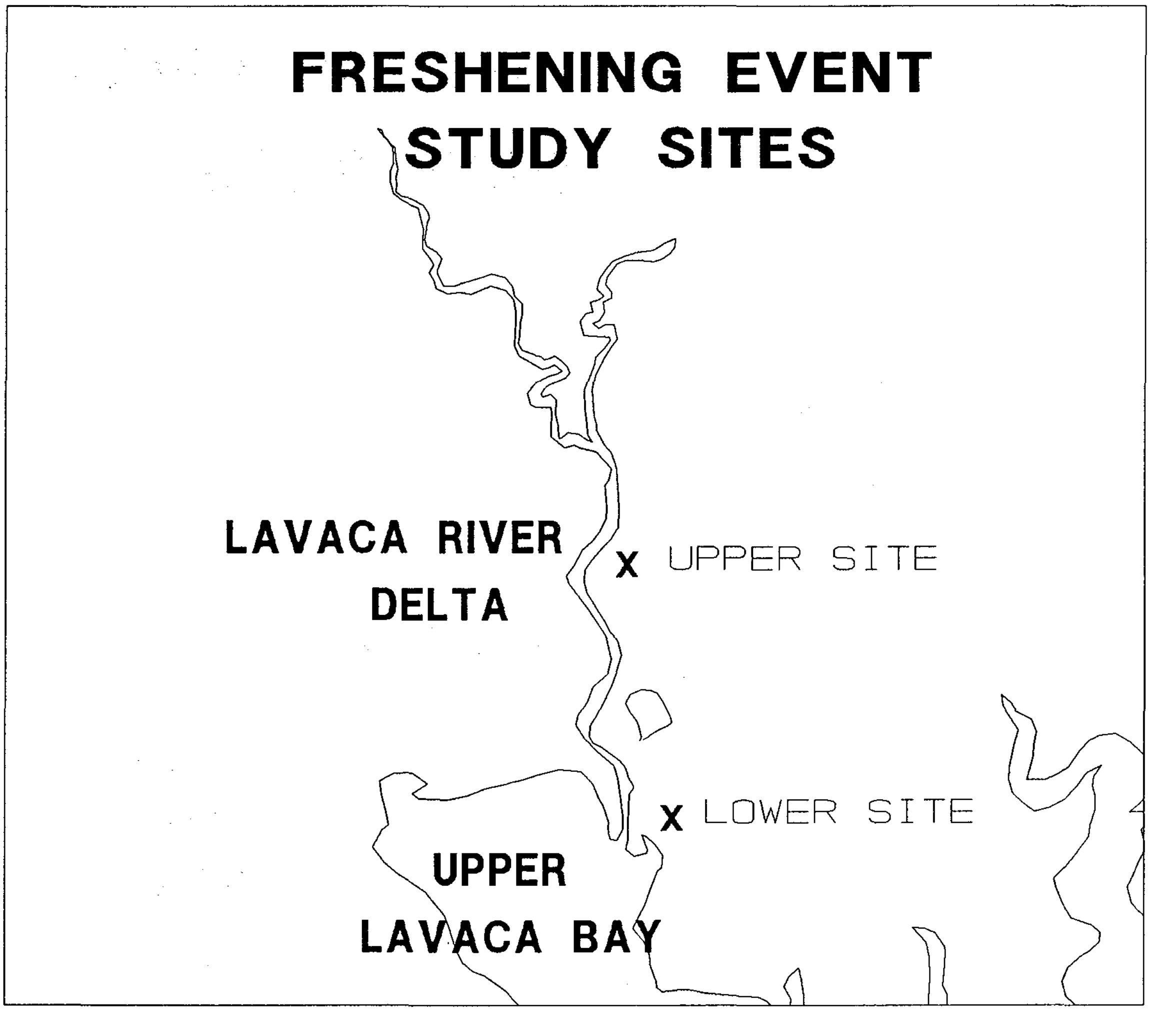

FIGURE 2. Marsh locations at the Lavaca River delta, Texas, compared for faunal usage before and after floods in the fall of 1986 and spring of 1987.

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.

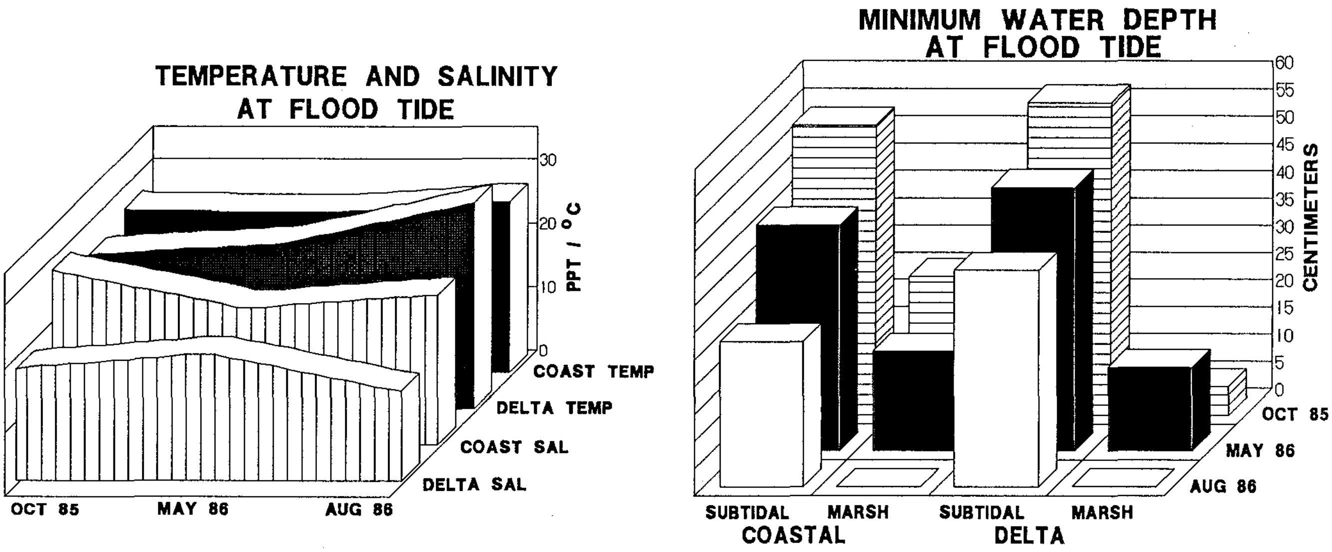

FIGURE 3. Temperature, salinity, and water depth associated with coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

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.

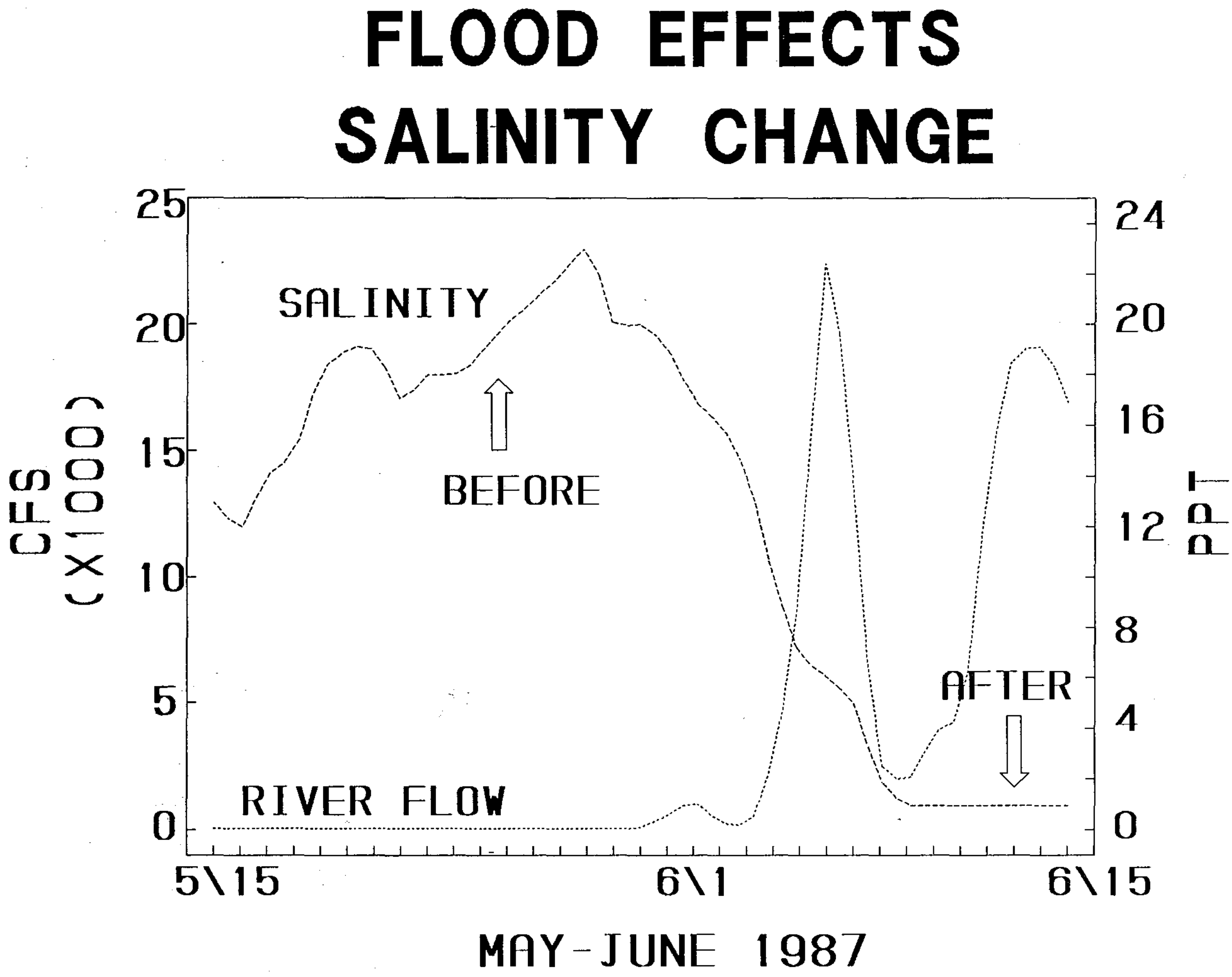

FIGURE 4. Salinity change in upper Lavaca Bay during flooding of the Lavaca River associated with high rainfall in May and June of 1987 (flood # 3).

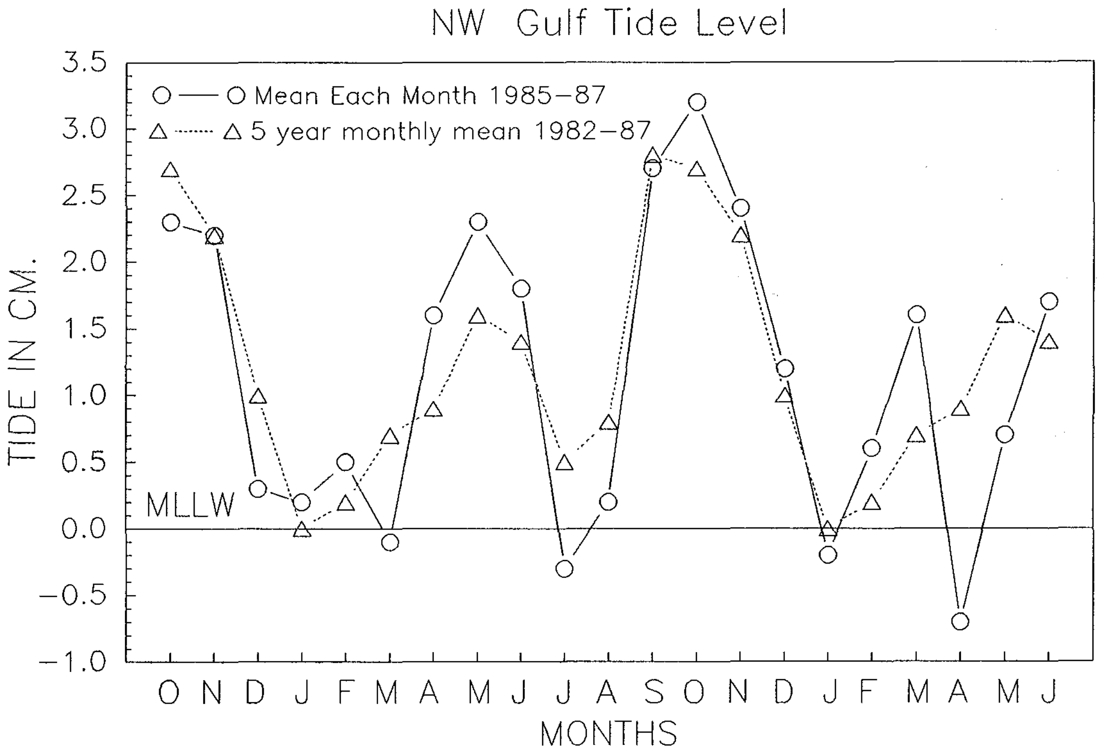

FIGURE 5. The seasonal pattern of tides in the northwestern Gulf of Mexico from records of the NOAA/NOS tide station No. 877-1450 at Galveston Texas.

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).

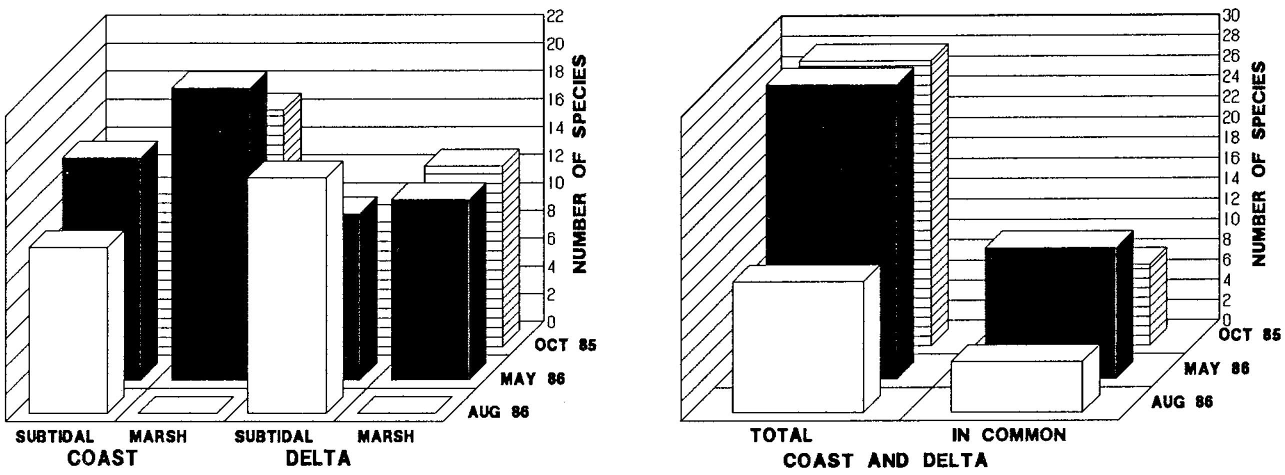

FIGURE 6. Number of fish species between habitats of coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

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

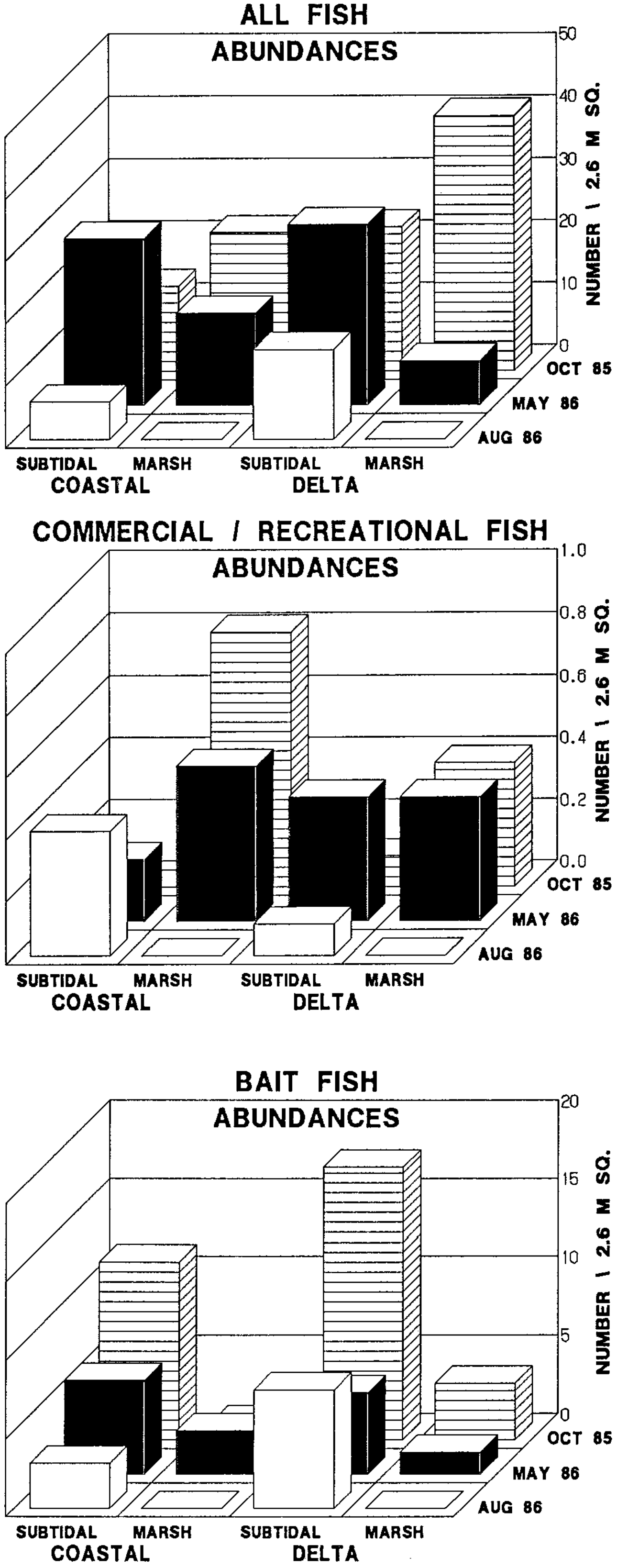

FIGURE 7. Mean abundances of fishes in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

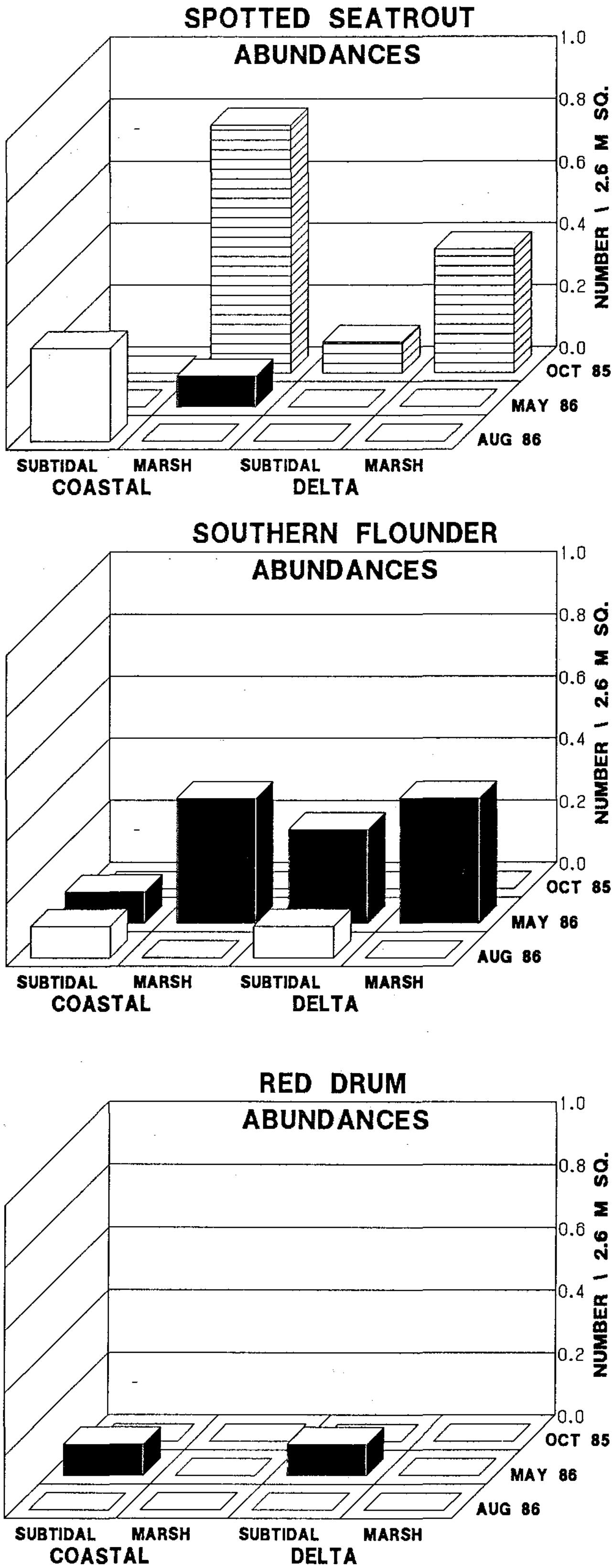

FIGURE 8. Mean abundances of spotted seatrout, southern flounder and red drum in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

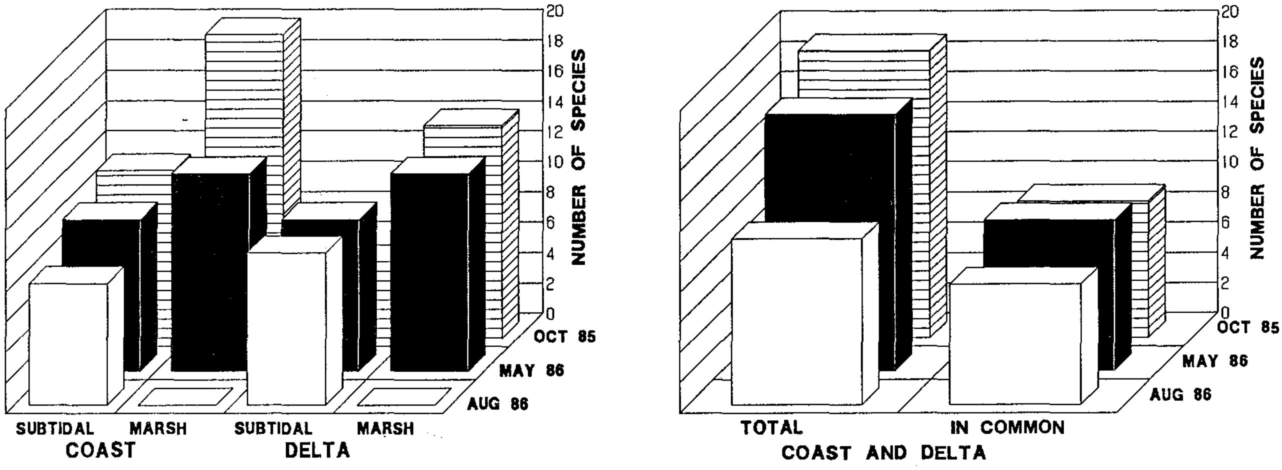

FIGURE 9. Numbers of decapod crustacean species in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

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.

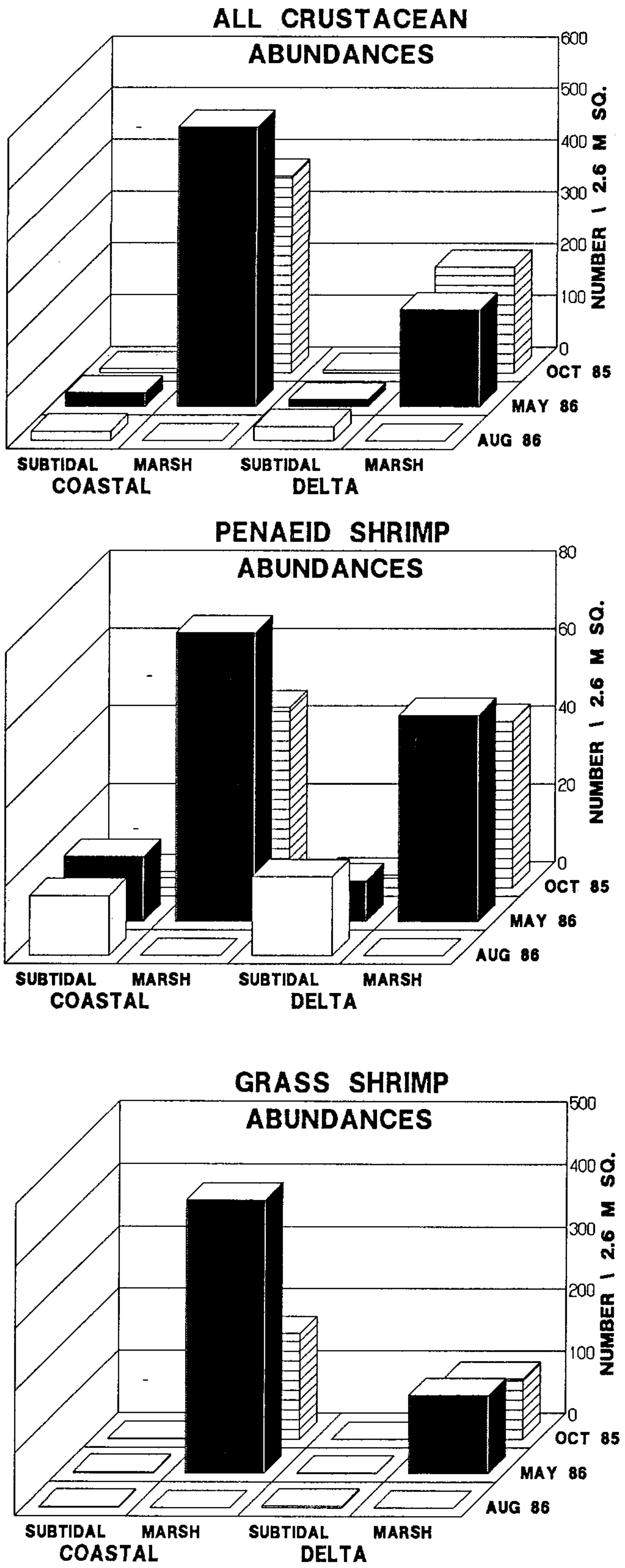

FIGURE 10. Mean abundances of decapod crustaceans in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

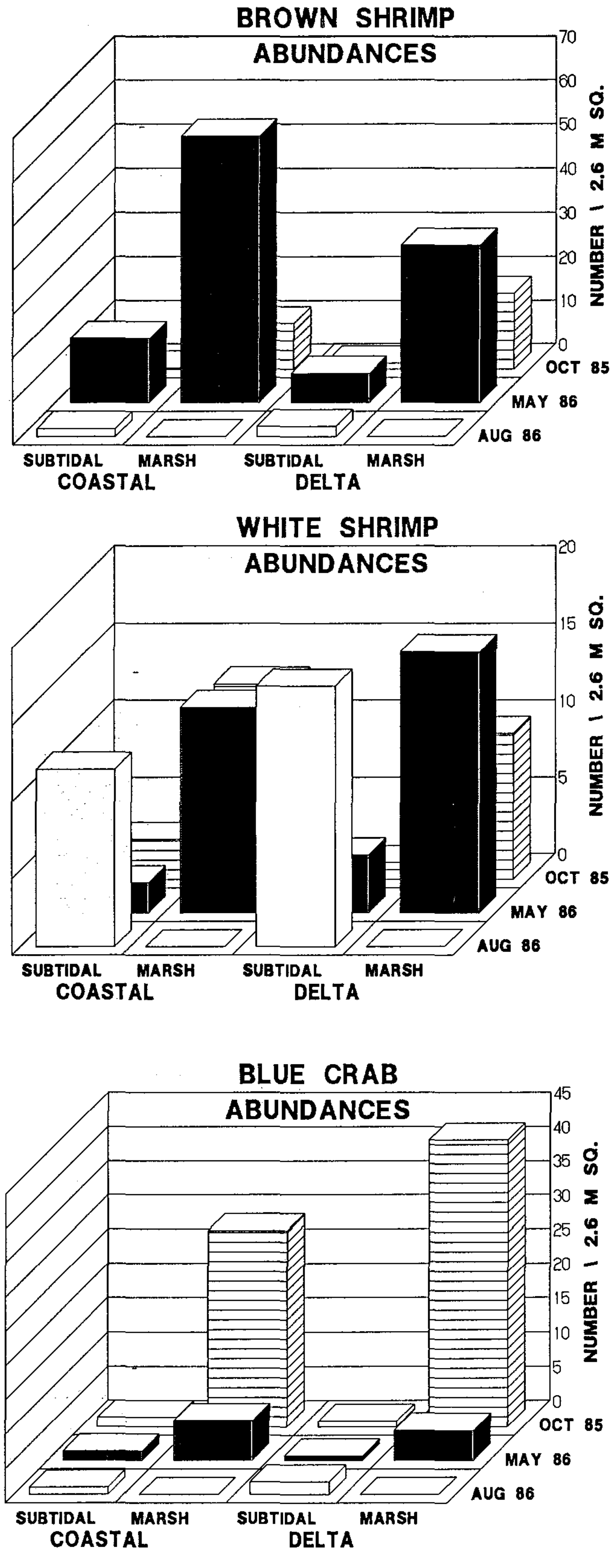

FIGURE 11. Mean abundances of brown shrimp, white shrimp and blue crab in coastal *Spartina* and deltaic *Juncus* marshes in Lavaca Bay, Texas.

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

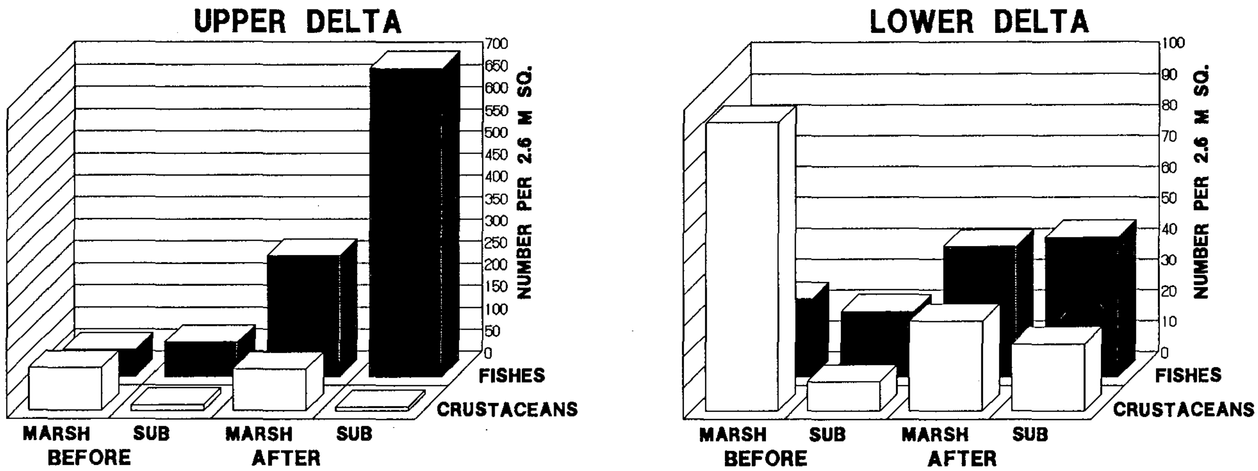

FIGURE 12. Abundances of fishes and decapod crustaceans in Lavaca River delta marshes before and after flooding during May and June of 1987 (flood event # 3).

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).

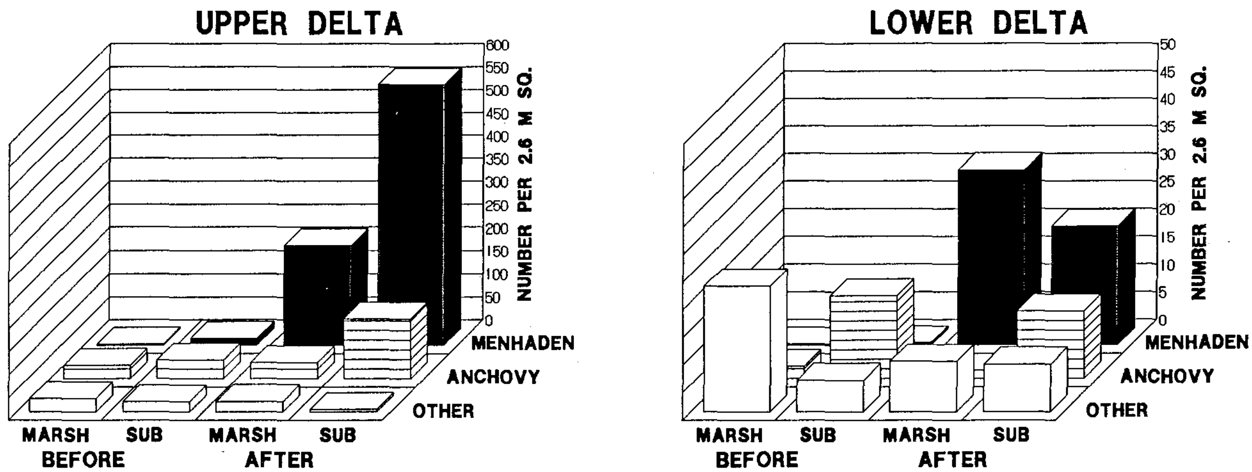

FIGURE 13. Abundances of fishes in Lavaca River delta marshes before and after flooding during May and June of 1987 (flood event # 3).

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).

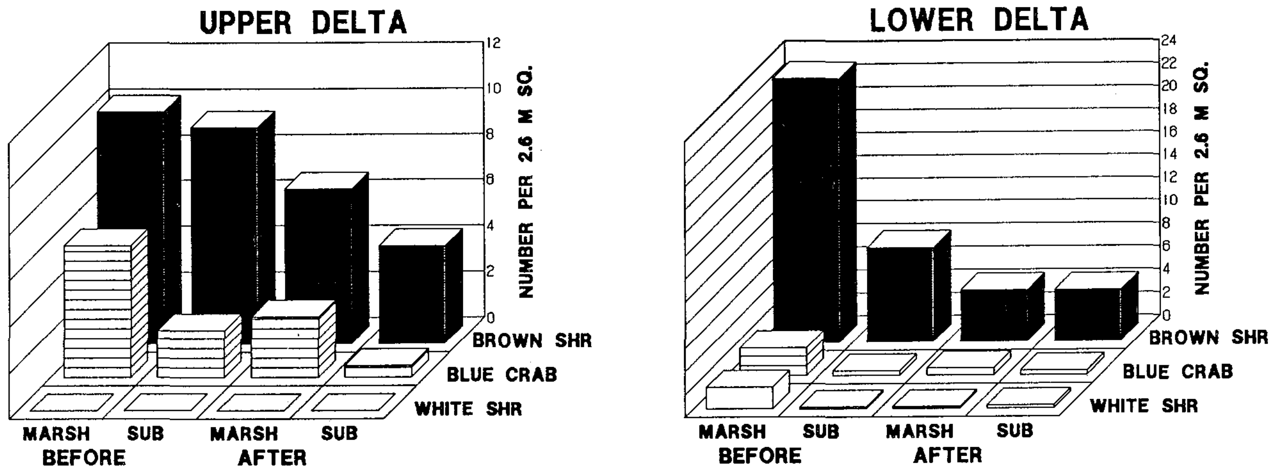

FIGURE 14. Abundances of economically important crustaceans in Lavaca River delta marshes before and after flooding in May and June of 1987 (flood event # 3).

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.

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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	LAVACA DELTA EAST				LAVACA DELTA RIVER				LAVACA DELTA WEST			
Macrofauna/2.6 m sq. (n=4) Samples not paired	*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	CHOCOLATE BAY				KELLER BAY				POWDERHORN LAKE			
May 26-30, 1986												
Macrofauna/2.6 m sq. (n=4)	*Spartina*		Non-vegetated		*Spartina*		Non-vegetated		*Spartina*		Non-vegetated	
Paired samples												
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	COASTAL AL SITE S						DELTA SITES					
August 19-20, 1986 Macrofauna/2.6 m sq. (n=4) Samples not paired	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	Chocolate Bay Site				Lavaca Delta Site			
October 15-18, 1985								
Macrofauna/2.6 m sq. (n=4)	*Juncus*		*Spartina*		*Juncus*		*Spartina*	
Samples not paired								
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	Chocolate Bay Site				Lavaca Delta Site			
May 28-29, 1986								
Macrofauna/2.6 m sq. (n=4)	*Juncus*		*Spartina*		*Juncus*		*Spartina*	
Paired Samples								
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
Citharichthys 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 Macrofauna/2.6 m sq. (n=4) May 12-13, 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	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	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
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 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
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	LOWER DELTA								UPPER DELTA							
AFTER EVENT																
Macrofauna/2.6 m sq. (n=4)	INNER MARSH				OUTER MARSH				INNER MARSH				OUTER MARSH			
June 11-12, 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	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
Citharicthys 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	0.5	0.5	0	0
Uca longisignalis	0	0	0.3	0.25	0.3	0.25	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	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