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THREE-YEAR COMPREHENSIVE MONITORING REPORT

COAST 2050 REGION 4
EAST MUD LAKE MARSH MANAGEMENT
CS-20

Third Priority List Marsh Management Project
of the Coastal Wetlands Planning, Protection, and Restoration Act
(Public Law 101-646)

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ABSTRACT

The relations among emergent vegetation, vegetation plantings, frequency and duration of flooding, salinity, fisheries, vertical accretion, and marsh surface elevation were evaluated over a 40 month period at the East Mud Lake Marsh Management project area located in Cameron Parish, Louisiana. Rehabilitation of an existing levee and improvements to 12 water control structures were completed in May 1996, during the most severe regional drought in 20 years. Drawdowns were initiated in 1996 and 1997, however, the drought in 1996 caused drying, cracking, and compaction of the soil surface in the project area and to a lesser degree in the reference area. Following the drought in November 1996, a month of heavy rain increased water levels to 0.4 m above marsh level with average salinity of 13.6 ppt inside the project area, further impacting emergent vegetation and decreasing cover values from 88.5 % $\pm$ 3.43 in 1995 to 64.5 % $\pm$ 6.85 in 1997. The dominant species, *Spartina patens*, experienced the greatest decrease in cover. In the reference area, cover values increased from 86.6 % $\pm$ 4.95 to 86.9 % $\pm$ 6.07. Despite the extreme conditions, project area water salinities remained below the target of 15 ppt for brackish marsh vegetation for most of the data collection period. Following the drought, marsh surface elevation dropped -1.76 $\pm$ .67 cm in the project and -1.73 $\pm$ .67 cm in the reference area. Poor drainage in the project area was exacerbated by this loss in elevation, water levels appeared to remain higher, and flooding events lasted longer in the project area than in the reference areas. Survival of *Spartina alterniflora* plantings was above 60% after one year. Access to the project area for transient fisheries species was apparently unchanged, but high variability in the data masked any project effects on resident species. Results suggest the marsh subsurface should not be allowed to dry completely despite high water salinity conditions outside the project area in brackish marsh habitats. In addition, flexibility in structure operations is essential in responding to conditions incurred by environmental extremes so prevalent in coastal Louisiana.

INTRODUCTION

Louisiana possesses a significant percentage of the total coastal wetland acreage in the contiguous United States. These wetlands are in a severe state of degradation due to natural and anthropogenic causes (Turner 1990). Mass harvesting of cypress timber beginning in the early 1900's and dredging of oil and gas access canals beginning in the 1940's led to a dramatic change in the landscape of coastal Louisiana (Myers et al. 1995; Reed and Rozas 1995). Various marsh management methods have been utilized in an attempt to mitigate wetland loss.

Marsh management has been widely used in coastal Louisiana for decades to improve conditions for waterfowl and furbearers (Chabreck 1960). Presently, marsh management techniques employ impoundments and a variety of water control structures such as fixed and variable crest weirs, flapgates and culverts to prevent the conversion of marsh into shallow open water areas. Water control structures are operated to moderate water level variability, reduce saltwater introduction, and seasonally change the volume of water in management areas for the benefit of both vegetation and wildlife. Results from previous studies indicate that this type of management can enhance vegetation growth when proper drawdown is achieved and increase waterfowl and wildlife numbers in management areas (Hess et al. 1989). However, in two studies located in the Chenier Plain of southwest Louisiana, marsh accretion rates have been reported to be lower in managed marshes than in comparable unmanaged reference marshes (Cahoon 1994), but not in others (Foret 1997).

The Chenier Plain developed approximately 3,000 years ago through westward littoral transport of Mississippi River delta sediments, combined with deposition of local fluvial sediments (Howe et al., 1935, Van Lopik and McIntire, 1957, Byrne et al., 1959; DeLaune et al., 1983). The development of cheniers (recessional beach ridges) coincided with eastward shifts in the course of the Mississippi River (Byrne et al., 1959, Gould and McFarlan, 1959: DeLaune et al., 1983). Intervening mudflats (marshes) are associated with westward shifts in the river's course. The Calcasieu River has historically maintained a channel through the central portion of Calcasieu Lake (Van Sickle 1977). Since 1871, the Calcasieu Ship Channel (CSC) has been intermittently dredged, from 32.8 ft (10 m) deep in 1937, to 39.36 ft (12 m) in 1946, and deepened in 1963 to 49.2 ft (15 m) with a final width of 400 ft (122 m) (USACE 1971). East Mud Lake is an irregularly shaped lake, probably representing an abandoned river or tidal stream course (Gosselink et al. 1979).

The East Mud Lake Marsh Management project area consists of 8,054 acres (3,222 ha) located in the Calcasieu/Sabine Basin in Cameron Parish, Louisiana. The project is bounded by the southern FINA Oil and Chemical Company property line to the south, La. Hwy. 27 to the west, the Sabine National Wildlife Refuge north of Magnolia Road, and an existing step levee and property line near Oyster Bayou to the east (figure 1). The Calcasieu/Sabine Basin suffers from anthropogenic hydrologic changes to the system (U.S. Department of Agriculture-Soil Conservation Service [USDA-SCS] 1993), which have led to the deterioration of the marsh since 1953. The CSC is 1 mi (1.6 km) east of the project area and provides an avenue for high salinity water (4–32 ppt) and rapid water movement into the East Mud Lake project area via West Cove, Oyster Bayou, and Mud Bayou (figure 1). These connections facilitate increases in turbidity and scouring within the

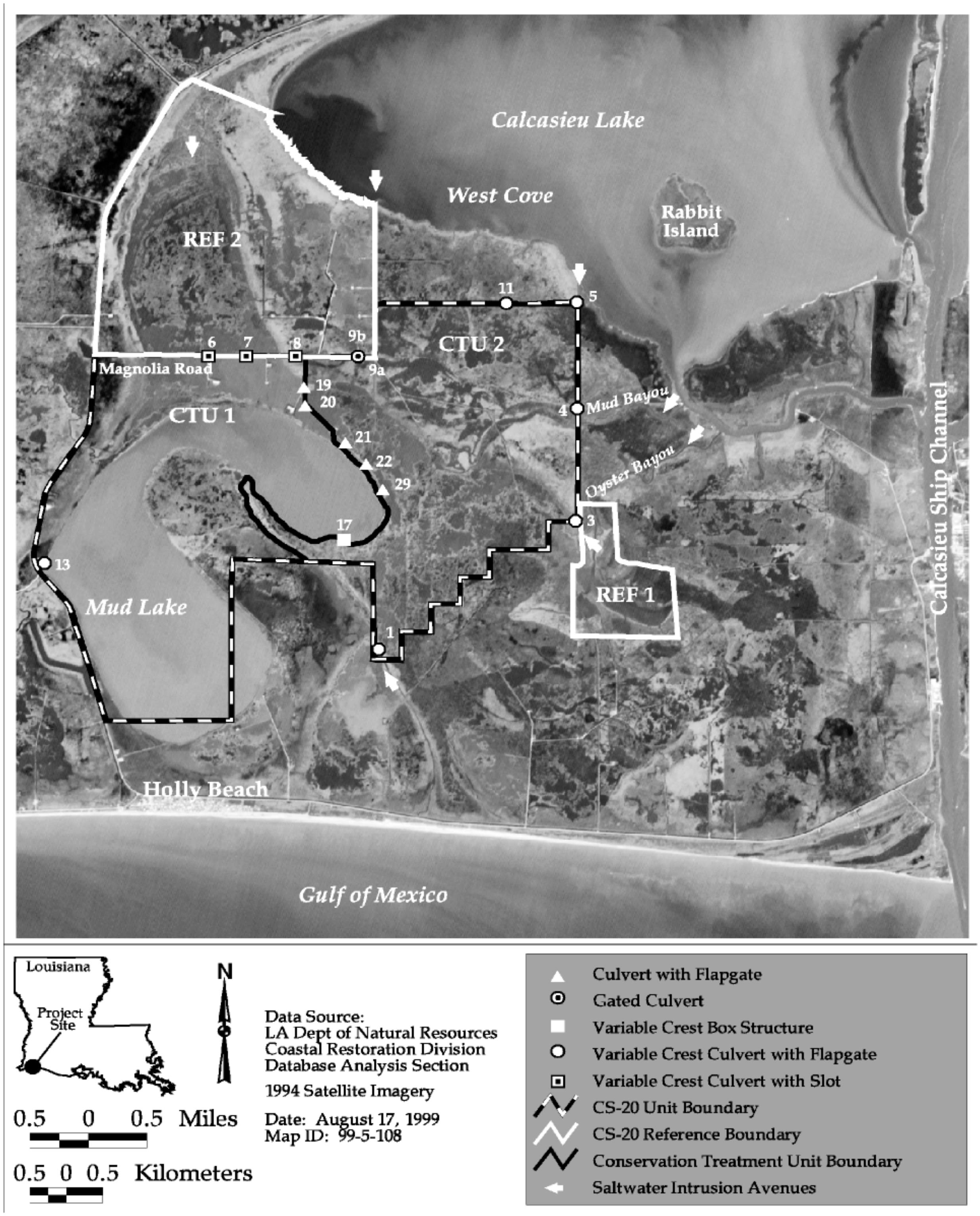


Figure 1. East Mud Lake (CS-20) project map depicting project boundaries, conservation treatment unit boundaries, reference area boundaries, project features, and saltwater intrusion avenues.

project area. The construction of La. Hwy 27 in 1936 reduced the input of freshwater from the west (USDA-SCS 1994). In the 1950's, portions of the project area were impounded by construction of Magnolia Road and a levee system on the north, east, and south (figure 1). Analysis of aerial photos of the project area indicates a marsh loss rate of 76 ac/yr (30.4 ha/yr) from 1953 to 1983 (USDA-SCS 1992). Excluding Mud Lake, the land to open water ratio deteriorated from 99:1 in 1953 to 70:30 by 1983.

Another problem in the project area is flooding of the marsh for prolonged time periods. Construction of La. Hwy. 27 to the west and La. Hwy. 82 to the south have decreased avenues for drainage from the western and southern areas of the project. This has lead to prolonged periods of high water levels and "ponding," which has resulted in the deterioration of the vegetation (USDA-SCS 1994). Subsidence and sea level rise have also exacerbated the problem, resulting in a relative water level increase of 0.25 in/yr (0.64 cm/yr) from 1942 to 1988 (Penland et al. 1989). The East Mud Lake project addresses these problems by increasing the total number of drainage outlets for the area.

The project area has been divided into two hydrologically separate Conservation Treatment Units (CTUs) that are managed independently (figure 1). CTU 1 contains Mud Lake and is managed passively. Structures and features in CTU 1 consist of vegetative plantings, earthen plugs, culverts with flapgates and variable-crest culverts. The variable-crest culverts at stations 6, 7, and 8 are set at 6 in (15 cm) below marsh level with vertical slots open except when salinities exceed 15 ppt. The variable-crest culvert at station 13 is set at 6 in (15 cm) below marsh level (BML) with flapgates locked open except when salinities exceed 7 ppt.

CTU 2 is actively managed and has drawdown capabilities in order to encourage shallow water areas to revert to emergent vegetation. Two drawdown events were planned for the first five years of the project. Structures and features present in CTU 2 consist of vegetative plantings, variable crest culverts with flapgates, a gated culvert, and a variable-crest box structure (figure 1). Phase I emphasizes curtailing marsh erosion and reclaiming emergent marsh by implementing a partial drawdown from February 15-July 15. All flapgates at variable-crest culverts 1, 3, 4, 5, 9a, and 11 are allowed to operate with all stoplogs removed. Stoplogs are set at 12 in (30.48 cm) above marsh level (AML) on the variable crest box structure at station 17. The screwgate at station 9 is opened and the flapgate allowed to operate.

Phase II, the maintenance phase, emphasizes stabilization of salinity and water levels while ensuring ingress and egress of fisheries species. During this phase of operation, flapgates at stations 3, 4, 5, 9a, 9b, and 11 are locked open. Stoplogs are set at 6 in (15 cm) below marsh level at stations 1, 3, 4, 9a, and 11 while at station 5, one bay is set at 6 in (15 cm) BML and one bay at 12 in (30.48 cm) BML. The screwgate at station 9b is opened and all stoplogs removed from station 17. To protect marsh vegetation during periods of high salinity, the ingress gates are closed when salinity inside the project area exceeds 15 ppt at stations 3 or 5.

Vegetation plantings were installed through a cooperative effort by the Louisiana Department of Natural Resources (LDNR), Soil and Water Conservation District, and Natural Resource Conservation Service (NRCS) from June 5 through July 8, 1995. A total of 7,200 *Spartina alterniflora* (smooth cordgrass) trade gallons were planted along the step levee in CTU 2 (figure 2). The cut bank configuration of most of the Mud Lake shoreline limited plantings to 480 plants in areas adjacent to structures 17, 13, and the earthen plug west of structure 17 in CTU 1.

Construction was completed May 1, 1996. The project objectives are to prevent wetland degradation by reducing vegetative stress, thereby improving the abundance of emergent and submergent vegetation and to stabilize the shoreline of Mud Lake through vegetative plantings. Specific goals are to (1) decrease the rate of marsh loss, (2) increase vegetative cover along the shoreline of East Mud Lake, (3) increase percent cover of emergent vegetation in shallow open-water areas, (4) increase abundance of vegetation in presently vegetated portions of the project area, (5) reduce water-level fluctuations to within 6 in (15 cm) BML to 2 in (5.08 cm) AML and salinity levels to 15 ppt or less, (6) decrease the duration and frequency of flooding over emergent marsh, (7) decrease the mean salinity in CTU 2, and (8) increase vertical accretion in CTU 2. Maintaining fisheries abundance is not a specific goal as addressed in the project documentation. However, because of concerns regarding potential fishery impacts, it has been included in the monitoring plan.

The area east of CTU 2, south of Oyster Bayou and Mud Bayou (reference area 1), was selected as the best reference area for the evaluation of the water level, salinity, and fisheries monitoring elements. The area north of Magnolia Road (reference area 2) is a suitable reference area for the evaluation of the vegetative, accretion, water-level, salinity, fisheries, and soil monitoring elements. The project area and both reference areas are classified as brackish marsh (Chabreck and Linscombe 1988) and contain mainly organic Bancker and Creole soils with ridges of Mermentau soils (USDA-NRCS 1995). All are directly influenced hydrologically by the CSC and are dominated by *Spartina patens* (marshhay cordgrass).

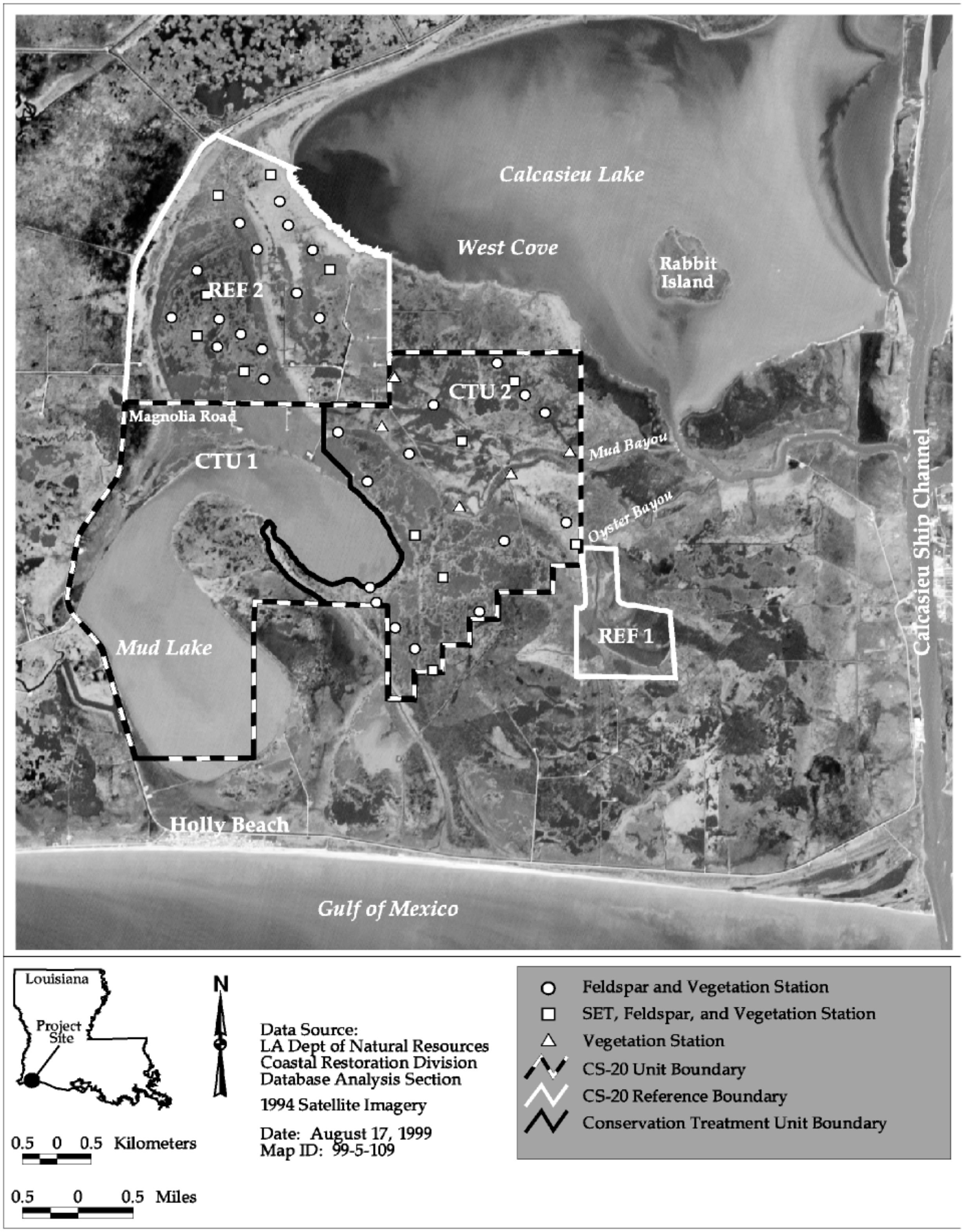


Figure 2. East Mud Lake (CS-20) project map depicting feldspar, emergent vegetation, and Sediment Erosion Table (SET) stations.

METHODS

A detailed description of the monitoring design can be found in Holbrook (1995).

Habitat mapping: At the NWRC, 1:12,000 scale color infrared aerial photography obtained on December 26, 1994 was classified and photo-interpreted to measure land to open water ratios and to map habitat types in the project area preconstruction.

To determine land to open water ratios, the aerial photographs were scanned at 300 pixels per inch and georectified using ground control data collected with a global positioning system (GPS) capable of sub-meter accuracy. These individually georectified frames were then mosaicked to produce a single image of the project and reference areas. Using geographic information systems (GIS) technology, the photo mosaic was classified according to pixel value and analyzed to determine land to water ratios in the project and reference areas. All areas characterized by emergent vegetation were classified as land, while open water, aquatic beds, and mud flats were classified as water. An accuracy assessment comparing the GIS classification of 100 randomly chosen pixels to aerial photography determined an overall classification accuracy of 96%.

Using the National Wetlands Inventory (NWI) Classification System, the photography was photo interpreted by NWRC personnel and classified to the subclass level (Cowardin et al.1992). The habitat delineations were transferred to 1:6,000 scale Mylar base maps, digitized, and checked for quality and accuracy.

The NWI classification system identifies habitat types by system, subsystem, class, and subclass. The estuarine system includes all tidal habitats in which waters consist of at least 0.5% ocean-derived salt and are diluted at least occasionally by freshwater runoff from the land. Palustrine habitats are nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and all wetlands that occur in tidal areas where ocean-derived salinities are less than 0.5% (Cowardin et al. 1992). Urban habitats are those whose areal coverage consists of less than 30% vegetation or other cover. Upland scrub-shrub habitats consist of at least 30% scrub-shrub, and upland forested habitats consist of at least 3% forest (Anderson et al. 1976). When describing both upland and wetland habitats, the term "scrub-shrub" refers to woody vegetation less than 20 ft (6 m) in height. The term "forested" refers to woody vegetation taller than 20 feet. Where more than one class of vegetation exists, the uppermost layer of vegetation with areal coverage greater than 30% determines the NWI habitat type.

Vegetation plantings: The plantings were divided into three land types due to different stress factors from boat wakes, wave energy, and herbivory. The canal plantings, located on a long, straight canal in CTU 2 are subject to herbivory from cattle year-round. The step levee plantings are located in CTU 2 on short canals where plants were installed at a farther distance from the shoreline. Lakeshore plantings are located on the shoreline of East Mud Lake in CTU 1 and subject to a high wave energy due to the long north-south fetch across the lake. To document planting success, 5% of the plants along the step levee and 5% of the plants along the East Mud Lake shoreline were sampled. Thirty-six plots along the step levee and 4 plots along the shoreline, consisting of 10 plants spaced 5 ft (1.5

m) apart, were selected and sampled for percent survival of planted vegetation, species composition of encroaching vegetation, and percent cover for each species present. Monitoring stations were placed every 1,000 ft (305 m). The 1-mo, 6-mo, and 1-yr postplanting sampling was conducted in July 1996, December 1996, and August 1997, respectively.

Planting survival and mortality was evaluated in terms of four variables (Harper 1977), which are defined and calculated as follows:

$$\text{survival frequency} = \text{number of live plants inside plot at timepoint } x$$

$$\text{survivorship } (l_x) = \text{probability (at planting time) of surviving until age } x = \frac{\text{no. live plants inside plot at timepoint } x}{\text{original no. plants inside plot}}$$

$$\text{mortality } (d_x) = \text{probability (at planting time) of dying during age interval } x, x+1 = l_x - l_{x+1}$$

$$\text{mortality rate } (q_x) = \text{probability of a planting at age } x \text{ dying before the age of } x+1 = \frac{l_x - l_{x+1}}{l_{..}} = \frac{d_x}{l_{..}}$$

Percent plant survival and percent cover were compared among the land types with the nonparametric Kruskal-Wallis test.

Existing vegetation: Sites to monitor existing vegetation were selected using a systematic transect pattern in which five transect lines were drawn in a northwest to southeast configuration from the Calcasieu Lake/West Cove shoreline in the project area and reference area 2. Five stations were chosen at equally spaced points along each transect line, for a total of 25 stations in the project area and 20 stations in reference area 2, to obtain an even distribution of stations throughout the marsh (figure 2). Percent cover, height of dominant plants, and species composition were monitored in 1.0-m^2 vegetation plots. Emergent vegetation data were collected in July 1995 and July 1997 at the preconstruction and 1-yr postconstruction sampling periods, respectively. Total cover and cover of *Spartina patens* were compared over time (pre- and postconstruction) with the Kruskal-Wallis test. A three-way analysis of variance (ANOVA) was performed to compare species richness and height among areas (project and reference), by station according to soil type, and over time (pre- and postconstruction). Species richness was log-transformed to improve normality; height did not require transformation. Abundances of other species were not analyzed because of few observations and limited distributions.

Soils: Soils from vegetation monitoring plots were analyzed for percent organic matter, and field moist bulk density. Cores were taken with a Swensen corer, refrigerated, and analyzed by personnel at the Louisiana State University (LSU) Agronomy Department where samples are first air dried and then oven dried at approximately 100º C for 24-48 hours. Preconstruction soil samples were collected in July 1996. Means and standard deviation for percent organic matter and field bulk

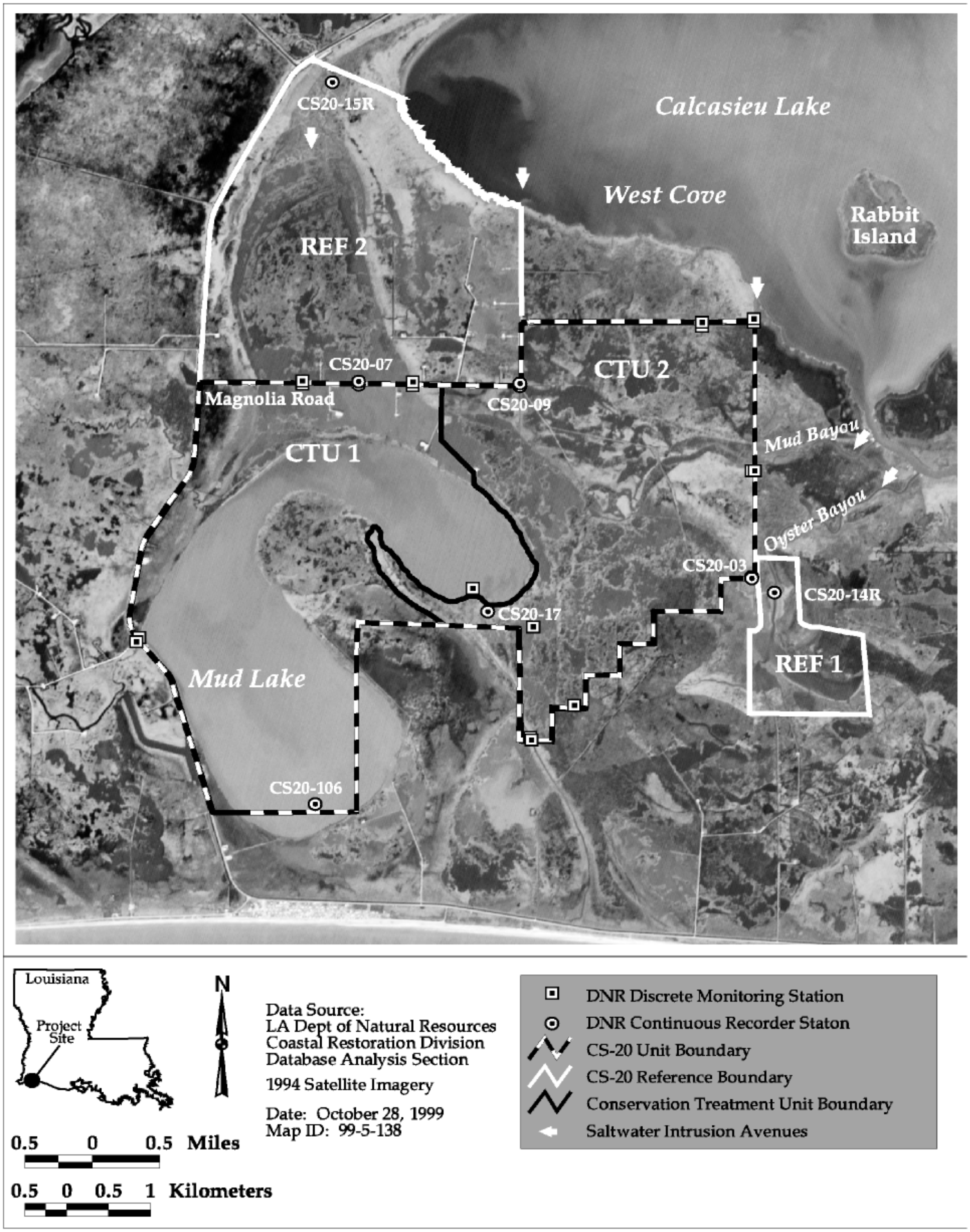


Figure 3. East Mud Lake (CS-20) project map depicting discrete monitoring stations, continuous recorder stations, and saltwater intrusion avenues.

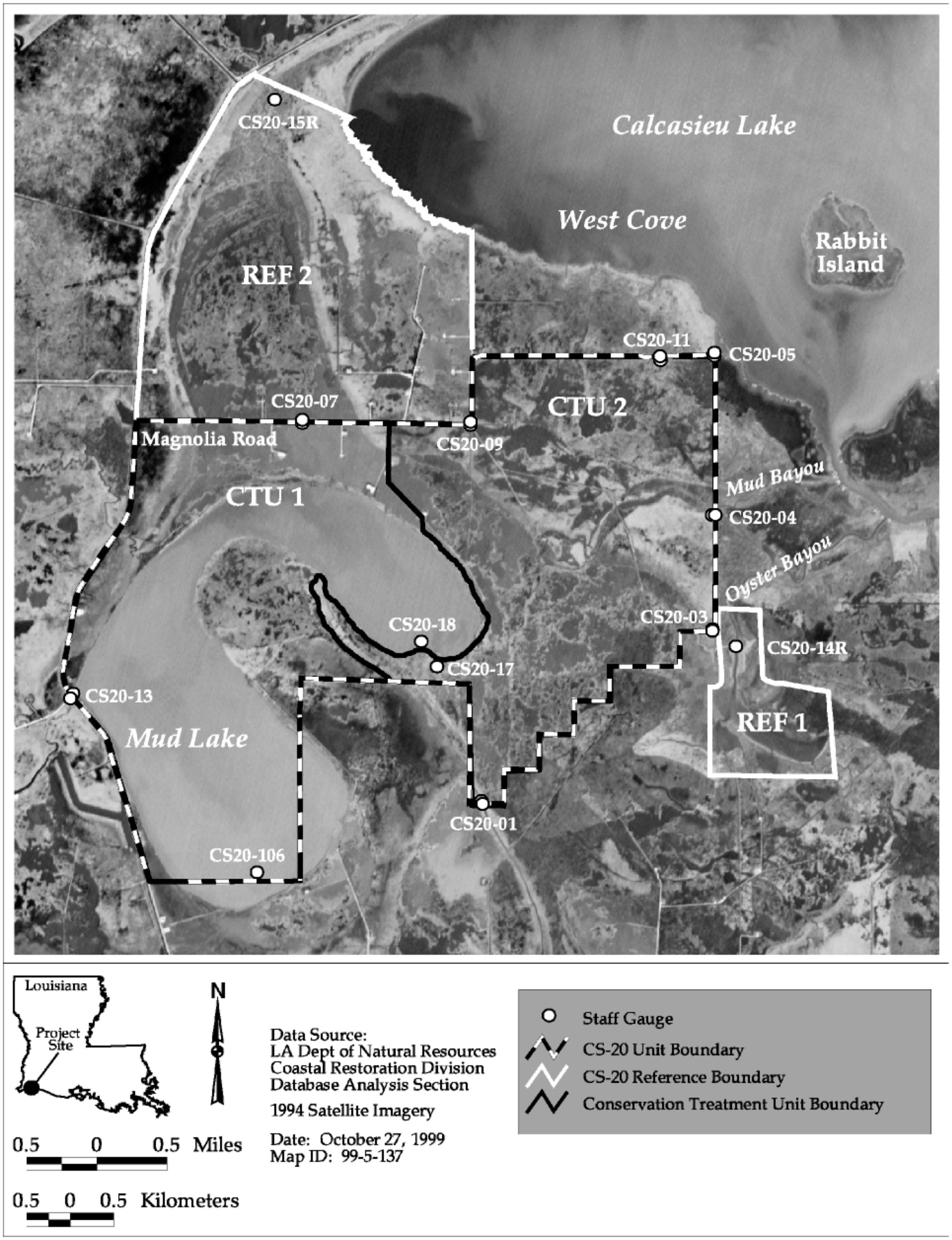


Figure 4. East Mud Lake (CS-20) project map depicting locations of staff gauges.

density in the project and reference areas were calculated. Field moist bulk density was calculated as:

$$\frac{(\text{weight of oven dry sample - weight of empty tube})}{\text{volume of field moist sample}}$$

Water quality: Water quality data were collected using seven (7) YSI 6000 continuous recorders at five stations inside the project area and 2 stations in the reference areas (figure 3). Stations 14r, 15r and 17 were installed in February 1995. Stations 3, 7, and 9 were installed in June 1996. Station 106 was installed in April 1997. Water level (ft NAVD), salinity (ppt), temperature (C), and specific conductance (μS) were recorded hourly at these stations. All continuous recorder data were shifted when necessary due to biofouling when error at time of retrieval exceeded 5%. Percent error due to biofouling was calculated at the time of retrieval by comparing dirty and clean discrete readings to those taken with a calibrated instrument. Missing data are usually due to instrument malfunction.

Discrete monthly samples were taken at 27 stations, 15 located inside the project area, and 12 in the reference areas (figure 3). Monthly staff gauge readings were taken at 11 stations located inside the project area, and 10 in the reference areas (figure 4). Some data are missing due to inaccessibility. Water level data presented were collected from June 1996 to December 1998 and were used to document frequency and duration of inundation inside and outside CTU 2 for 1996, 1997 and 1998. The distribution of flooding and drainage events was compared between the inside and outside of CTU 2 with the Kolmogorov-Smirnov critical value (Conover 1980). Because no data was collected at station 9 from September 25, 1996 through April 23, 1997, data from that time period at station15R was not included in the comparison.

Monthly means of continuous water salinity data collected from June 1996 to December 1998 were calculated. Maximum and minimum salinities in the project and reference areas were compared to determine if the areas differed in variability of water salinity during non-drawdown periods. Data were not included in this comparison if more than 50% of the monthly observations were missing. The percent of hourly salinity measurements greater than or equal to15 ppt at each station during each year of operation was calculated to determine if the project was effective at maintaining salinities less than or equal to15 ppt.

Discrete salinity data collected from October 1994 to December 1998 were used to determine whether the project was effective at lowering mean salinity. Postconstruction mean salinity using monthly bottom measurements was compared inside and outside of both CTU 1 and CTU 2 with t-tests (SAS Institute, 1996). For CTU 1, the comparison was made between treatments (inside and outside of the project) with data collected at stations 6, 6r, 7, 7r, 8, 8r, 13, and 13r. Stations numbers followed by "r" are located outside of the project structures. For CTU 2, mean salinity was compared between treatments during two different structure operations (open or closed) with data collected at stations 1, 1r, 3, 3r, 4, 4r, 5, 5r, 9, 9r, 11, and 11r to evaluate structure effectiveness.

Vertical accretion: Feldspar platforms were constructed August 1995 at 20 stations in CTU 2 in the project area and 19 stations in reference area 2 along the same transect lines as the vegetation stations to detect changes in vertical accretion (figure 2). In July 1996, two feldspar marker horizon plots were established at 14 stations in CTU 2 and 16 stations in reference area 2. Sites that were inaccessible in July were established in December 1996, 6 stations in CTU 2 and 3 stations in reference area 2. New feldspar plots were laid in December 1997 and the original plots were abandoned. Postconstruction data was collected December 1996, July 1997, December 1997, and June 1998. All sites were not visited during all sampling periods due to inaccessibility.

Feldspar was placed in 0.5 x 0.5 m plots marked with 2 PVC poles at opposite corners to enable location of the feldspar over time, and cores from randomly selected locations within each plot were taken with a cryogenic corer (Knauss and Cahoon 1990). Vertical accretion (sediment depth above the feldspar) was measured to the nearest millimeter with a vernier caliper at 1-7 locations within each core. A maximum of 3 cores per plot were taken at each sampling period, however, feldspar was not always clearly visible on any of the three cores. After the measurement was taken, the core material was returned to the sample hole to prevent sediment trapping.

Cumulative accretion was calculated over the 23-mo post-construction sampling period only at stations where plots were laid July 1996. Mean cumulative accretion was compared between project and reference areas with a t-test (SAS Institute, 1996) using only these 30 stations. Vertical accretion rates (cm/ 6-mo) were calculated for each plot for each sampling period and standardized to reflect 6-mo intervals. Mean vertical accretion rates were compared with analysis of variance (ANOVA), which tested the main effects of treatment (project and reference), sampling period, and the interaction of treatment and sampling period (SAS Institute, 1996). A repeated measures design was not appropriate because of missing data. When effects were significant at the alpha = 0.05 level, post-ANOVA comparisons were made with least square means tests.

<u>Surface elevation</u>: Sediment erosion table stations (SETs) were established in August 1995 at 12 of the 40 feldspar stations to detect changes in marsh surface elevation due to subsidence and accretion/erosion combined (figure 2). Six SET stations were located in the project area and 6 in reference area 2. Stations in the Bancker soils include stations 27, 29, and 29A in the reference area, and stations 5, 7, and 8 in the project area. Stations located on Creole soil types include stations 31, 31A, and 35A in the reference area, and stations 15, 18, and 22 in CTU 2 of the project area. Stations 15 and 31A are in close associations with a ridge of the Mermentau soil type. Nine pin measurements were taken in four directions at each of the stations. Detailed procedures for the SET are documented in Steyer et al. (1995). Marsh surface elevation was measured pre-construction in December 1995, and postconstruction in July 1996, December 1996, July 1997, December 1997, and June 1998. Due to low water levels, only 10 of the 12 SET station sites were accessible for the first two measurements.

Cumulative marsh surface elevation change (cm) was calculated over the 23-mo post-construction period only at stations sampled in July 1996 due to missing data. Mean cumulative change was compared between treatments (project and reference) with a t-test (SAS Institute, 1996).

Mean rates of marsh surface elevation change were calculated for each station at each sampling period, standardized to reflect 6-mo intervals, and compared separately pre- and post-construction with ANOVA (SAS Institute, 1996). Mean rates were compared between treatments (project and reference) for pre-construction data. For post-construction data, the main effects of treatment and sampling period and the interaction of treatment and sampling period were tested. Because of missing data, a repeated measures design was not appropriate. When effects were significant at the alpha = 0.05 level, post-ANOVA comparisons were made with least square means.

Fisheries: Fisheries monitoring was conducted to estimate abundance and species composition in the project and reference areas to determine whether the project affected fish abundance. Thirty samples each were collected from CTU 2 in the project area and reference area 2, concurrently, during each sampling period with a 1-m^2 throw trap with 1-m high walls constructed of 1.6 mm mesh nylon netting (Kushlan 1981). A 0.25 in (0.64-cm) diameter steel bar, bent into a square, was attached to the bottom of the net to make it sink rapidly in the water. A floating collar of plastic pipe 0.75 in (1.91-cm) diameter was attached to the top of the net to keep the throw trap vertical in the water column after deployment. Additional samples were collected randomly using a 20-ft (6.1 m) minnow seine with 3/16 in (0.48 cm) mesh to compensate for the potential deficiency of the throw traps for determining species composition. A minimum of three seine pulls were conducted in the project area and both reference areas at each sampling event to determine whether throw traps adequately depict species composition. Mean density, relative abundance, and total biomass (dry weight in grams) of each species were recorded. A water sample was collected at each site and measurements taken for water temperature (C), salinity (ppt), dissolved oxygen (mg/l), water depth (cm) and distance to the marsh edge (m). At each site, presence or absence of SAV was noted. Sampling locations were randomly chosen from a grid pattern for each sampling trip. Personnel from LDNR/CRD conducted sampling in June 1995, October 1995, April 1996 (during drawdown), October 1996, and March 1997. National Marine Fisheries Service (NMFS) personnel and the LDNR/CRD monitoring manager conducted sampling in April 1997 (during drawdown) and September 1997. NMFS analyzed data from June and October 1995 and April 1996 and determined that throw trap sampling depicted species composition of the area at least as well as seine sampling, and seines were discontinued prior to further sampling.

Density and biomass means and standard errors for each fish and crustacean species were calculated for the project and reference area for each sampling period. Means and standard errors for all environmental variables collected were calculated for the project and reference area per sampling period. Although construction was not completed until after the April 1996 sampling time, access to the project area was disturbed by the ongoing construction and April 1996 was thus considered postconstruction. Two factor ANOVA's with interaction were used to compare mean animal densities and environmental variables between the project and reference areas for preconstruction sampling times to estimate the suitability of the reference area (Appendix A). The specific environmental variables tested were salinity, temperature, dissolved oxygen, depth, and distance to edge and the animal variables were total fishes, total crustaceans, transient fishes, transient crustaceans, resident fishes, and resident crustaceans. Resident species spend most of their life cycle within the estuary, whereas transient species spawn in nearshore or offshore waters and use shallow estuarine habitats as nursery areas. The same set of environmental and animal variables were then compared between preconstruction and postconstruction sampling times with a one-way ANOVA for each area separately (Appendix A). Prior to statistical analyses, Hartley's F-max test was used to determine if variances in the treatment cells were equal (Milliken and Johnson 1992). We performed a ln(x+1) transformation on the density, species richness, and biomass data, because cell means were positively related to standard deviations. In cases where cell means were positively related to variances (i.e., salinity, water temperature, dissolved oxygen concentration, water depth, distance to edge), we used a square root transformation prior to analyses. These transformations generally reduced the relationships between means and standard deviations or variances. However, F-max tests still indicated heterogeneity for some variables. Despite this failure to meet the assumption of homogeneity of variances in all cases, we decided to proceed with ANOVA's on transformed data because the test is considered robust, and failure to correct heterogeneity does not preclude its use (Green 1979, Underwood 1981). An alpha level of 0.05 was used to determine statistical significance for all ANOVA tests.

RESULTS

Structure operations: Operational changes were carried out by FINA personnel according to permit specifications (table 1). The project permit allows a drawdown twice in the first 5 years following end of construction. Unfortunately, low water occurred during the most severe drought in 20 years (LOSC 1996). Low water conditions occurred in spring 1996, optimizing conditions for drawdown. The parish experienced mild to moderate drought conditions from February through July 1996. Cumulative statewide precipitation totaled less than two-thirds of the normal level from January to May 1996, ranking as the fifth driest January to May total in the last century (LOSC 1996). Gulf low water levels resulting from lack of southerly winds were as influential upon low water levels in the marsh at this time as lack of rainfall. Upon completion of construction, the first Phase I drawdown was initiated on May 5, 1996. The drawdown was terminated July 17, 1996, as stop logs were set in place and flaps were opened. However, water levels did not return to normal until October 1996 due to extended low water levels outside the project area.

A second drawdown was initiated March 3, 1997, when weather conditions favorable to lower water levels predominated. During this time, the parish experienced mild drought conditions from May through August. The second drawdown was terminated July 15, 1997. Structure 4 experienced repeated vandalism throughout the summer as attempts were made to keep flapgates open. The vandalism included removal of stoplogs in July, an excavation of a 2 ft trench in the levee adjacent to the structure, and permanent removal of a flapgate from one of the five bays in October 1997.

During1998, flapgates remained open from January 14 to May 13, but high salinities forced the closure of flapgates at structures 1, 3, 4, 5, and 11 in CTU 2. At this time, FINA personnel attempted to close the open bay at structure 4 with a plywood board to prevent high salinities from entering the project area.

Habitat mapping: The GIS land-water analysis of aerial photography revealed the proportion of land to water in the project area, including CTU 1 and 2, Reference Area 1, and Reference Area 2 (figure 5). Analysis of preconstruction photography obtained in 1994 documented a land area of 3,020.6 acres (1,222.42 hectares) inside the project area. The project area land to water ratios was 41.9% land to 58.1% water (figure 5). These values reflect an error of 4%.

Habitats in the project and reference areas represent two NWI habitat systems: the estuarine system and the palustrine system (table 2). Classification of photography to the NWI class level yielded 11 distinct habitat classes in the project and reference areas, for the purpose of mapping change. The habitat classes included 3 upland , 1 urban, 1 wetland scrub-shrub, 1 mud flat, 2 marsh, 1 submerged aquatic, and 2 open water.

Vegetative Plantings: Overall survivorship was 100% at1 mo, then decreased to 96% at 6 mo with mortality increasing from 0.0 to 0.04 at this time (table 3). At 12 mo, survivorship was only 62% due to a mortality rate of 0.35 between 6 and 12 mos. There were no differences in survivorship and mortality among land types during the 1-mo and 6-mo periods, but survivorship (χ^2_{df2}= 17.15, P

Table 1. Operational changes for each of the structures at East Mud Lake (CS-20).

Structure number	Date and Operation Performed				
	5/2/96 (Phase I)	6/11/96	6/18/96	7/18/96(Phase II)	7/26/96
17	stoplogs 12" AML			stoplogs removed	
1	stoplogs removed			stoplogs 6" BML flapgates locked open	
3	stoplogs removed flapgates operating			stoplogs 6" BML flapgates locked open	
4	stoplogs removed flapgates operating			stoplogs 6" BML flapgates locked open	
5	stoplogs removed flapgates operating			stoplogs1 bay 6" BML, 1 bay 12" BML flapgates locked open	
9a	stoplogs removed flapgates operating			stoplogs 6" BML flapgates locked open	
11	stoplogs removed flapgates operating	flapgates locked open 24 hrs (planting access)	flapgates locked open 24 hrs (planting access)	stoplogs removed flapgates operating	stoplogs 6" BML flapgates locked open
13	stoplogs 6" BML flapgates locked open			stoplogs 6" BML flapgates operating	
6	stoplogs 6" BML			stoplogs 6" BML	
7	stoplogs 6" BML			stoplogs 6" AML	stoplogs1 bay 6" BML, 1 bay 12" BML
8	stoplogs 6" BML			stoplogs 6" BML	
9b	flapgates operating screwgate open			flapgates locked open screwgate open	

Table 1, continued. Operational changes for each of the structures at East Mud Lake.

Structure number	Date and Operation Performed				
	8/3/96	3/12/97 (Phase I)	6/10/97	7/15/97 (Phase II)	8/26/97*
17		stoplogs 12" AML		stoplogs removed	
1		stoplogs removed		stoplogs 6" BML	
3	flapgates operating 24 hrs‡	stoplogs stuck 6" BML flapgates operating		stoplogs 6" BML flapgates locked open	stoplogs 6" BML flapgates operating
4			12 stoplogs removed 48 hrs‡	stoplogs 6" BML boards bolted ‡ flapgates locked open	
5		stoplogs removed flapgates operating		stoplogs1 bay 6" BML, 1 bay 12" BML flapgates locked open	stoplogs1 bay 6" BML, 1 bay 12" BML flapgates operating
9a		stoplogs removed flapgates operating		stoplogs 6" BML flapgates locked open	stoplogs 6" BML flapgates locked open
11		stoplogs removed flapgates operating		stoplogs 6" BML flapgates locked open	stoplogs 6" BML flapgates operating
13		stoplogs 6" BML flapgates locked open		stoplogs 6" BML flapgates operating	
6		stoplogs 6" BML		stoplogs 6" BML	
7		stoplogs 6" BML		stoplogs1 bay 6" BML, 1 bay 12" BML	
8		stoplogs 6" BML		stoplogs 6" BML	
9b		flapgates operating screwgate open		flapgates operating screwgate open	

Table 1, continued. Operational changes for each of the structures at East Mud Lake.

Structure number	Date and Operation Performed				
	9/5/97	10/12/97	10/20/97	1/14/98	5/13/98*
17					
1					stoplogs 6" BML flapgates operating
3	flapgates operating 24 hrs‡			stoplogs 6" BML flapgates locked open	stoplogs 6" BML flapgates operating
4		2' hole dug in levee adjacent to structure‡	1 flapgate permanently removed from culvert ‡		stoplogs 6" BML flapgates operating plywood in open bay
5				stoplogs1 bay 6" BML, 1 bay 12" BML flapgates locked open	stoplogs 6" BML flapgates operating
9a				stoplogs 6" BML flapgates locked open	
11					stoplogs 6" BML flapgates operating
13				stoplogs 6" BML flapgates locked open	
6	stoplogs 6" AML**				
7					
8	stoplogs 6" AML**				
9b					

Table 1, continued. Operational changes for each of the structures at East Mud Lake.

Structure number	Date and Operation Performed				
	6/15/98*	9/2/98**	9/23/98***	9/30/98	10/5/98
17					
1					
3					
4					2 flaps open ‡
5					
9a	stoplogs 6" BML flapgates operating				
11					
13					
6		close slots			
7		close slots	remove stoplogs to exit high water	stoplogs1 bay 6" BML, 1 bay 12" BML	
8		close slots			
9b					

* Salinities exceeded 15 ppt in CTU 2.
** Salinities exceeded 15 ppt in CTU 1
*** Response to high water levels from Tropical Storm Charley
‡ Vandalism
AML=above march level, BML=below marsh level

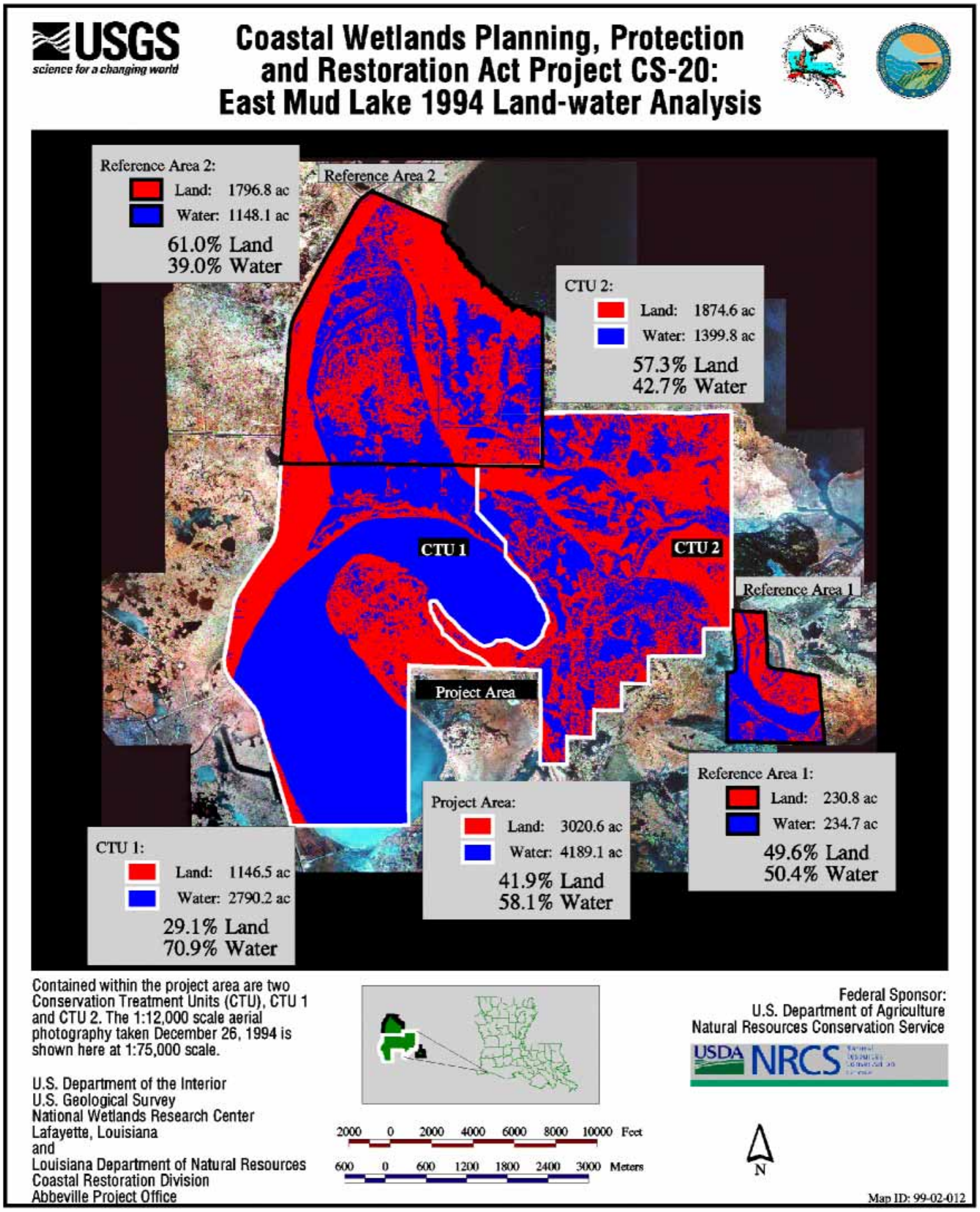


Figure 5. Land to water ratios in the East Mud Lake (CS-20) project and reference areas.

Table 2. Acreage (hectares) of habitat types derived from photointerpretation of the 1994 aerial photography in the East Mud Lake (CS-20) project and reference areas.

Habitat Class	Project Area		Reference Areas	
	CTU 1	CTU 2	1	2
Open Water - Fresh	0.10 (0.04)	0.00 (0.00)	0.00 (0.00)	0.20 (0.08)
Open Water - Salt	2,786.2 (1,114.5)	1,398.30 (559.32)	201.60 (80.64)	1,146.90 (458.76)
Submerged Aquatics - Salt	0.80 (0.32)	0.10 (0.04)	0.00 (0.00)	4.30 (1.72)
Fresh Marsh	0.10 (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Salt Marsh	1,007.7 (403.08)	1,819.80 (727.92)	256.30 (102.52)	1,710.80 (684.32)
Mud Flats - Salt	2.10 (0.84)	1.70 (0.68)	0.20 (0.08)	0.60 (0.24)
Wetland Scrub-Shrub - Salt	115.60 (46.24)	21.30 (8.52)	2.50 (1.00)	24.10 (9.64)
Upland Scrub-Shrub	6.30 (2.52)	15.00 (6.00)	4.00 (1.60)	17.10 (6.84)
Upland Forested	0.70 (0.28)	0.00 (0.00)	0.40 (0.16)	0.10 (0.04)
Agricultural/Range	2.40 (0.96)	11.40 (4.56)	0.00 (0.00)	0.90 (0.36)
Urban	12.60 (5.04)	5.30 (2.12)	0.00 (0.00)	4.00 (1.60)
TOTAL	3,934.60 (1,573.84)	3,272.90 (1,309.16)	464.90 (185.96)	2,909.00 (1,163.60)

= 0.0002) and mortality (χ^2_{df2} =18.33, P = 0.0001) differed among the land types at 12 mo. Percent survival remained above 90% in the canal plantings, but declined to 45.6% in the step levee and to 15% in the lake at 1-yr postplanting (figure 6).

Percent cover differed among the land types at 1-mo (χ^2_{df2} = 6.09, P = 0.047), at 6-mo (χ^2_{df2} =7.47, P= 0.02), and at 1-yr (χ^2_{df2} =16.83, P= 0.0002). Cover continually increased over time in the canal (figure 7) and the step levee but not in the lakeshore plantings (table 4). Native species colonizing the step levee and shoreline included *Distichlis spicata* (saltgrass), *S. patens*, *Heliotropium currassivicum* (seaside heliotrope), *Lycium carolinianum* (salt matrimony-vine) and *Salicornia bigelovii* (glasswort).

<u>Existing vegetation</u>: Total cover did not differ significantly between CTU 2 in the project area and reference area 2. Total cover did not differ in reference 2 between 1995 and 1997, nor was there a difference in total coverage or coverage of *S. patens* between high Creole and Mermentau soil and lower Bancker soils. Significant differences were detected in total cover (χ^2_{df1} =7.81, P = 0.0005) and coverage of *S. patens* (χ^2_{df1} =18.30, P = 0.0001) within CTU 2 in the project area between 1995 and 1997. Within the low soil type in the project area, significant differences were found in both total cover (χ^2_{df1} = 4.50, P = 0.034) and cover of *S. patens* (χ^2_{df1} =11.63, P = 0.0006) between 1995 and 1997. Cover of *S. patens* on the high ground in the project area was significantly different between 1995 and 1997 (χ^2_{df1} = 6.75, P= 0.009).

Total cover decreased in the project area from 88.52% in 1995 to 64.5% in 1997, but remained stable in the reference area with 86.6% in 1995 and 86.9% in 1997 (table 5). A shift in species was noted in both the project and reference areas (table 6). Cover of *S. patens* decreased in the project area from 84% in 1995 to 31.4% in 1997, while cover of *S. alterniflora*, *Amaranthus australis* (southern amaranth), and *Distichlis spicata* (saltgrass) increased from 1.4%, 0%, and 0.2% in 1995 to 5.4%,14.5%, and 6.3%, respectively in 1997 (figure 8). In the reference area, cover of *S. patens* decreased from 86.6% to 71.0% over time, while *A. australis* and *D. spicata* increased from 0% to 4.2% and 0% to 12.4%, respectively, from 1995 to 1997.

Mean species richness increased in both the project and reference areas with 1.56 and 1.0 species per station, respectively, in 1995 and 2.21 and 1.6 species per station in 1997 (table 5). Richness was higher in the project area at both sampling periods.

Plant height inside the vegetation sample plots was not significantly different between the project and reference areas in July 1995 ($F_{1,33}$ =2.82, P = 0.1028). Analysis of 1995 and 1997 data combined indicated no interaction between plant height among the areas over time ($F_{1,32}$ =1.39, P = 0.2476). Mean height decreased slightly in the project area, from 4.37 ft (1.33 m) in 1995 to 4.11 ft (1.25 m) in 1997 while in the reference area, mean height decreased from 4.89 ft (1.91 m) in 1995 to 3.83 ft (1.17 m) in 1997 (table 5).

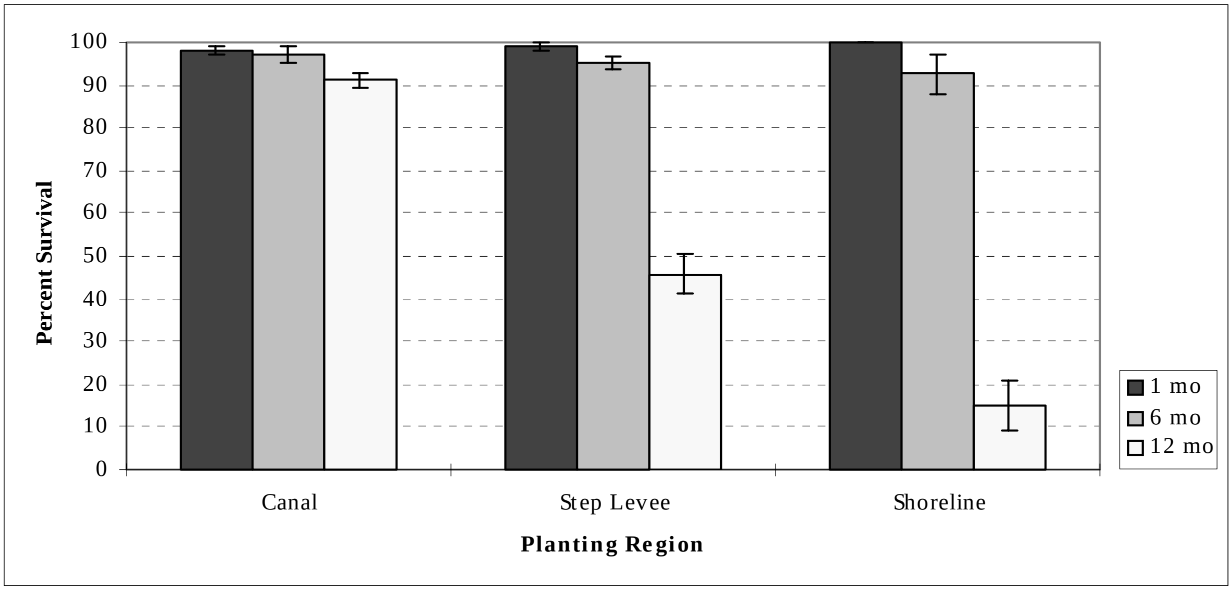


Figure 6. Average percent survival of *Spartina alterniflora* plantings in the East Mud Lake (CS-20) project area from data collected 1-mo, 6-mo, and 12-mo postplanting.

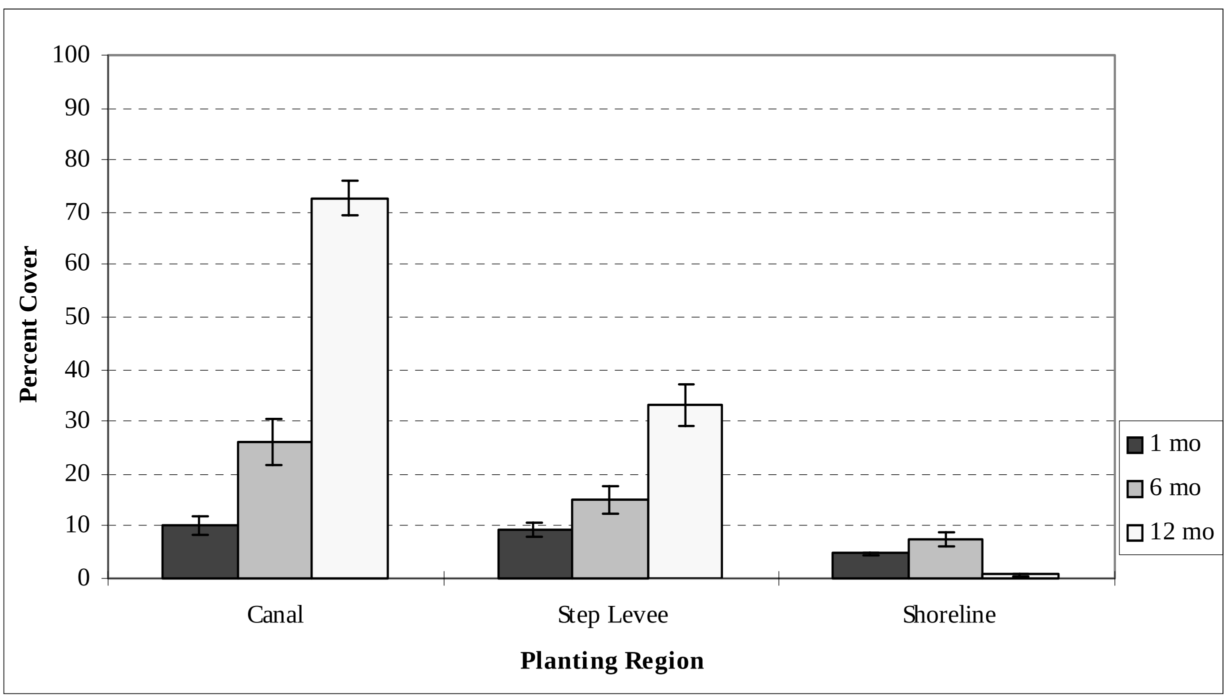


Figure 7. Average percent cover of *Spartina alterniflora* plantings in the East Mud Lake (CS-20) project area from data collected 1-mo, 6-mo, and 12-mo postplanting.

Table 3. Partial life table of *Spartina alterniflora* plantings in the East Mud Lake (CS-20) project area, based on means of data collected from forty 10-plant sampling plots, from July 1996 to December 1996, at 1-mo, 6-mo, and 1-yr postplanting.

Age (mo)	**Survival Frequency (n)**	**Survivorship (l_x)**	**Mortality (d_x)**	**Mortality Rate (q_x)**
0	10	1.0	0.0	0.0
1	10	1.0	0.04	0.04
6	9.6	0.96	0.34	0.35
12	6.2	0.62		

n=mean number of live plants per plot

Table 4. Percent cover (standard deviation) of *Spartina alterniflora* plantings in the East Mud Lake (CS-20) project area at 1-mo, 6-mo, and 1-yr postplanting.

	Percent Cover		
	1 month	6 months	1 year
canal	10.2 (7.23)	26.1 (18.0)	72.8 (28.6)
step levee	9.2 (6.2)	15.2 (11.8)	33.2 (34.9)
lakeshore	4.7 (0.5)	7.6 (2.9)	0.8 (1.4)

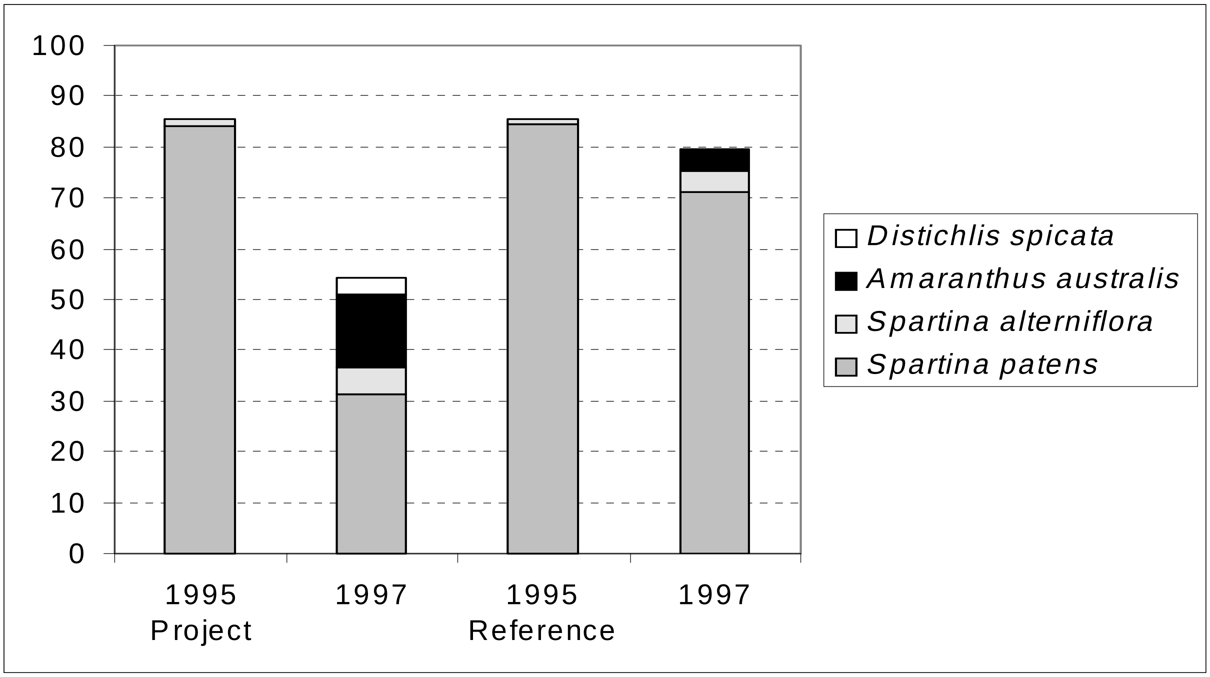


Figure 8. Mean percent cover of dominant emergent vegetation species at East Mud Lake (CS-20) project and reference areas from data collected at 25 stations preconstruction (July 1995) and postconstruction (July 1997).

Table 5. Height, species richness, and percent total cover of emergent vegetation (SE) in the East Mud Lake (CS-20) project and reference area from data collected at 25 monitoring stations preconstruction (June 1995) and postconstruction (June 1997).

	Project Area		Reference Area	
	1995	1997	1995	1997
Height (cm)	43.72 (1.62)	41.08 (3.62)	48.9 (2.72)	38.3 (1.98)
Richness	1.56 (0.15)	2.21 (0.18)	1.0 (0.0)	1.6 (0.22)
% Total cover	88.52 (3.43)	64.5 (6.85)	86.6 (4.95)	86.9 (6.07)

Table 6. Mean percent cover and standard error (SE) of emergent vegetative species in the East Mud Lake (CS-20) project and reference area from data collected at 25 monitoring stations preconstruction (June 1995) and postconstruction (June 1997).

	Project Area				Reference Area			
	1995		1997		1995		1997	
Species	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Amaranthus australis (Gray) Sauer			14.47	(4.20)			4.20	(3.98)
Aster spp.	0.02	(0.02)	2.92	(2.35)				
Atriplex pentandra (Jacq.) Standl.			1.25	(1.25)				
Cyperus odoratus L.			4.40	(2.20)			4.00	(4.00)
Distichlis spicata (L.) Greene	0.20	(0.20)	6.25	(4.17)			12.40	(9.83)
Erechtities hieracifolia (L.) Raf. *ex.*DC.			0.01	(0.01)				
Ipomoea sagittata Poir.			1.25	(1.25)				
Iva frutescens L.	0.04	(0.03)						
Paspalum vaginatum Swartz.	0.02	(0.02)	0.42	(0.42)				
Ruppia maritima L.			0.02	(0.02)				
Scirpus americanus Pers.	2.02	(2.00)	2.29	(2.29)				
Scirpus robustus Pursh	1.00	(0.71)	3.13	(2.01)				
Spartina alterniflora Loisel.	1.40	(0.98)	5.38	(4.26)				
Spartina cynosurioides (L.) Roth	1.40	(0.98)	0.17	(0.17)				
Spartina patens (Ait.) Muhl.	84.00	(4.40)	31.35	(7.99)	84.60	(4.98)	71.00	(10.42)
Spartina spartinae (Trin.) Hitchc.	3.00	(3.00)						
Solanum douglasii Dunal			0.21	(0.21)				

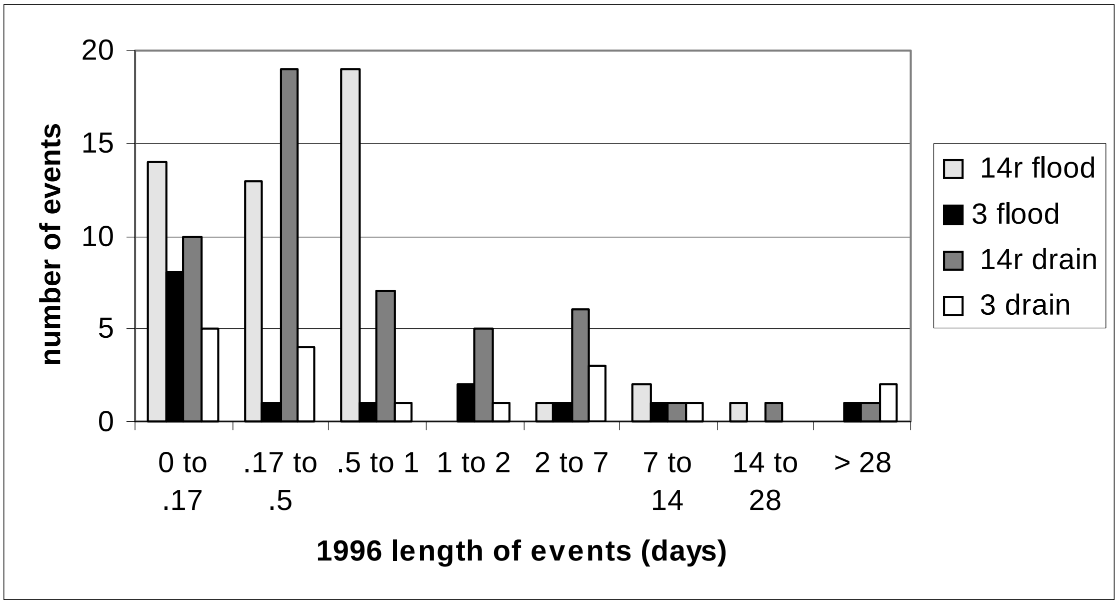
Soils: Preconstruction, mean bulk density was 0.43 gm/cm^3 in the reference area and 0.40 gm/cm^3 in the project area. Mean organic matter was 42.7% was in the reference area and 39.7% in the project area.

Water Level: Mean marsh elevation was surveyed in February 1996 at 3 stations in CTU 2 (3, 9, and 17), station 14r in reference 1 and station 15r in reference 2. Mean marsh elevation was 1.51 ft (0.46 m) National Geodetic Vertical Datum (NGVD) at station 3 and 1.25 ft (0.38 m) NGVD at station 9 in CTU 2, 1.28 ft (0.39 m) NGVD at station 14r in reference area 1, and 1.3 ft (0.40 m) NGVD at station 15r in reference area 2. Water level in CTU 2 was at or below mean marsh elevation for 65.1 % of the time from June 10 to December 31, 1996, 91.8 % from January 1 to December 31, 1997, and 73.8% from January 1 to December 31, 1998 at station 3, for 61.2 % of 1996 , 65.0 % of 1997, and 36% at station 17 during the same time period. Water level in reference area 1 (station 14r) was at or below mean marsh elevation for 72.7% of 1996, 77.6 % of 1997, and 57.1% of 1998. Water level in reference area 2 (station15r) was at or below mean marsh elevation for 82.8 % of 1996, 72.4 % of 1997, and 51.4% of 1998.

The drought that began in February 1996 was recorded as a 15.5 week drainage event at the end of construction, from June 10 to September 27, at stations 3 and 9 in the project area (figure 9). This time period included a drawdown, from May 2 to July 18, 1996. A brief rain in late August raised water levels above the marsh for 2 days only. In reference area 1, water levels were below marsh level for 13.4 weeks. At station 15r, water levels rose above marsh level from July 17 to August 8, and from August 20-29, breaking the durations of water below marsh level into periods of 6.3 weeks, 1.5 weeks, and 3.7 weeks, respectively. A prolonged flooding event occurred October 3 to November 27, 1996 as water overtopped Magnolia Road and the northern levee of CTU 2. Station 3 experienced flooding conditions for 7 weeks with an average depth of 0.47 m (1.54 ft) above marsh level (AML). Station 14r experienced flooding in shorter durations during this time period with drainage between floods, for 2.3 weeks from October 3-18 with average depth 0.67 m (2.20 ft) AML, and for 1.3 weeks from November 6-25 with average depth of 0.48 m (1.57 ft) AML.

In 1997 in the project area, stations 3 and 9 experienced continuous drainage events of 7.5 and 8.6 months, respectively, from May 3 to December 31. This time period included a drawdown from March to July 15. The water was above marsh level briefly in late April. There were no prolonged drainage or flooding events in either of the reference areas in 1997 (figure 10).

In 1998, station 9 experienced a drainage event of 7.5 months, from January 24 to September 10 (figure 11). During this drainage event, station 3 experienced breaks when water levels rose above the marsh for one week in April and one week in early May. Both reference areas (stations 14r and 15r) experienced drainage events of 4.1 weeks from July 5 to August 3. On August 31, tropical storm Charley deposited 8 inches of rain and produced strong southerly winds and high tides. Water remained on the marsh for 8 weeks at station 9 with an average depth of 1.18 ft (0.36 m) over the marsh and 4.5 weeks with average depth of 1.32 ft (0.40 m) over the marsh. Reference areas 1 and 2 experienced high water for 5 and 6 weeks, respectively, with average depth over the marsh of 1.08 ft (0.33 m) and 1.17 ft (0.36 m), respectively.



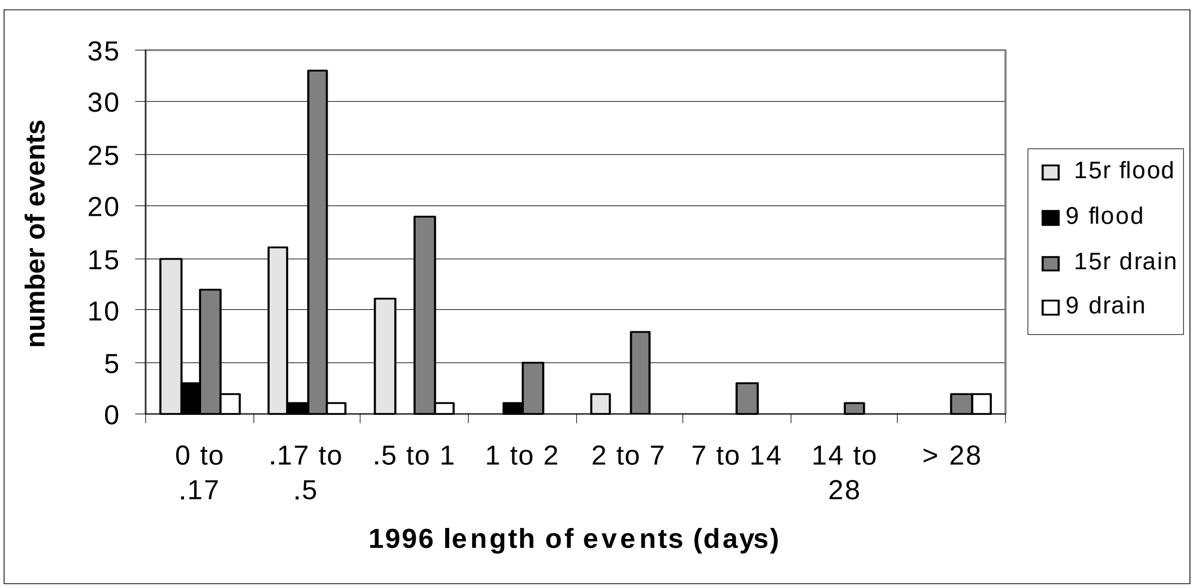
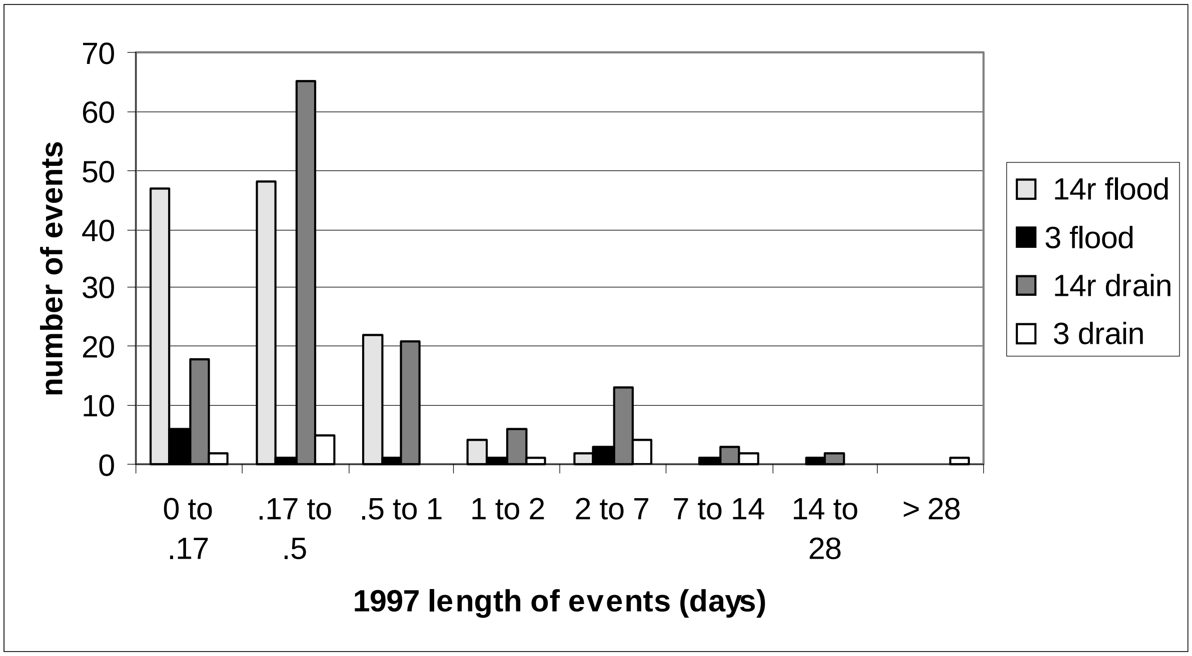


Figure 9. Frequency and duration of flooding and drainage events in 1996 in the southern portion of CTU 2 (station 3) and reference 2 (station 14r) and the northern portion of CTU 2 (station 9) and reference 1 (station 15r).



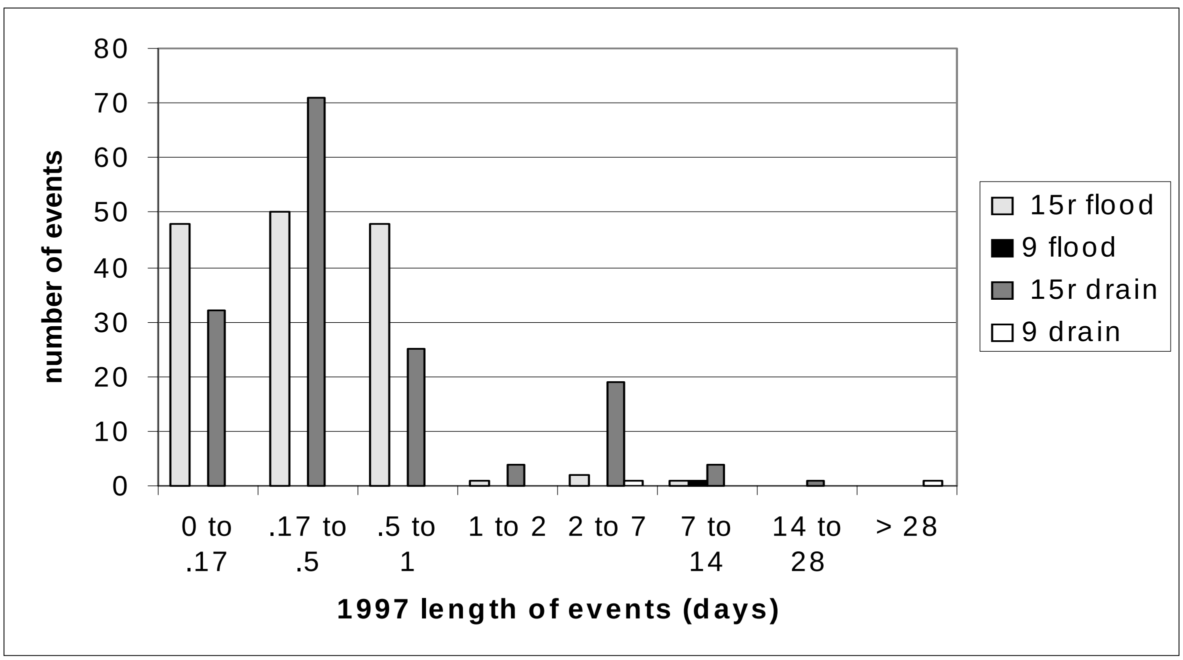
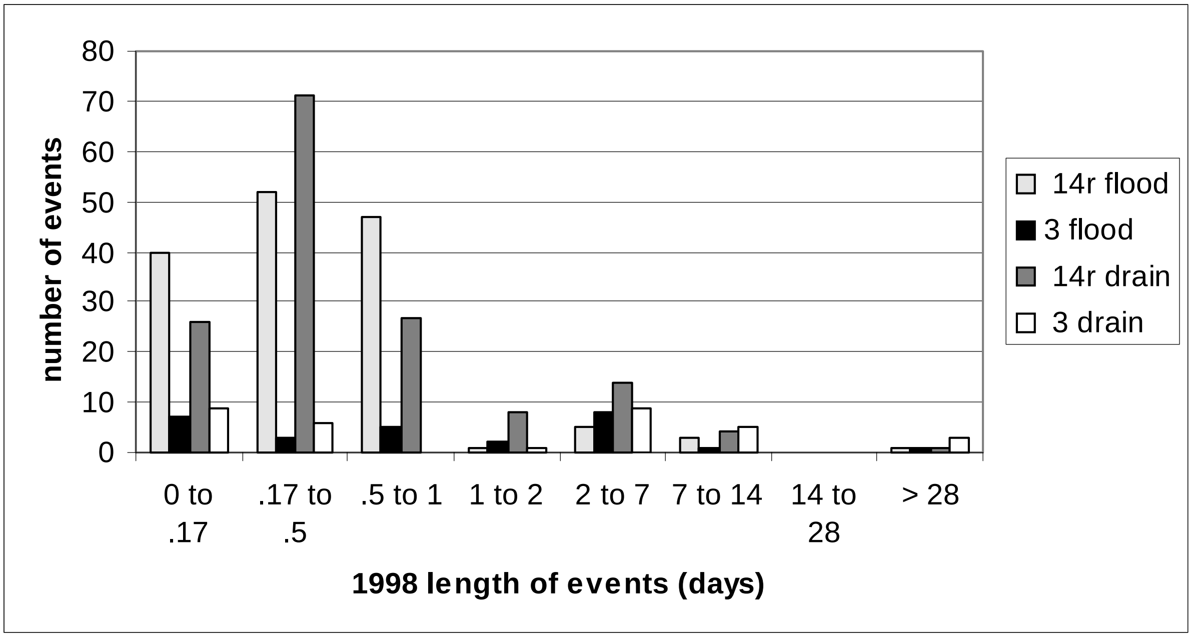


Figure 10. Frequency and duration of flooding and drainage events in 1997 in the southern portion of CTU 2 (station 3) and reference 2 (station 14r) and the northern portion of CTU 2 (station 9) and reference 1 (station 15r).



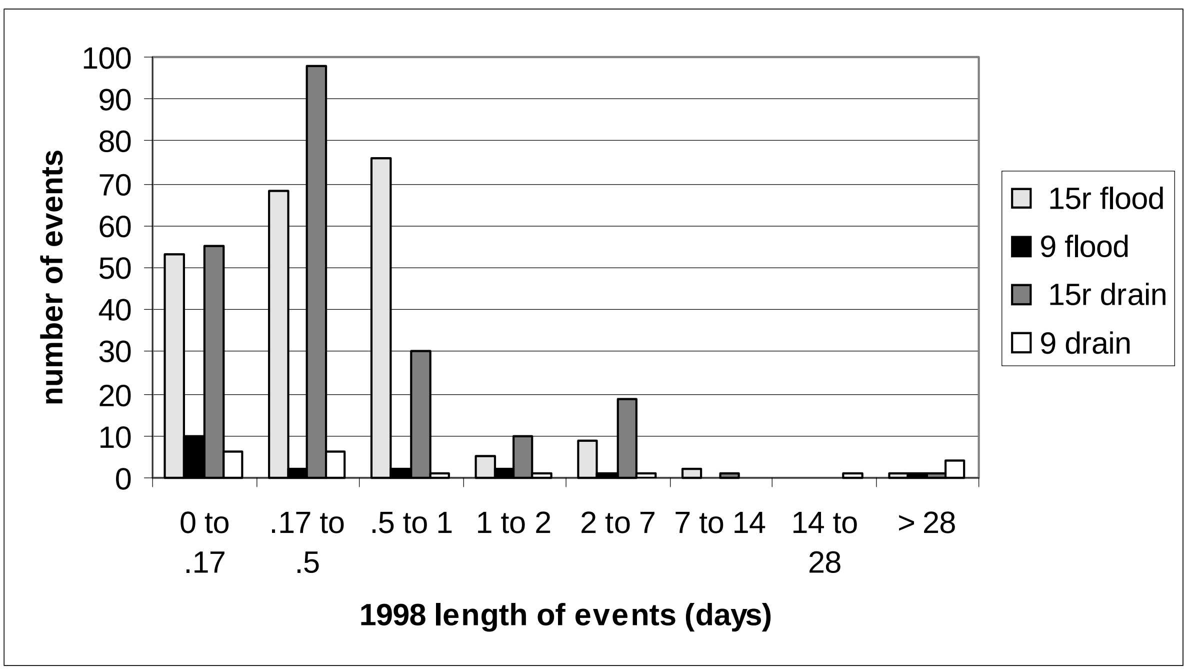


Figure 11. Frequency and duration of flooding and drainage events in 1998 in the southern portion of CTU 2 (station 3) and reference 2 (statio 14r) and the northern portion of CTU 2 Station 9) and reference 1 (station 15r).

Distribution of the duration of flooding events was significantly different between inside and outside CTU 2 at stations 3 and 14r for flooding (test statistic = 0.377) and drainage (test statistic = 0.389) in 1998, Kolmogorov-Smirnov critical value of 0.28 and 0.26, respectively. Significant differences were not found between any of the stations in 1996 or 1997, or between stations 9 and 15r in 1998. Daily tidal influences apparently accounted for 94.7% and 94.2% of the flooding events less than 24 hrs long in reference areas 1 and 2 (stations 15r and 14r), respectively, and for 81.8% and 63.0% of the flooding in CTU 2 at stations 9 and 3, respectively.

Salinity: Monthly discrete data showed mean salinity did not differ significantly ($t = 0.08$, $p = 0.94$) inside ($\bar{x} = 9.1$ ppt) and outside ($\bar{x} = 9.0$ ppt) of CTU1. Mean salinity in CTU 2 did not differ significantly between treatments ($t = 0.53$, $p = 0.60$) when the structures were open. When the structures were closed, however, mean salinity was significantly higher outside the project area ($t = -2.58$, $p = 0.01$) (figure 12).

Monthly mean salinity values for all continuous recorder stations were calculated (figure 13). Continuous water salinity data were analyzed to determine if the project and reference areas differed in variability of water salinity during non-drawdown periods using monthly minimum and maximum salinity at each station (figure 14). Both analyses indicate that the reference areas (stations 14r and 15r) experienced higher salinity values than CTU 2 (stations 3 and 9) due to tidal exchange from the Gulf of Mexico via the CSC. Salinity trends in the project area follow those in the reference areas to a lesser magnitude. Typically, all three areas experience highest salinities from August to October. Stations 106 and 17 experience the lowest salinity values because they are influenced by Mud Lake and receive fresh water from Second Bayou, and are farthest removed from the influence of a salt water avenue.

Continuous salinity data were used to calculate percent of hourly measurements at each station which were greater than or equal to 15 ppt, the salinity threshold used for managing the structures (table 7). In CTU 2 from June 1996 to May 1997, salinities exceeded 15 ppt 36.5%, 20.1% and 14.2 % at stations 3, 9, and 17, respectively, compared to 48.1% and 8.8% in reference areas 1 and 2. This time period encompassed severe drought and flood. From June 1997 to May 1998, salinities exceeded 15 ppt less than 20% at all stations in the project area. From June 1998 to December 1998, during an intense tropical storm season, salinities at stations 3 and 9 in CTU 2 exceeded 15 ppt 15.1% and 30.0%, respectively compared to 73.3% and 29.7% in reference areas 1 and 2.

Accretion: Feldspar markers were not recovered at all plots. Recovery success rates for individual plots were: 98.6 % at 6-mo, 97.2% at 12-mo, and 90.2% at 18-mo. Cumulative accretion for the 23-mo sampling period was significantly lower ($t = -4.42$, $p < .01$) in the project area (1.10 cm ± 0.23) than in the reference area (2.77 cm ± 0.30) (figure 15). Mean vertical accretion rate (cm/6-mo) was also significantly lower ($F = 8.17$, $p < 0.01$) in the project area (0.30 cm / 6 mo ± 0.09) than in the reference area (0.66 cm / 6 mo ± 0.09). Mean accretion rates differed significantly among sampling periods ($F = 8.98$, $p < 0.01$), with lowest accretion rates in both the project and reference areas from July 1997 to December 1997, and highest accretion rates occurring from December 1997 to June 1998 (table 8).

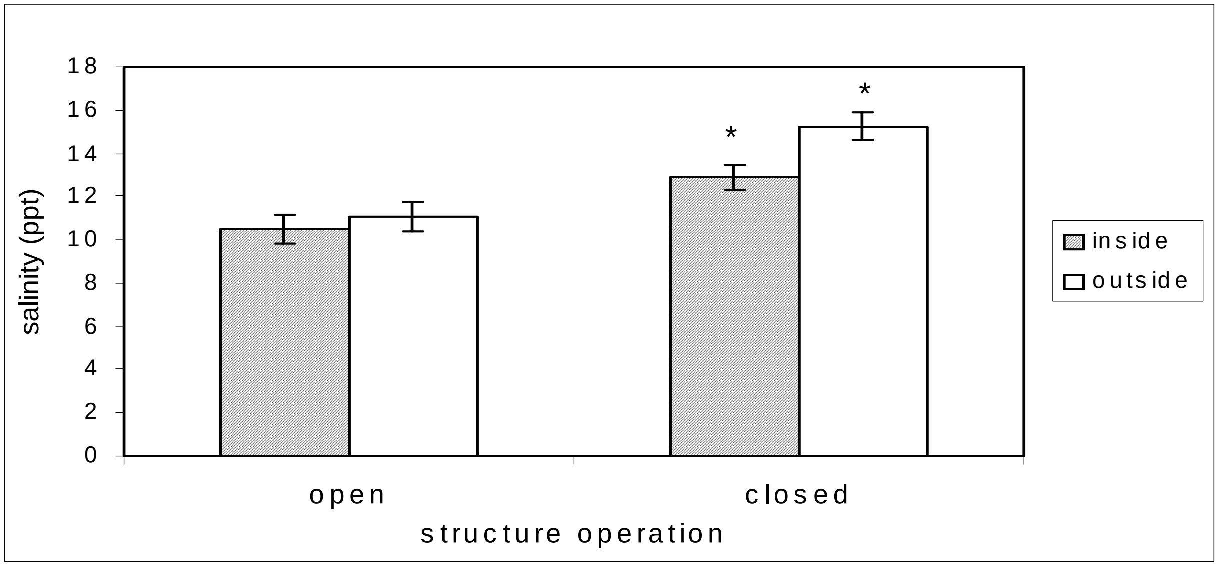


Figure 12. Mean salinity values (±SE) inside and outside CTU 2 when structures were open and closed from monthly discrete data collected October 1994 to December 1998 at East Mud Lake (CS-20).

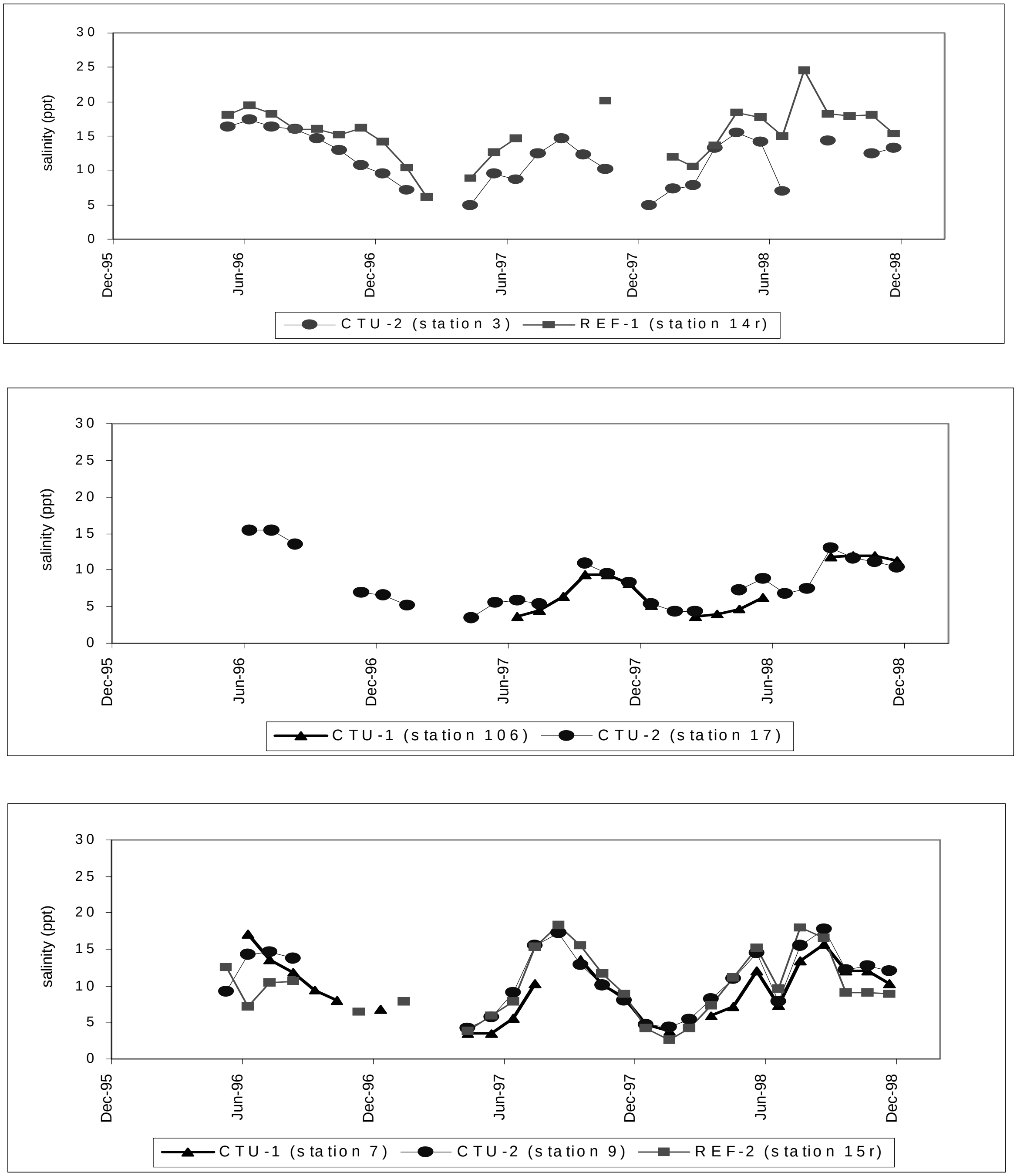


Figure 13. Monthly mean salinity values for all continuous recorder stations postconstruction from June 1996 to December 1998 at East Mud Lake (CS-20).

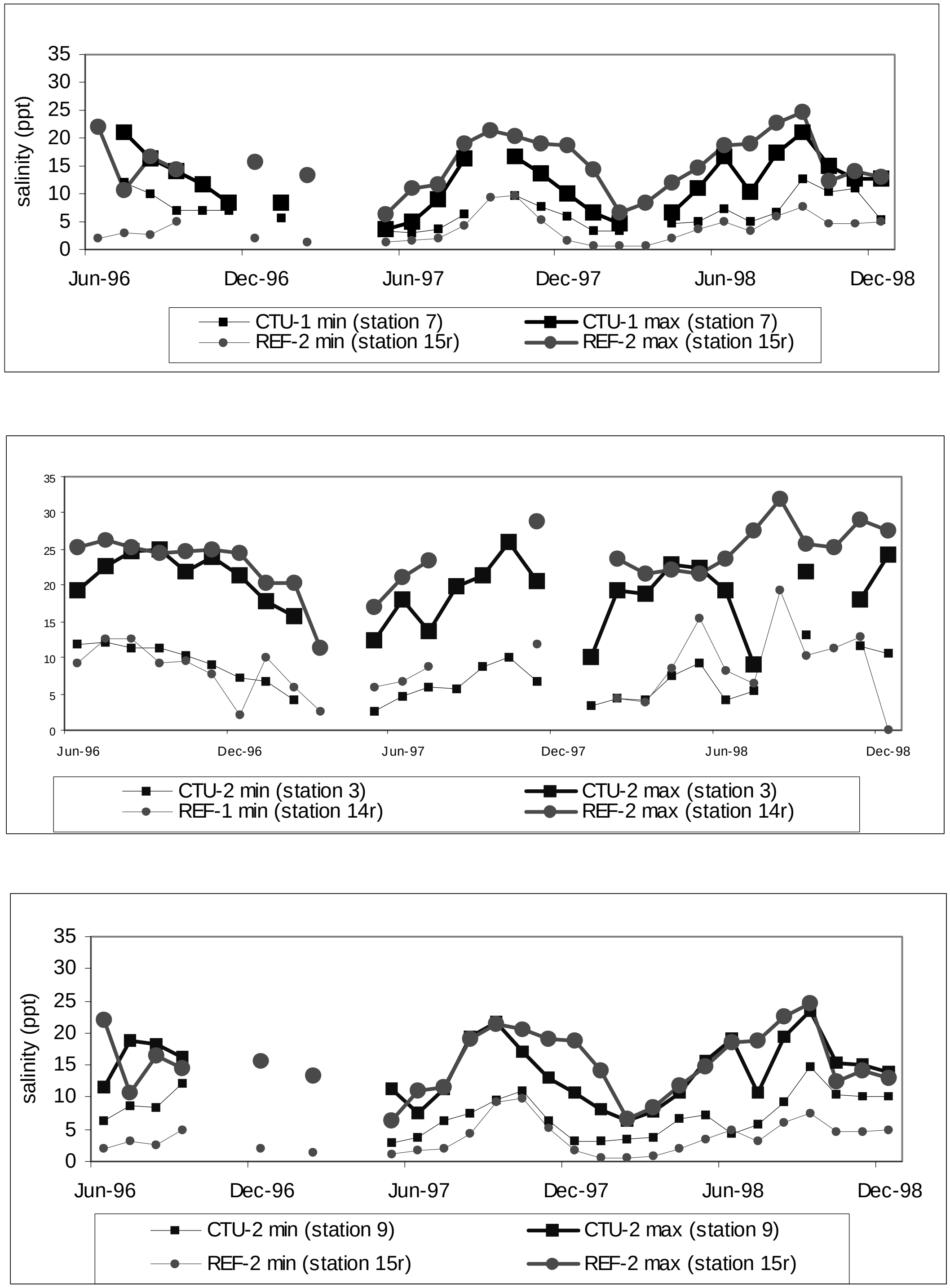


Figure 14. Minimum and maximum monthly salinity values for all continuous recorder stations postconstruction from June 1996 to December 1998 at East Mud Lake (CS-20).

Table 7. Percent of hourly salinity measurements greater than or equal to 15 ppt at each continuous recorder station at East Mud Lake (CS-20) for 1-year intervals during preconstruction and postconstruction periods.

area	station	pre-construction				post-construction					
		6/94-5/95		6/95 to 5/96		6/96 to 5/97		6/97 to 5/98		6/98 to 12/98*	
		n	%	n	%	n	%	n	%	n	%
CTU-1	7					4708	12.8%	7284	4.0%	5131	10.8%
	106							7496	0.0%	3647	0.1%
CTU-2	3					7044	36.5%	8036	18.1%	3533	15.1%
	9					3429	20.1%	8477	12.4%	5134	30.0%
	17	4673	0.0%	6863	16.6%	5327	14.2%	7028	0.0%	5133	0.3%
ref-1	14r			4668	64.9%	7679	48.1%	4996	49.1%	5132	73.3%
ref-2	15r			6869	53.2%	5247	8.8%	8718	19.7%	5131	29.7%

***** Latest data analyzed for this report, only a 7-month interval.

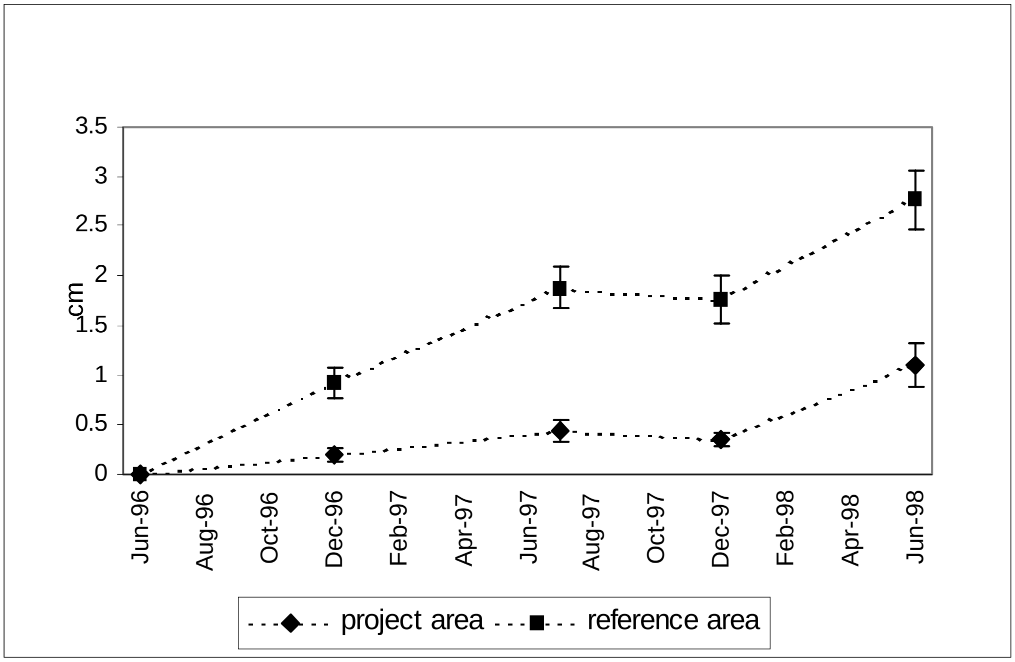


Figure 15. Mean cumulative accretion (cm) in CTU 2 and reference 1 from June 1996 to June 1998 at East Mud Lake (CS-20).

Table 8. Accretion rates (mean ± SE), standardized to reflect exact 6-mo time intervals, in project and reference areas of East Mud Lake (CS-20).

treatment	**Vertical accretion rates**							
	7/96 to 12/96		12/96 to 7/97		7/97 to 12/97		12/97 to 7/98	
	n	cm/6mo	n	cm/6mo	n	cm/6mo	n	cm/6mo
project	28	0.24 ± .20	34	0.26 ± .18	33	-0.11 ± .18	38	0.80 ± .17
reference	32	1.10 ± .18	37	0.75 ± .17	31	-0.02 ± .19	36	0.83 ± .17

Elevation: Mean cumulative change in marsh surface elevation for the 23-mo post-construction period was significantly higher ($t = 2.90$, $p < 0.01$) in the project area at 1.05 cm (± 0.32) than in the reference area at -0.11 cm (± 0.24). This resulted mainly from the last sampling period, December 1997 to June 1998, when elevation in the reference area dropped sharply while the project area experienced a gain (figure 16). Mean rate of marsh surface elevation change did not differ significantly preconstruction ($F = 0.00$, $p = 0.97$) between the project area at -1.76 cm/6-mo (± 0.67) and reference area at -1.73 cm/6-mo (± 0.67) (table 9). Rates also did not differ significantly post-construction ($F = 0.19$, $p = 0.67$), with only slightly lower rates in the project area at 0.23 cm/6-mo (± 0.25) than in the reference area at 0.28 cm/6-mo (± 0.25). Post-construction rates differed significantly among sampling periods ($F = 11.35$, $p < 0 .01$), with lowest rates occurring in both project and reference areas between July 1997 and December 1997. The interaction of treatment (project and reference) and sampling period was significant ($F = 9.99$, $p = < 0.01$)

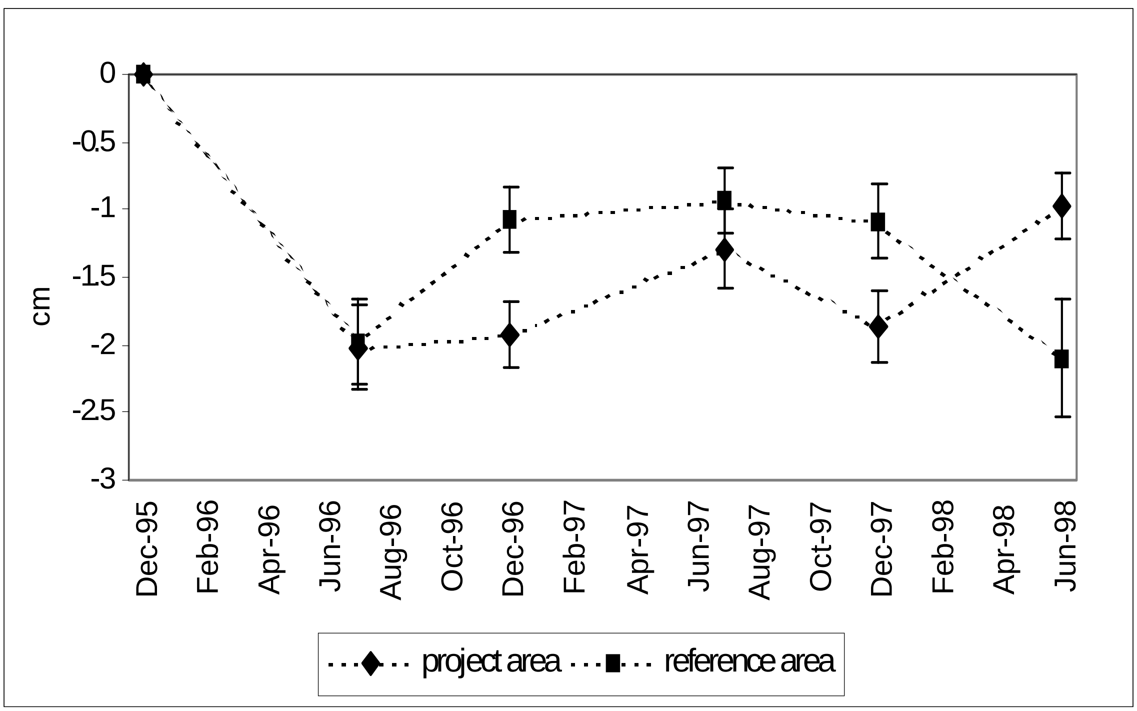


Figure 16. Mean cumulative change (±SE) in marsh elevation (cm) in CTU 2 and reference 1 from December 1995 to June 1998 at East Mud Lake (CS-20).

Table 9. Rates of marsh surface elevation change (mean ± SE), standardized to reflect exact 6-mo time intervals, in project and reference areas of East Mud Lake (CS-20).

	Mean rate of marsh surface elevation change									
	12/95 to 6/96*		6/96 to 12/96		12/96 to 7/97		7/97 to 12/97		12/97 to 6/98	
	n	cm/6mo	n	cm/6mo	n	cm/6mo	n	cm/6mo	n	cm/6mo
project	180	-1.76 ± .67^{A}	180	0.18 ± .32^{A}	216	0.51 ± .31^{A}	216	-0.65 ± .31^{A}	216	0.86 ± .31^{A}
reference	180	-1.73 ± .67^{A}	180	1.31 ± .32^{B}	216	0.17 ±..31^{A}	216	-0.20 ± .31^{A}	216	-0.16 ± .31^{B}

*Pre-construction
^{A} Values within columns with different letters are significantly different at the a=0.05 level.

Fisheries: Densities and biomass of all fishery species and supporting environmental data over all sampling periods are presented in Appendix A. The most abundant resident fish species include *Poecilia latipinna* (sailfin molly), *Gambusia affinis* (western mosquitofish), *Menidia beryllina* (inland silversides), and *Cyprinodon variegatus* (sheepshead minnow), while *Brevoortia patronus* (gulf menhaden) and *Anchoa mitchilli* (bay anchovy) represent the most abundant transient fish species. The most abundant resident decapod taxa include *Palaemonetes intermedius* (brackish grass shrimp), *P. pugio* (daggerblade grass shrimp), and *Palaemonetes* sp., while *Penaeus setiferus* (white shrimp), *P. aztecus* (brown shrimp), and *Callinectes sapidus* (blue crab) represent most abundant transient decapod species.

Environmental data collected on both project and reference areas before project construction (June 1995 and October 1995) showed significant ($p < 0.05$) interaction effects between area and sampling times for all variables except dissolved oxygen. This interaction essentially means that the difference between the two areas was not constant across sampling times, and precludes any meaningful interpretation of the main effects (sampling time and area) alone. A graphic illustration of interaction is indicated by the crossing or nonparallel lines representing the means in each area across sampling times (Appendix A). Dissolved oxygen, the only variable where meaningful interpretation of main effects was possible, was significantly higher in October 1995 than June 1995 for both areas.

During the post-construction period, data for some environmental variables were not collected or had inadequate replicate samples for certain sampling times (Appendix A). However, all environmental variables were temporally variable and changed similarly over time in both project and reference areas. No differential response to project construction was seen between the areas.

Density and biomass of fisheries variables showed the same relationships and patterns of statistical significance across sampling times and areas, indicating individual sizes were probably quite similar. Consequently, we are presenting results only on density; biomass data are available in Appendix A.

During preconstruction, no differences ($p>0.05$) in total crustacean density were found between project and reference areas or sampling times (figure 17). Resident crustacean density was significantly higher in the project area ($p<0.05$), and transient crustaceans were significantly higher in the reference area, but no differences were found among sampling times. For fish species, a significant area*sampling time interaction during the preconstruction period was found for total fish and resident fish (figure 18). Transient fish were significantly higher in the reference area. A test of overall fisheries species richness showed no differences ($p>0.05$) between areas or sampling times.

After construction, mean densities were only different from pre-construction for some crustacean variables. In the project area, transient crustacean density was higher ($p<0.05$) post-construction (figure 17). In the reference area, all 3 crustacean variables were significantly higher post-construction than preconstruction. No differences in overall fisheries species richness were found.

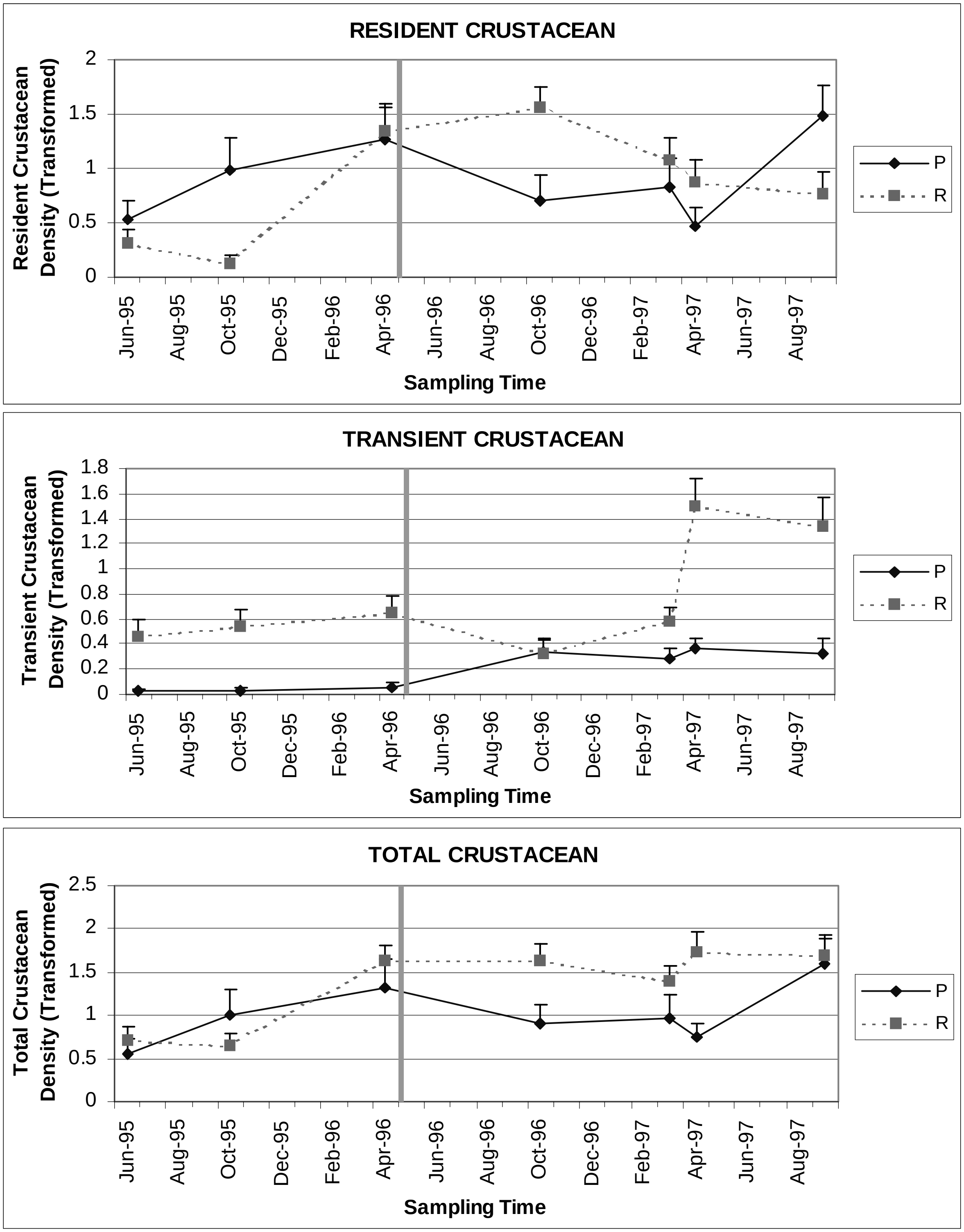


Figure 17. Log-transformed densities of crustacean species caught during 7 sampling times on project (P) and reference (R) areas at East Mud Lake (CS-20). Vertical bar marks the completion of project construction.

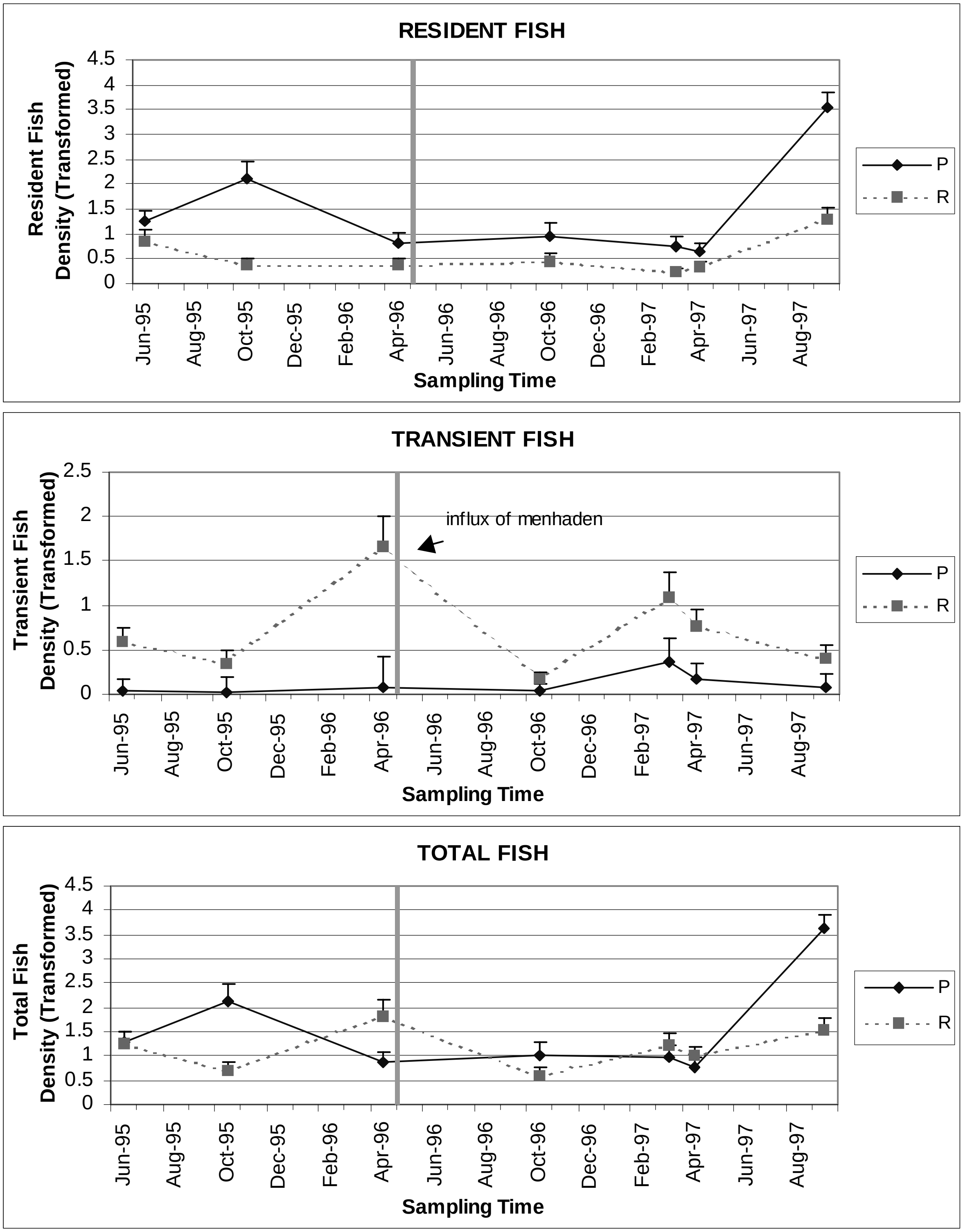


Figure 18. Log-transformed densities of fish species caught during 7 sampling times on project (P) and reference (R) areas at East Mud Lake. Vertical bar marks the completion of project construction.

DISCUSSION

The East Mud Lake Marsh Management (CS-20) project has proven partially successful in meeting the project goals. Overall, salinities remained at or below the target level of 15 ppt for a brackish marsh despite vandalism to structures where flow into the project was introduced during periods of high salinity. The project has been less effective in maintaining water levels at the target range of 6 in BML and 2 in AML. In an effort to prevent salinities above15 ppt from burning brackish marsh vegetation inside CTU 2 during the drought in 1996, structures remained closed according to the operational plan, until mid July 1996. By this time, the surface and subsurface soils of CTU 2 dried out, producing open cracks that did not close when the soil was hydrated for over one year. In the reference area, only the soil surface dried.

Reduction of the flooding events has not been achieved to satisfactory levels. The project area was impounded for many years prior to construction, linked hydrologically to the outside by open culverts. Installation of structures was intended partially to increase the drainage capacity of CTU 2 and reduce the duration and frequency of flooding. Although water levels remained within target levels during much of the study period, drainage during flooding events is impeded.

Following the drought of 1996, flooding stress resulted from prolonged rains and high tides lasting from October 3 to November 27. Analysis of water level and salinity data from this time indicated that water levels averaged 1.4 ft (0.4 m) over the marsh surface and salinity averaged 13.6 ppt in the project area, while water levels and salinity averaged 0.8 ft (0.2 m) above the marsh surface and 10.4 ppt in reference area 2. This event may have further aggravated damaged root systems by causing possibly anoxic conditions in the soil, which when coupled with high salinities, can result in root oxygen deficiencies, decreased nutrient uptake, and a buildup of sulfides in the soil (Mendelssohn and McKee 1989). Water levels during this time were lower outside the project area, although they were above marsh level more than 50% of the time, impeding drainage as indicated by water levels averaging 0.3 ft (0.09 m) above the marsh surface in reference area 1, where salinity averaged 15.6 ppt. To reduce flooding duration in the project area, DNR proposed removal of one board (6 in) from the structures 1, 3, 4, 5, 6, 7, 8, 9, and 11. NRCS and the landowners agreed and this operation was enacted on March 31, 2000.

High survival rates (90%) of *S. alterniflora* were detected in the canal plantings despite heavy herbivory from cattle along the eastern levee. If the stress from herbivory could be removed, the plantings should stabilize and protect the shoreline from erosion. Lower survival rates (45.6%) were detected in plantings along the newly refurbished step levee. The surviving plants appear to be10-15 ft (3.05-4.57 m) from the shoreline of the levee, which may have settled over time. At this distance, water levels are high and plants remain inundated except in the lowest water conditions. As water levels decrease due to the operational change, the surviving plantings could produce tillers and colonize open mudflats. Low survival (15%) in the Mud Lake lakeshore plantings most likely resulted from high wave energy from the long fetch across the lake. The failure of these lakeshore plantings indicates that Mud Lake may be too harsh an environment for survival of *S. alterniflora*. Aerial photography flown in 2000 will determine the acreage of marsh created by the plantings.

Although there were no significant differences in cover of existing vegetation between the project and reference areas, both experienced a decrease in cover of *S. patens*. This effect was more pronounced on the low soils in the southwestern portion of the project area. Here, *S. patens*, which tolerates less waterlogging than *S. alterniflora* (Mendelssohn and McKee 1988), is being slowly replaced by *D. spicata* and *Paspalum vaginatum* in these poorly drained soils. *S. patens* dieback and the resultant formation of small, shallow inland ponds is occurring. This dieback may have been initiated as a result of drought stress coupled with high soil salinity. High soil salinities were detected in brackish marsh soils adjacent to Black Lake near Hackberry La. following a 1986 drawdown accompanied by drought (Lehto and Murphy 1988). In artificially dried surface horizons of brackish marsh soils collected at Hackberry, La., significant increases in concentration of water-soluble Na, Fe, Mn, Mg, and Ca, as well as a decrease in soil pH were detected (Sigua and Hudnall 1988).

As cover values of dominant species such as *S. patens* decreased, opportunistic species such as *A. australis, Cyperus odoratus,* and *A. subulatus* increased in both the project and reference areas. *P. vaginatum*, a perennial edge species, benefitted from the low water conditions and spread from pond edges 2-15 ft (0.6 - 4.6 m) into the interior of many ponds in CTU 2 of the project area and in the reference area. The data from vegetation plots did not adequately reflect the increase in abundance of this species because plots are generally not located on pond edges. If increased coverage by *P. vaginatum* persists, then future analyses of aerial photography may detect decreases in water area.

Mean cumulative accretion was higher in the reference area the first year postconstruction (June 1996 to May 1997) possibly due to extreme drought and two consecutive drawdown years which may have limited sediment input into the project area. Reduction of water level fluctuations can indicate a reduction in the net exchange of nutrients and sediments, leading to decreases in accretion (Boumans and Day 1994; Cahoon 1994). The second year postconstruction (June 1997 to May1998) accretion in the project area mirrored that in the reference area, with no significant differences. This indicates that differences in the accretion rates may not be due to management of the project. In the absence of preconstruction data, it is difficult to determine if the project actually changed the accretion rates. Mean accretion rates in the project area were similar to those measured near Cameron, Louisiana in hydrologically restricted marshes (0.43 $\pm$ 0.09 and 0.35 $\pm$ 0.12) (Cahoon and Turner 1989). Higher accretion rates in unmanaged marshes versus managed marshes have been found in other paired studies. In Terrebonne Parish, Louisiana, sediment deposition was usually (but not always) significantly lower at sites outside of fixed crest weirs than at sites within them (Reed and Cahoon 1992), however, deteriorating marshes have been shown to accrete at a faster rate than stable marshes and do not maintain intertidal elevation as well as stable marshes (Boumans et al. 1984). In southwestern Louisiana, two marshes influenced by a major levee system had significantly lower accretion rates than adjacent marsh with direct hydrological exchange (Cahoon and Turner 1989).

The decrease in elevation from December 1995 to July 1996 in both the project and reference areas may be the result of soil compaction resulting from the drought of February through July 1996. Initial subsidence of organic soils is estimated to result in a reduction of thickness of the organic materials above the water table by about 50%, accompanied by permanent open cracks that do not close when the soil is hydrated. Shrinkage then continues at a fairly uniform rate as biochemical oxidation of organic materials continues (Murphy 1988). A prolonged flooding event from October 3 through November 27, 1996 occurred as water overtopped Magnolia Road and the northern levee of CTU 2. Reabsorption of water to soil particles was only partially achieved in the project area by December 1996, even though elevation increased in both the project and reference areas, 0.18 cm and 1.31 cm, respectively. The project area did not recover the loss in elevation from the drought as quickly as the reference area because soils in the reference area did not dry out completely as did soils in the project area and because the project area had lower accretion rates the first year following the drought. By June 1997, the project area showed significant recovery (0.51 cm) while reference area recovery slowed (0.17 cm). Both project and reference areas experienced losses in elevation from June to December 1997 when the project area was in drawdown. Elevation in the reference area continued to decrease from December 1997 to June 1998 (-0.16 cm) while the project area experienced an increase of 0.86 cm.

The major part of the preconstruction fisheries data analysis was to determine the suitability of the reference area for fisheries sampling. Several variables had statistically significant interaction effects between area (Project and Reference) and sampling times. This indicates that the two areas may have been functionally different with respect to variability of environmental variables. This is expected since the project area historically has been at least somewhat impounded. Still, the environmental variables appear to be similar enough not to dismiss the suitability of the reference area on that basis alone. When the distributions of animals in both areas preconstruction is considered along with the high temporal variability in both fisheries and environmental variables, it is difficult to dismiss the reference area as inappropriate. Only 2 true preconstruction samples were collected; more intense preconstruction sampling would have been necessary to more accurately determine the suitability of the reference area.

Resident fishes and crustaceans were generally more abundant in the project area and transient fishes and crustaceans were generally more abundant in the reference area before and after project construction. This likely indicates a previous and present access restriction for transient species to the project area, and a more suitable habitat for resident species in the project area. Fisheries species densities were temporally variable in both areas, and despite a trend toward higher crustacean densities after project construction in both areas, the project did not have a significant effect on total fisheries species densities. Although transient crustacean densities did increase significantly postconstruction in the project area, there was a much greater significant postconstruction increase in the reference area in total, transient, and resident crustacean densities, which means that the increase was due to effects other than those of the project. The high transient fish density in the reference area in April 1996 was due to large catches of gulf menhaden. Menhaden form large schools and therefore sampling can yield huge or very small catches. The very low numbers of menhaden collected in the project area during the same sampling trip could be the result of missing schools of the fish, but the low numbers may also be indicative of a lack of access to the project area for the transient menhaden during this year of extreme drought.

CONCLUSION

Extreme weather conditions were prevalent in Cameron Parish the first year after construction of this project. A six month drought caused drying, cracking, and compaction of the soil surface in the project area at periods when water salinity was high, thus increasing soil salinities. Following the drought, high water levels of 1.4 ft AML with average salinity of 13.6 ppt inside the project area may have further damaged emergent vegetation as well as recent plantings of *S. alterniflora*. Emergent vegetation of the broken marsh on the low, fluid Bancker soils in the southern portion of the project area experienced a dramatic decrease in cover values due to these stressors. As cover of *S. patens*, the dominant species, decreased, *P. vaginatum* colonized pond edges while *D. spicata* grew in higher elevations of decomposing *S. patens* clumps.

Following the drought, marsh elevation was lowered on both project and reference area and neither has recovered their "pre-drought" elevations. The reference area experienced a loss in elevation from December 1997 to June 1998 equaling the loss it experienced in the drought of 1996. These sudden environmental changes leading to loss of marsh vegetation may reduce the potential for marsh accretion to keep pace with subsidence and sea level rise. Results from the project area indicate that in a brackish marsh, the marsh subsurface should not be allowed to dry completely despite high salinity conditions outside the project area.

Water levels were low for a large percentage of the postconstruction period due to two consecutive drawdown years and three consecutive dry years. However, water levels appear to remain higher, and flooding events last longer in the project area compared to both reference areas. A change in structure operations was necessary to exit water from CTU 2 to prevent further damage to vegetation. Flexibility in structure operations is essential for responding to conditions created by environmental extremes so prevalent in coastal Louisiana.

The project apparently has not changed transient aquatic animal access to the project area. Any effect on the density of resident animals is apparently masked by the temporal variability of the data in this analyses. Longer term studies are needed to determine if the difference in animal densities between areas increases enough over time to be detected over the naturally existing variability.

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APPENDIX

Fisheries Data

	June 1995									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	1.23	(0.38)	22.0	(2.46)	8.06	(4.22)	16.83	9.89	278	1165
Inland silverside *Menidia beryllina*	0.45	(0.16)	2.10	(0.79)	0.07	(0.04)	0.20	(0.10)	15.56	69
Spot *Leiostamus xanthurus**	0.31	(0.31)	0.07	(0.07)	0.45	(0.45)	0.07	(0.07)	22.67	4
Gulf killifish *Fundulus grandis*	0.17	(0.17)	0.03	(0.03)	0.00	(0.00)	0.00	(0.00)	5.05	1
Unidentified goby	0.12	(0.05)	1.83	(0.69)	0.01	(0.01)	0.10	(0.07)	3.99	58
Western mosquitofish *Gambusia affinis*	0.08	(0.04)	2.13	(1.47)	0.88	(0.69)	5.77	(4.02)	28.76	237
Sheepshead minnow *Cyprinodon variegatus*	0.03	(0.03)	0.10	(0.10)	0.55	(0.46)	0.43	(0.37)	17.54	16
Naked goby *Gobiosoma bosc*	0.03	(0.03)	0.03	(0.03)	0.01	(0.01)	0.13	(0.06)	1.09	5
Diamond killifish *Adinia xenica*	0.02	(0.02)	0.03	(0.03)	0.01	(0.01)	0.03	(0.03)	0.95	2
Sailfin molly *Poecilia latipinna*	0.01	(0.01)	0.07	(0.05)	3.62	(2.72)	7.53	(5.24)	109.3	228
Bayou killifish *Fundulus pulvereus*	0.01	(0.01)	0.03	(0.03)	0.51	(0.37)	0.67	(0.47)	15.62	21
Pipefish *Sygnanthus spp.*	0.01	(0.01)	0.03	(0.03)	0.00	(0.00)	0.00	(0.00)	0.21	1
Rainwater killifish *Lucania parva*	0.01	(0.01)	0.03	(0.03)	0.00	(0.00)	0.00	(0.00)	0.14	1
White mullet *Mugil cerema**	0.00	(0.00)	0.00	(0.00)	1.60	(1.60)	0.03	(0.03)	48.06	1
Bay anchovy *Anchoa mitchilli**	0.00	(0.00)	0.00	(0.00)	0.11	(0.07)	0.83	(0.38)	3.34	25
Gulf flounder *Paralicthys albigutta**	0.00	(0.00)	0.00	(0.00)	0.07	(0.05)	0.07	(0.05)	2.0	2
Gulf menhaden *Brevortia patronus**	0.00	(0.00)	0.00	(0.00)	(0.00)	(0.04)	0.03	(0.03)	1.29	1

	June 1995									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
Blackcheek tonguefish *Symphurus plagiusa**	0.00	(0.00)	0.00	(0.00)	0.04	(0.02)	0.40	(0.20)	1.04	12
Freshwater goby *Gobionellus shufeldti*	0.00	(0.00)	0.00	(0.00)	0.02	(0.01)	0.30	(0.13)	0.68	9
Sharptail goby *Gobionellus hastatus*	0.00	(0.00)	0.00	(0.00)	0.02	(0.02)	0.03	(0.03)	0.62	1
Darter goby *Gobionellus boleosoma*	0.00	(0.00)	0.00	(0.00)	0.01	(0.01)	0.03	(0.03)	0.42	1
Bay whiff *Citharicthys spilopterus**	0.00	(0.00)	0.00	(0.00)	0.02	(0.02)	0.03	(0.03)	0.45	1
Green goby *Microgobius thalassinus*	0.00	(0.00)	0.00	(0.00)	0.01	(0.01)	0.03	(0.03)	0.14	1
Speckled worm eel *Myrophis punctatus**	0.00	(0.00)	0.00	(0.00)	0.004	(0.03)	0.07	(0.05)	0.12	2
Pipefish *Sygnanthus louisiane*	0.00	(0.00)	0.00	(0.00)	0.04	(0.02)	0.03	(0.03)	1.04	1
TOTAL CRUSTACEANS	0.51	(0.28)	2.47	(1.47)	1.25	(0.39)	2.30	(0.86)	52.66	143
Brown shrimp *Penaeus aztecus**	0.25	(0.25)	0.03	(0.03)	1.10	(0.36)	1.43	(0.80)	40.44	44
Unidentified grass shrimp *Palaemonetes* spp.	0.25	(0.15)	2.27	(1.48)	0.14	(0.06)	0.83	(0.38)	11.52	93
Daggerblade grass shrimp *Palaemonetes pugio*	0.01	(0.01)	0.13	(0.08)	0.01	(0.01)	0.03	(0.03)	0.50	5
grass shrimp *Palaemonetes vulgaris*	0.01	(0.01)	0.03	(0.03)	0.00	(0.00)	0.00	(0.00)	0.20	1

	October 1995									
	Project Area n = 25				Reference Area n = 25					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	4.66	(1.47)	28.08	(8.40)	0.63	(0.25)	2.16	(0.74)	132.33	756
Western mosquitofish *Gambusia affinis*	1.91	(0.65)	13.92	(4.31)	0.01	(0.01)	0.04	(0.04)	48.04	349
Inland silverside *Menidia beryllina*	1.31	(0.94)	6.60.	(5.25)	0.25	(0.16)	0.56	(0.36)	38.99	179
Sheepshead minnow *Cyprinodon variegatus*	1.12	(0.42)	5.36	(1.74)	0.00	(0.00)	0.00	(0.00)	28.0	134
Unidentified goby	0.08	(0.07)	0.12	(0.01)	0.00	(0.00)	0.00	(0.00)	1.94	3
Sailfin molly *Poecilia latipinna*	0.21	(0.17)	2.00	(1.48)	0.00	(0.00)	0.00	(0.00)	5.36	50
Bay anchovy *Anchoa mitchilli**	0.02	(0.02)	0.04	(0.04)	0.27	(0.20)	0.96	(0.65)	7.27	25
Clown goby *Microgobius gulosus*	0.01	(0.01)	0.04	(0.04)	0.01	(0.01)	0.04	(0.04)	0.42	2
Naked goby *Gobiosoma bosc*	0.00	(0.00)	0.00	(0.00)	0.03	(0.02)	0.24	(0.14)	0.72	6
Red drum *Sciaenops ocellatus**	0.00	(0.00)	0.00	(0.00)	0.01	(0.01)	0.20	(0.14)	0.20	5
TOTAL CRUSTACEANS	0.80	(0.26)	9.44	(3.98)	1.14	(0.43)	1.56	(0.52)	48.39	275
Unidentified grass shrimp *Palaemonetes* spp.	0.65	(0.25)	9.20	(4.00)	0.03	(0.02)	0.28	(0.20)	16.2	237
Blue crab *Callinectes sapidus**	0.00	(0.00)	0.00	(0.00)	0.01	(0.00)	0.16	(0.07)	0.12	4
White shrimp *Peneaus setiferus**	0.13	(0.13)	0.04	(0.04)	1.01	(0.44)	0.6	(0.28)	28.35	16
Brown shrimp *Penaeus aztecus**	0.00	(0.00)	0.00	(0.00)	0.10	(0.05)	0.52	(0.40)	2.53	13
Daggerblade grass shrimp *Palaemonetes pugio*	0.02	(0.01)	0.20	(0.16)	0.00	(0.00)	0.00	(0.00)	0.44	5

	April 1996									
	Project Area n = 25				Reference Area n = 20					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	1.17	(0.36)	3.24	(1.10)	3.04	(1.29)	20.95	(10.35)	90.17	500
Inland silverside *Menidia beryllina*	0.57	(0.22)	0.68	(0.24)	0.05	(0.05)	0.05	(0.05)	15.30	18
Spot *Leiostamus xanthurus**	0.00	(0.00)	0.00	(0.00)	0.12	(0.06)	0.5	(0.27)	2.32	10
Western mosquitofish *Gambusia affinis*	0.46	(0.18)	2.16	(0.87)	0.12	(0.10)	0.75	(0.65)	13.89	69
Sheepshead minnow *Cyprinodon variegatus*	0.04	(0.04)	0.04	(0.04)	0.09	(0.07)	0.20	(0.09)	2.80	5
Sailfin molly *Poecilia latipinna*	0.05	(0.04)	0.16	(0.13)	0.00	(0.00)	0.00	(0.00)	1.18	4
Bayou killifish *Fundulus pulvereus*	0.03	(0.03)	0.08	(0.08)	0.00	(0.00)	0.00	(0.00)	0.77	2
White mullet *Mugil cerema**	0.00	(0.00)	0.00	(0.00)	0.04	(0.04)	0.05	(0.05)	0.82	1
Atlantic croaker *Micropogonius undulatus**	0.00	(0.00)	0.00	(0.00)	0.13	(0.06)	0.35	(0.17)	2.59	7
Sheepshead *Archosargus probatocephalus**	0.00	(0.00)	0.00	(0.00)	0.01	(0.01)	0.10	(0.10)	0.11	2
Gulf menhaden *Brevortia patronus**	0.02	(0.01)	0.12	(0.09)	2.50	(1.32)	18.95	(10.46)	50.39	382
TOTAL CRUSTACEANS	1.58	(0.66)	15.32	(7.63)	0.93	(0.24)	5.80	(1.09)	58.20	499
Unidentified grass shrimp *Palaemonetes* spp.	1.58	(0.66)	15.24	(7.63)	0.54	(0.15)	0.05	(0.05)	50.04	470
grass shrimp *Palaemonetes intermedius*	0.00	(0.00)	0.00	(0.00)	0.02	(0.02)	4.45	(0.97)	0.28	1
Blue crab *Callinectes sapidus**	0.01	(0.01)	0.08	(0.06)	0.40	(0.25)	1.30	(0.34)	7.88	28

	October 1996									
	Project Area n = 25				Reference Area n = 25					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	1.83	(0.62)	6.60	(2.32)	0.60	(0.21)	1.84	(0.73)	117.30	313
Inland silverside *Menidia beryllina*	1.68	(0.61)	5.2	(2.07)	0.12	(0.08)	0.20	(0.12)	36.54	135
Sheepshead minnow *Cyprinodon variegatus*	0.40	(0.25)	0.52	(0.30)	0.00	(0.00)	0.00	(0.00)	8.07	13
Western mosquitofish *Gambusia affinis*	0.07	(0.04)	0.36	(0.22)	0.11	(0.08)	0.96	(0.58)	4.10	33
Sailfin molly *Poecilia latipinna*	0.04	(0.03)	0.16	(0.13)	0.05	(0.05)	0.12	(0.12)	2.17	7
Unidentified goby	0.03	(0.03)	0.20	(0.16)	0.02	(0.01)	0.12	(0.09)	1.02	8
Bayou killifish *Fundulus pulvereus*	0.00	(0.00)	0.00	(0.00)	0.11	(0.11)	0.04	(0.04)	2.70	1
Pipefish *Sygnanthus* spp.	0.00	(0.00)	0.00	(0.00)	0.02	(0.02)	0.04	(0.04)	0.46	1
Unidentified fish	0.01	(0.01)	0.08	(0.06)	0.01	(0.01)	0.08	(0.06)	0.48	4
TOTAL CRUSTACEANS	2.59	(0.77)	5.40	(2.82)	3.76	(0.79)	6.56	(1.35)	158.15	299
White shrimp *Peneaus setiferus**	1.40	(0.66)	0.60	(0.21)	0.87	(0.43)	0.56	(0.27)	49.91	29
Unidentified grass shrimp *Palaemonetes* spp.	1.21	(0.58)	4.72	(2.68)	2.86	(0.52)	5.92	(1.20)	95.60	266
Blue crab *Callinectes sapidus**	0.01	(0.01)	0.08	(0.06)	0.02	(0.02)	0.08	(0.06)	0.88	4

TAXA	March 1997									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	2.5	(1.13)	6.2	(2.79)	1.9	(0.89)	11.9	(7.18)	110.0	453
Gulf menhaden *Brevortia patronus**	0.8	(0.71)	2.6	(2.28)	1.0	(0.51)	10.1	(6.11)	44.3	318
Inland silverside *Menidia beryllina*	1.4	(0.68)	1.9	(0.87)	0.2	(0.12)	0.2	(0.12)	39.9	53
Spot *Leiostomus xanthurus **	0.0	(0.01)	0.0	(0.04)	0.3	(0.35)	1.1	(1.08)	8.9	28
Sheepshead minnow *Cyprinodon variegatus*	0.2	(0.09)	1.5	(1.17)	0.1	(0.05)	0.0	(0.04)	5.5	38
Atlantic croaker *Micropogonias undulatus **	0.0	(0.00)	0.0	(0.00)	0.2	(0.08)	0.3	(0.11)	4.8	7
Naked goby *Gobiosoma bosc*	0.1	(0.14)	0.1	(0.08)	0.0	(0.01)	0.0	(0.04)	3.9	3
Bay anchovy *Anchoa mitchilli**	0.1	(0.06)	0.1	(0.08)	0.0	(0.01)	0.0	(0.04)	1.9	3
Western mosquitofish *Gambusia affinis*	0.0	(0.02)	0.0	(0.04)	0.0	(0.00)	0.0	(0.00)	0.5	1
Code goby *Gobiosoma robustum*	0.0	(0.00)	0.0	(0.00)	0.0	(0.02)	0.0	(0.04)	0.4	1
Rainwater killifish *Lucania parva*	0.0	(0.00)	0.0	(0.04)	0.0	(0.00)	0.0	(0.00)	0.1	1
TOTAL CRUSTACEANS	2.5	(1.27)	8.3	(4.28)	1.7	(0.59)	5.2	(1.40)	104.5	337
Blue crab *Callinectes sapidus**	1.3	(1.12)	0.5	(0.17)	1.0	(0.47)	1.0	(0.24)	57.7	38
Brackish grass shrimp *Palaemonetes intermedius*	0.6	(0.40)	3.6	(2.49)	0.3	(0.14)	1.7	(0.79)	22.3	134
Daggerblade grass shrimp *Palaemonetes pugio*	0.4	(0.20)	3.8	(1.86)	0.4	(0.10)	2.4	(0.70)	20.2	154
Marsh grass shrimp *Palaemonetes vulgaris*	0.1	(0.08)	0.4	(0.21)	0.0	(0.00)	0.0	(0.00)	2.9	9
Harris mud crab *Rhithropanopeus harrisi*	0.0	(0.00)	0.0	(0.00)	0.1	(0.06)	0.0	(0.04)	1.4	1
Brown shrimp *Penaeus aztecus**	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	(0.04)	0.0	1

	April 1997									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	1.3	(0.46)	3.5	(1.41)	2.0	(0.71)	4.1	(1.86)	99.9	229
Atlantic croaker *Micropogonias undulatus* *	0.2	(0.17)	0.0	(0.03)	1.0	(0.53)	0.3	(0.13)	35.2	10
Inland silverside *Menidia beryllina*	0.6	(0.42)	1.2	(0.67)	0.2	(0.17)	0.2	(0.08)	26.0	40
Gulf menhaden *Brevortia patronus**	0.2	(0.15)	0.3	(0.17)	0.3	(0.20)	2.7	(1.79)	16.0	89
Sheepshead minnow *Cyprinodon variegatus*	0.1	(0.05)	1.5	(1.04)	0.1	(0.09)	0.1	(0.06)	7.1	48
Gulf killifish *Fundulus grandis*	0.0	(0.00)	0.0	(0.00)	0.1	(0.11)	0.0	(0.03)	3.3	1
Western mosquitofish *Gambusia affinis*	0.1	(0.09)	0.5	(0.47)	0.0	(0.00)	0.0	(0.00)	3.0	15
White mullet *Mugil cerema**	0.1	(0.08)	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	2.3	1
Bay anchovy *Anchoa mitchilli**	0.0	(0.00)	0.0	(0.00)	0.1	(0.04)	0.2	(0.10)	2.1	7
Clown goby *Microgobius gulosus*	0.0	(0.00)	0.0	(0.00)	0.1	(0.06)	0.1	(0.05)	2.0	2
Southern flounder *Paralicthys lethostigma**	0.0	(0.00)	0.0	(0.00)	0.0	(0.04)	0.0	(0.03)	1.2	1
Diamond killifish *Adinia xenica*	0.0	(0.00)	0.0	(0.00)	0.0	(0.02)	0.0	(0.03)	0.6	1
Bay whiff *Citharicthys spilopterus**	0.0	(0.00)	0.0	(0.00)	0.0	(0.01)	0.1	(0.06)	0.5	1
Ladyfish *Elops saurus* *	0.0	(0.00)	0.0	(0.00)	0.0	(0.01)	0.0	(0.03)	0.3	2
Darter goby *Gobionellus boleosoma*	0.0	(0.00)	0.0	(0.00)	0.0	(0.01)	0.1	(0.07)	0.2	2
Speckled worm eel *Myrophis punctatus**	0.0	(0.00)	0.0	(0.00)	0.0	(0.01)	0.0	(0.03)	0.2	2
Rainwater killifish *Lucania parva*	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	2
Skilletfish *Gobiesox strumosus*	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	1
Unidentified goby Family Gobiidae	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.0	1

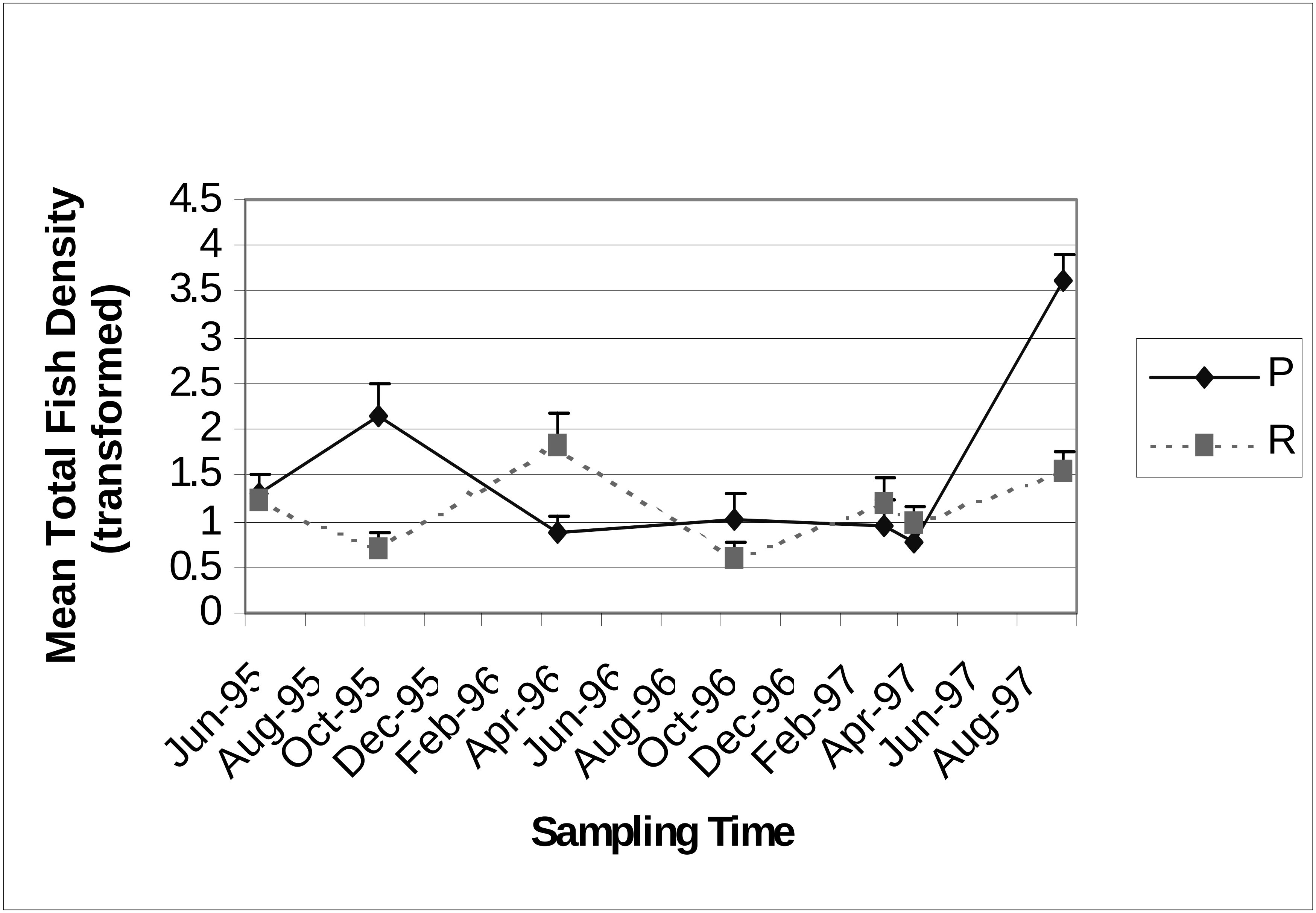
	April 1977									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL CRUSTACEANS	13.4	(6.01)	3.3	(1.84)	7.3	(3.33)	11.6	(3.49)	620.7	445
Blue crab *Callinectes sapidus* *	12.8	(6.02)	0.6	(0.15)	4.7	(3.26)	1.7	(0.38)	526.4	68
Brown shrimp *Penaeus aztecus**	0.0	(0.02)	0.1	(0.05)	1.3	(0.35)	5.6	(1.55)	41.1	169
Daggerblade grass shrimp *Palaemonetes pugio*	0.1	(0.08)	0.7	(0.60)	1.0	(0.42)	2.9	(1.21)	32.2	109
Brackish grass shrimp *Palaemonetes intermedius*	0.4	(0.31)	1.9	(1.28)	0.3	(0.15)	1.3	(0.73)	20.2	97
Harris mud crab *Rhithropanopeus harrisii*	0.0	(0.00)	0.0	(0.00)	0.0	(0.02)	0.0	(0.03)	0.6	1
Marsh grass shrimp *Palaemonetes vulgaris*	0.0	(0.00)	0.0	(0.00)	0.0	(0.01)	0.0	(0.03)	0.2	1

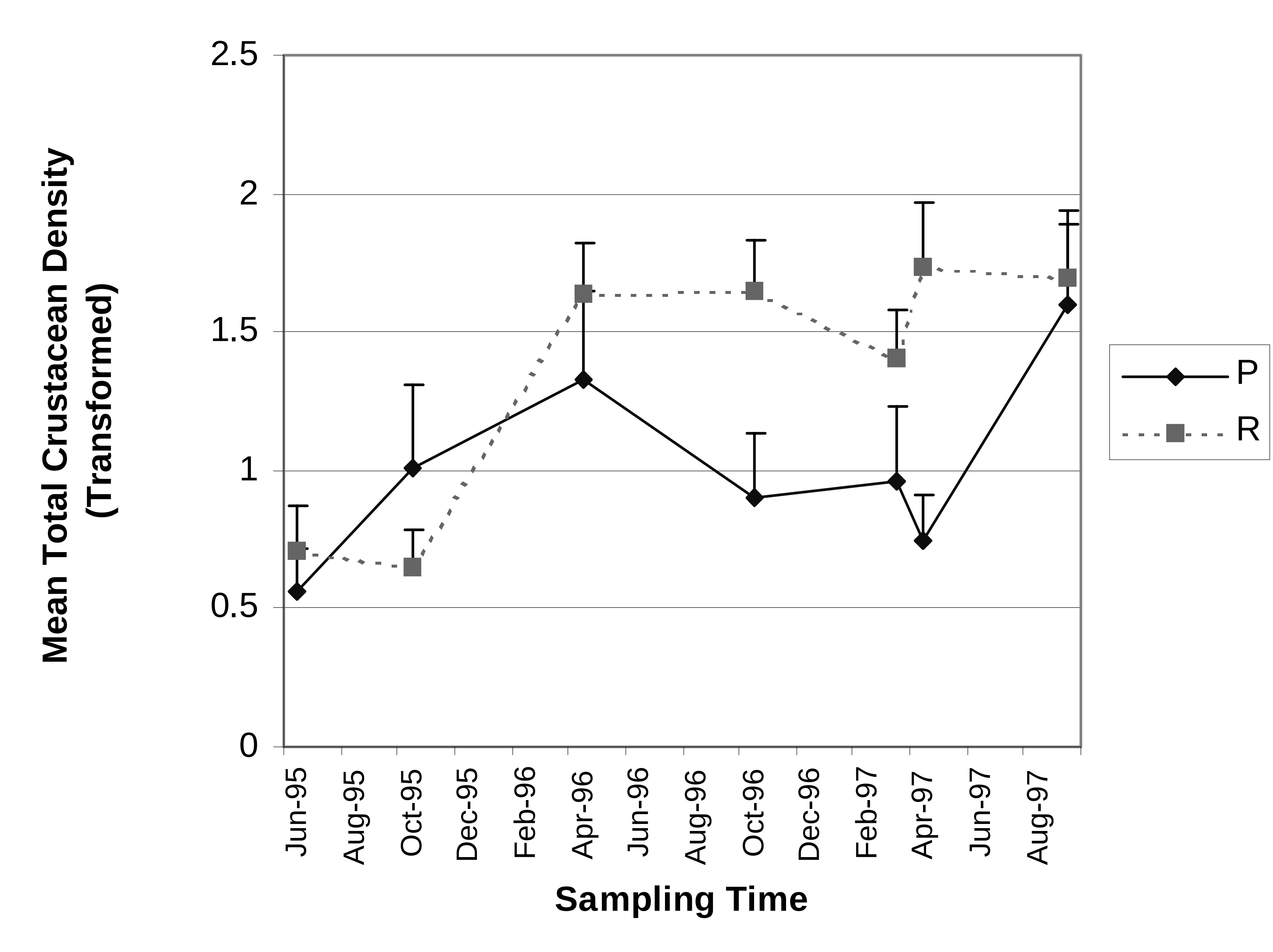
TAXA	September 1997									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
TOTAL FISHES	18.4	(4.48)	92.2	(25.41)	2.3	(0.83)	9.3	(3.27)	621.2	3044
Sailfin molly *Poecilia latipinna*	8.1	(2.80)	43.8	(15.04)	0.2	(0.23)	1.7	(1.70)	248.4	1364
Sheepshead minnow *Cyprinodon variegatus*	5.3	(1.25)	14.9	(2.66)	0.1	(0.09)	1..5	(1.13	162.6	492
Western mosquitofish *Gambusia affinis*	2.8	(1.11)	30.5	(10.28)	0.0	(0.00)	0.0	(0.00)	84.6	916
Gulf menhaden *Brevortia patronus**	1.6	(1.57)	0.4	(0.40)	0.5	(0.51)	0.1	(0.07)	62.4	14
Blackcheek tonguefish *Symphurus plagiusa**	0.0	(0.00)	0.0	(0.00)	0.5	(0.49)	0.0	(0.03)	14.8	1
Inland silverside *Menidia beryllina*	0.2	(0.06)	0.6	(0.23)	0.2	(0.13)	1.4	(0.88)	11.6	59
Bay anchovy *Anchoa mitchilli**	0.0	(0.00)	0.0	(0.00)	0.4	(0.25)	1.4	(0.95)	11.0	41
Rainwater killifish *Lucania parva*	0.3	(0.17)	1.3	(0.79)	0.0	(0.05)	0.2	(0.20)	9.8	46
Gulf killifish *Fundulus grandis*	0.2	(0.20)	0.3	(0.21)	0.0	(0.01)	0.2	(0.14)	7.0	15
Spotted seatrout *Cynoscion nebulosus**	0.0	(0.00)	0.0	(0.00)	0.2	(0.19)	0.1	(0.09)	5.7	4
Speckled worm eel *Myrophis punctatus**	0.0	(0.00)	0.0	(0.00)	0.0	(0.03)	0.0	(0.03)	0.9	1
Code goby *Gobiosoma robustum*	0.0	(0.02)	0.3	(0.18)	0.0	(0.00)	0.0	(0.03)	0.8	9
Naked goby *Gobiosoma bosc*	0.0	(0.00)	0.0	(0.03)	0.0	(0.01)	1.4	(0.66)	0.7	44
Saltmarsh topminnow *Fundulus jenkinsi*	0.0	(0.01)	0.1	(0.05)	0.0	(0.00)	0.0	(0.00)	0.4	2
Clown goby *Microgobius gulosus*	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.3	(0.19)	0.2	10
Unidentified goby	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.8	(0.35)	0.2	24
Darter goby *Gobionellus boleosoma*	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	0.0	(0.03)	0.1	1

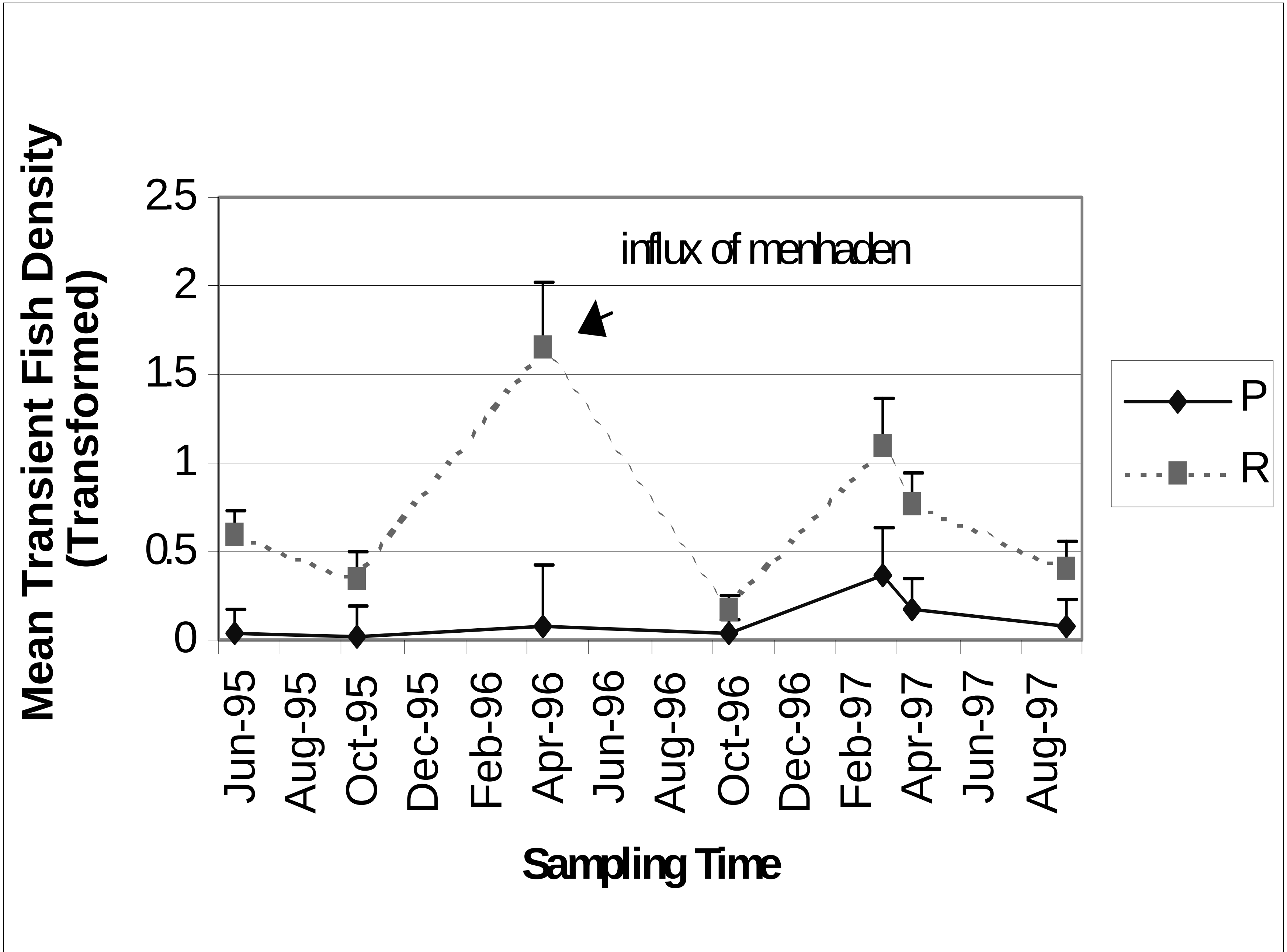
	September 1997									
	Project Area n = 30				Reference Area n = 30					
	Biomass		Density		Biomass		Density			
TAXA	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	TOTAL BIOMASS	TOTAL DENSITY
Green goby *Microgobius thalassinus*	0.0	(0.00)	0.0	(0.03)	0.0	(0.00)	0.0	(0.00)	0.0	1
TOTAL CRUSTACEANS	3.1	(0.90)	16.6	(5.63)	3.2	(1.26)	12.7	(4.02)	188.1	879
White shrimp *Peneaus setiferus**	1.1	(0.50)	0.8	(0.33)	2.0	(0.85)	7.0	(2.49)	90.9	233
Brackish grass shrimp *Palaemonetes intermedius*	1.1	(0.39)	8.4	(3.22)	0.3	(0.19)	2.1	(1.31)	42.0	316
Daggerblade grass shrimp *Palaemonetes pugio*	0.8	(0.38)	7.2	(2.82)	0.1	(0.05)	1.5	(0.61)	27.8	29.6
Brown shrimp *Penaeus aztecus**	0.0	(0.01)	0.0	(0.03)	0.5	(0.29)	0.6	(0.32)	14.7	20
Blue crab *Callinectes sapidus**	0.1	(0.06)	0.1	(0.07)	0.3	(0.17)	1.1	(0.38)	12.2	35
Harris mud crab *Rhithropanopeus harrisi*	0.0	(0.00)	0.0	(0.00)	0.0	(0.01)	0.1	(0.07)	0.4	2
Unidentified grass shrimp *Palaemonetes* spp.	0.0	(0.00)	0.1	(0.07)	0.0	(0.00)	0.2	(0.14)	0.1	8
Unidentified penaeid*	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.1	(0.05)	0.1	2
Unidentified xanthid crab	0.0	(0.00)	0.0	(0.00)	0.0	(0.00)	0.1	(0.07)	0.0	2

ENVIRONMENTAL VARIABLES

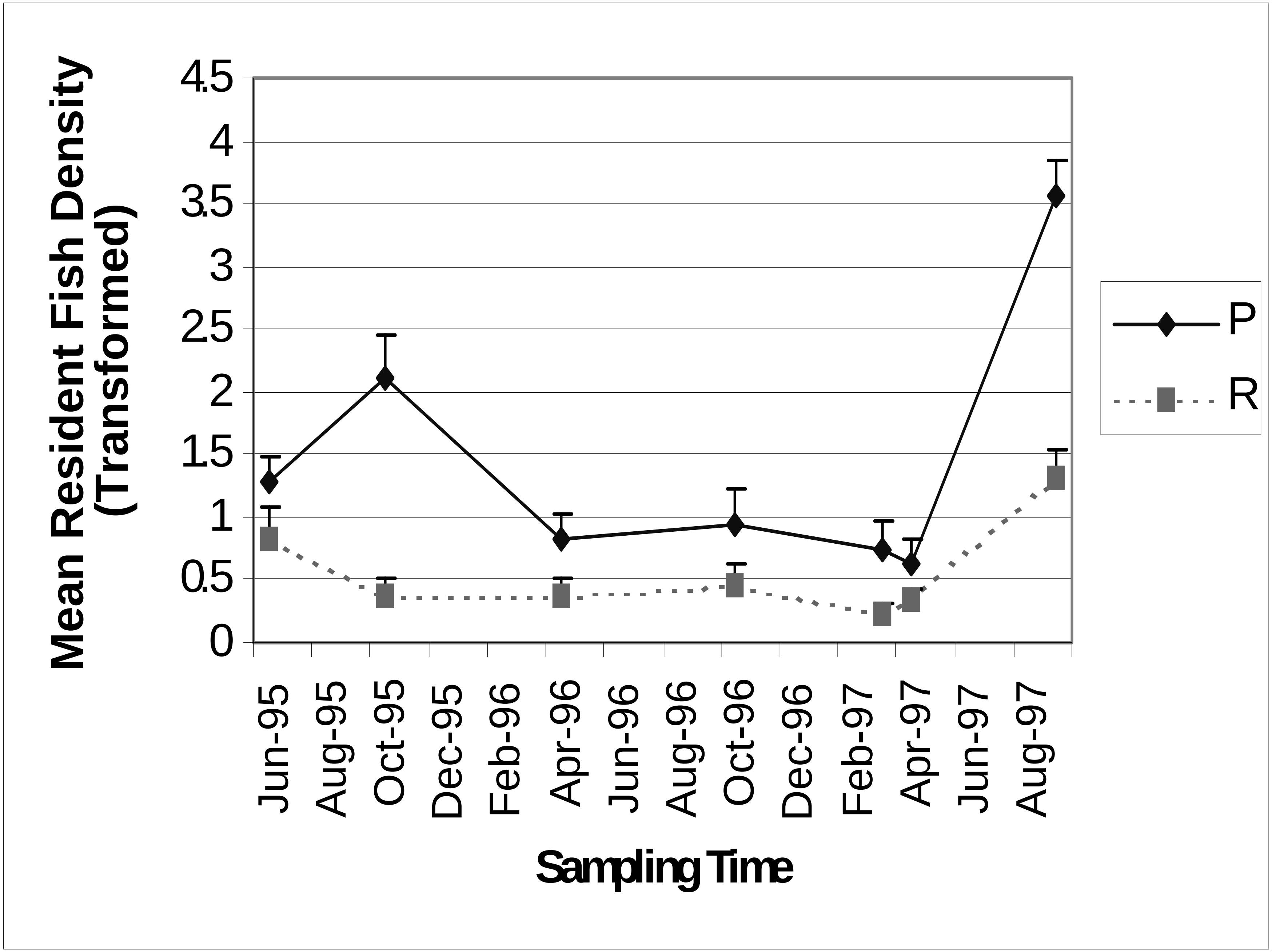
Sampling Period and Site	Salinity (ppt)		D. O. (ppm)		Temp (C)		Depth (cm)		Distance (m)		SAV(%)
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean
Jun 95 Project	7.91	(0.32)	7.52	(0.31)	32.15	(0.40)	30.48	(6.49)	8.90	(6.49)	8
Jun 95 Reference	6.73	(0.24)	7.34	(1.20)	30.29	(0.26)	33.29	(2.99)	17.80	(3.69)	7
Oct 95 Project	14.95	(0.62)	9.18	(0.42)	16.92	(0.34)	40.43	(3.49)	10.05	(2.32)	64
Oct 95 Reference	19.46	(0.59)	7.66	(0.45)	18.53	(0.47)	68.48	(3.54)	8.10	(2.09)	12
Apr 96 Project	8.50	(0.23)	11.49	(0.41)	21.05	(0.58)	14.61	(1.20)	14.65	(7.84)	0
Apr 96 Reference	15.39	(0.96)	10.91	(0.35)	19.71	(0.76)	20.06	(3.60)	4.66	(0.69)	0
Oct 96 Project	11.99	(0.38)	nd	nd	22.68	(0.48)	69.67	(8.05)	2.43	(0.23)	31
Oct 96Reference	nd	nd	nd	nd	nd	nd	nd	nd	1.15	(0.15)	26
Mar 97 Project	4.7	(0.11)	10.9	(0.37)	18.9	(0.19)	62.4	(4.30)	5.6	(1.89)	4
Mar 97 Reference	5.2	(0.30)	9.3	(0.63)	19.9	(0.31)	35.2	(2.87)	50.6	(16.54)	0
Apr 97 Project	4.6	(0.14)	8.8	(0.39	17.2	(0.43)	32.9	(1.13)	25.3	(4.91)	14
Apr 97 Reference	6.1	(0.20)	7.9	(0.28)	17.3	(0.44)	35.0	(1.81)	8.5	(1.55)	0.7
Sept 97 Project	11.4	(0.72)	7.4	(0.76)	30.2	(0.58)	26.8	(1.65)	10.0	(1.99)	37
Sept 97 Reference	19.0	(0.39)	5.5	(0.29)	29.7	(0.35)	43.4	(2.29)	8.8	(2.64)	7


Mean Total Fish Density (transformed)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R

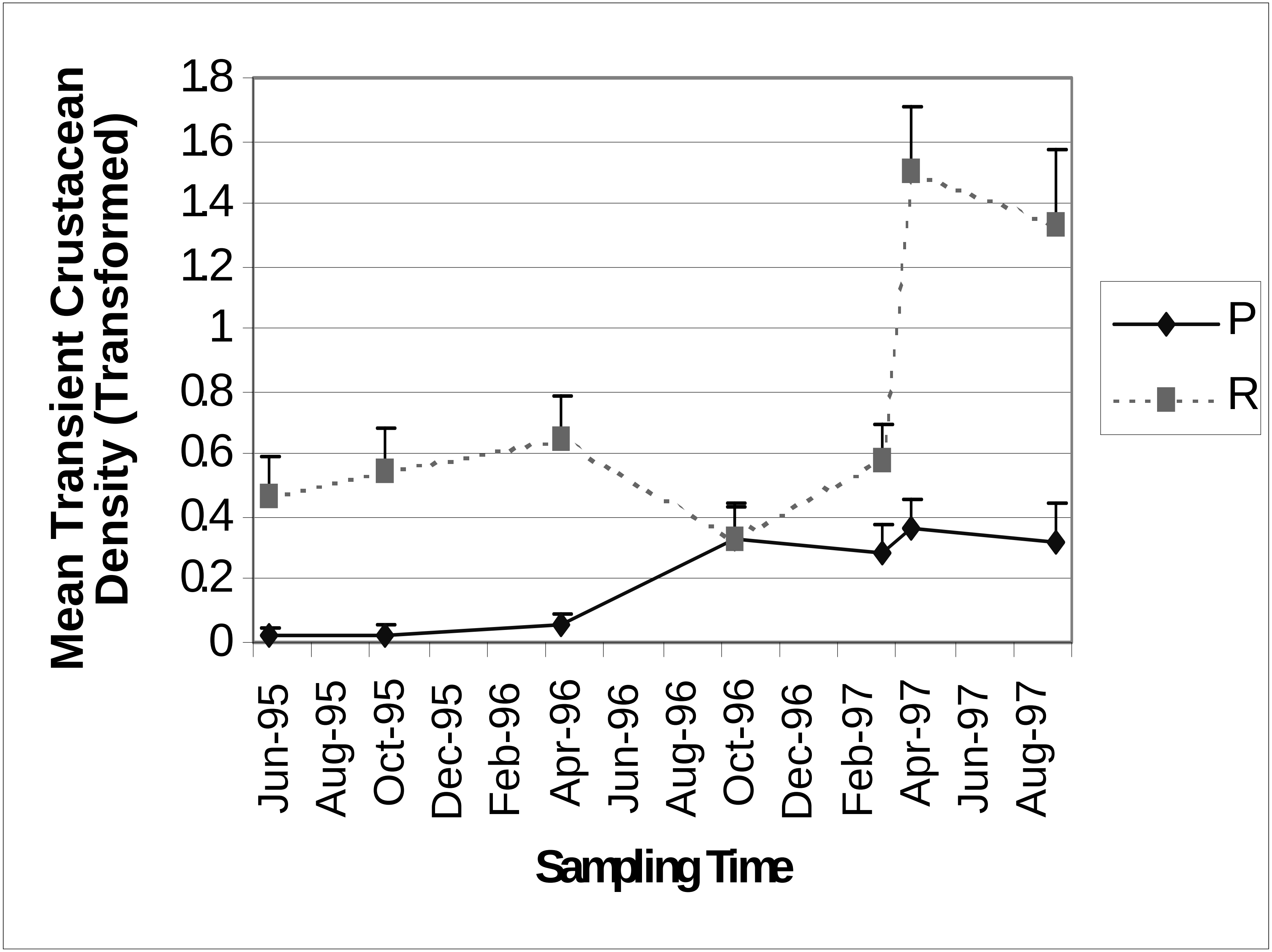

Mean Total Crustacean Density
(Transformed)
2.5
2
1.5
1
0.5
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R



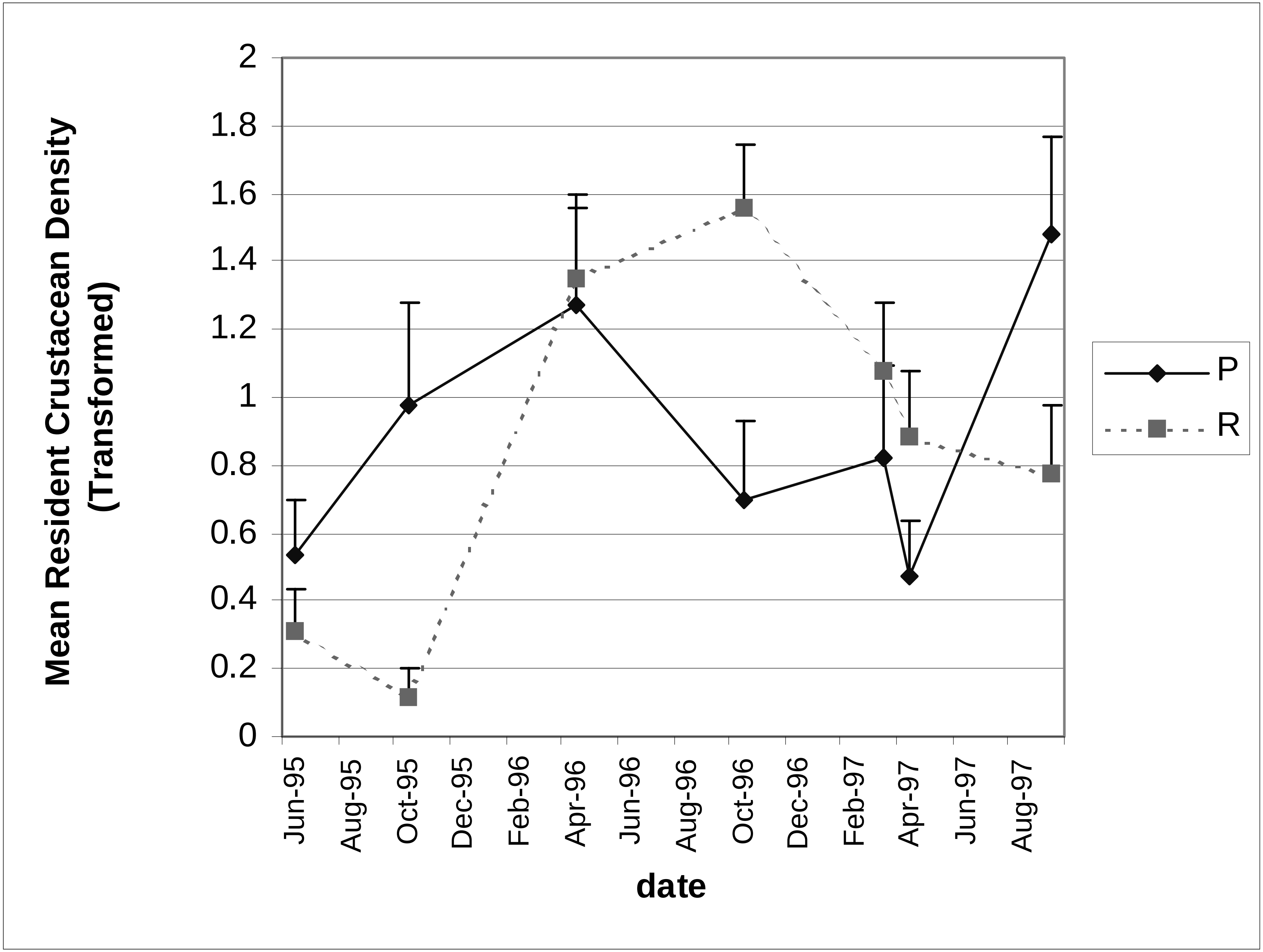
Mean Transient Fish Density (Transformed)
2.5
2
1.5
1
0.5
0
influx of menhaden
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R

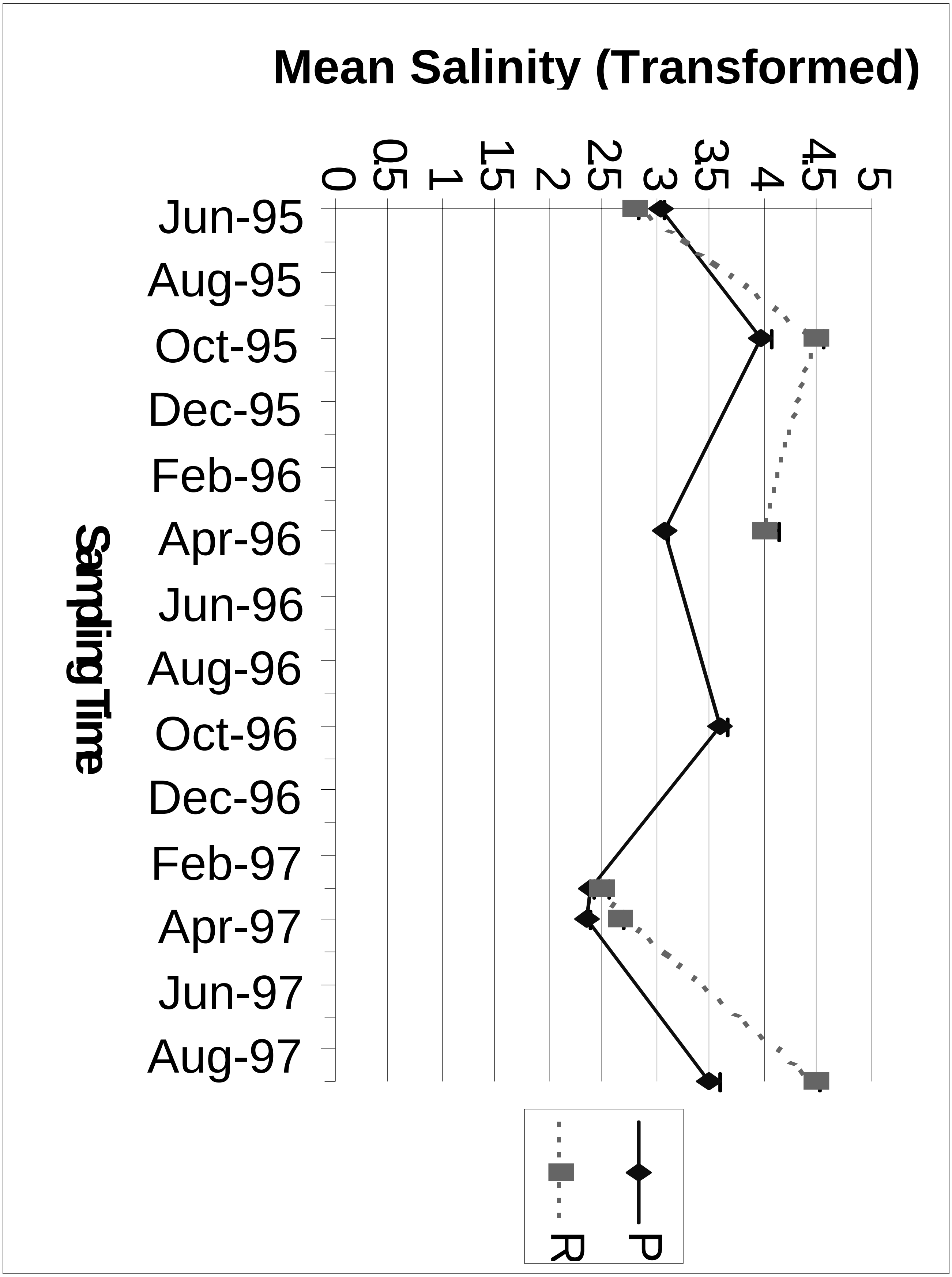


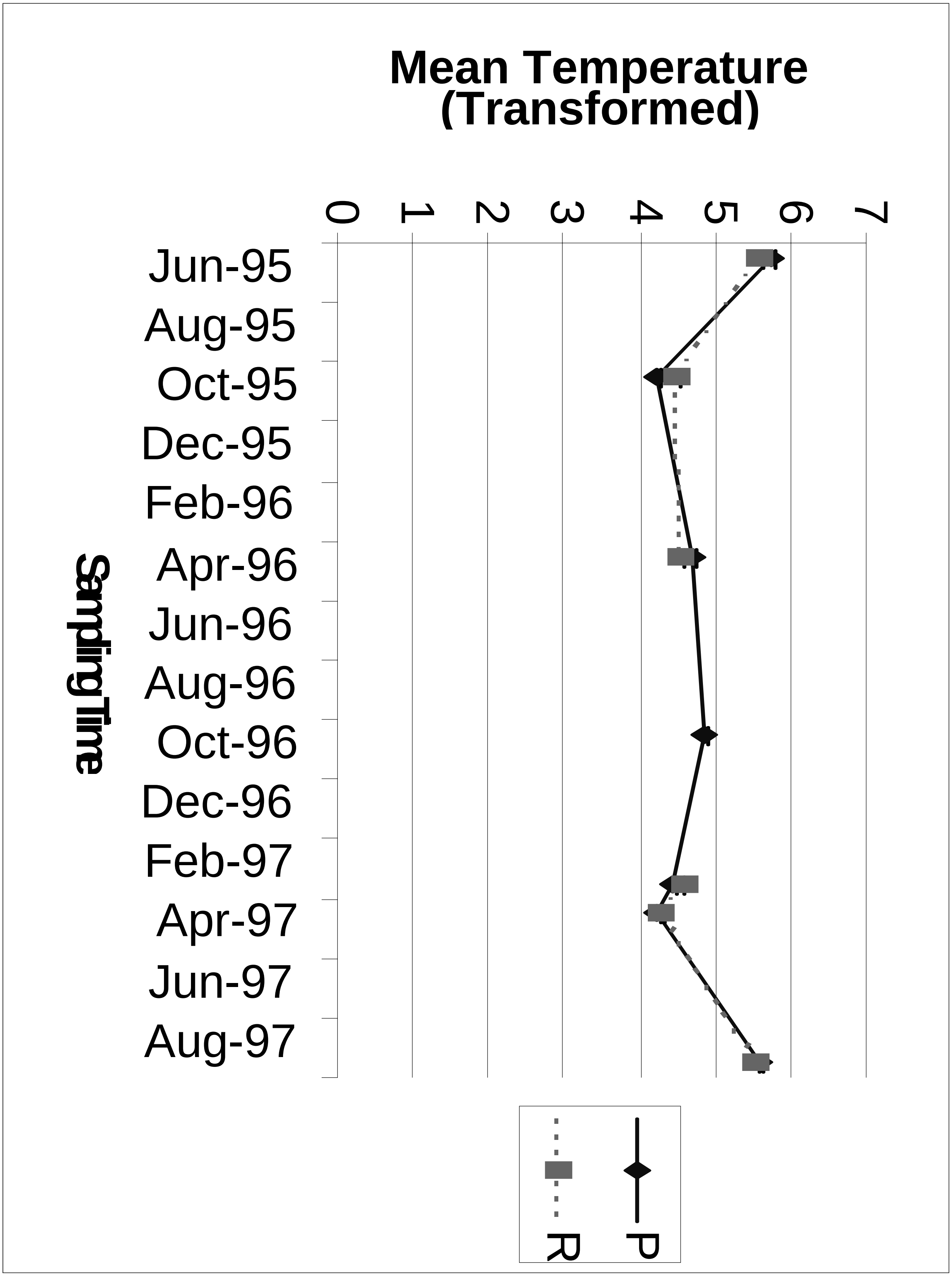
Mean Resident Fish Density (Transformed)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R

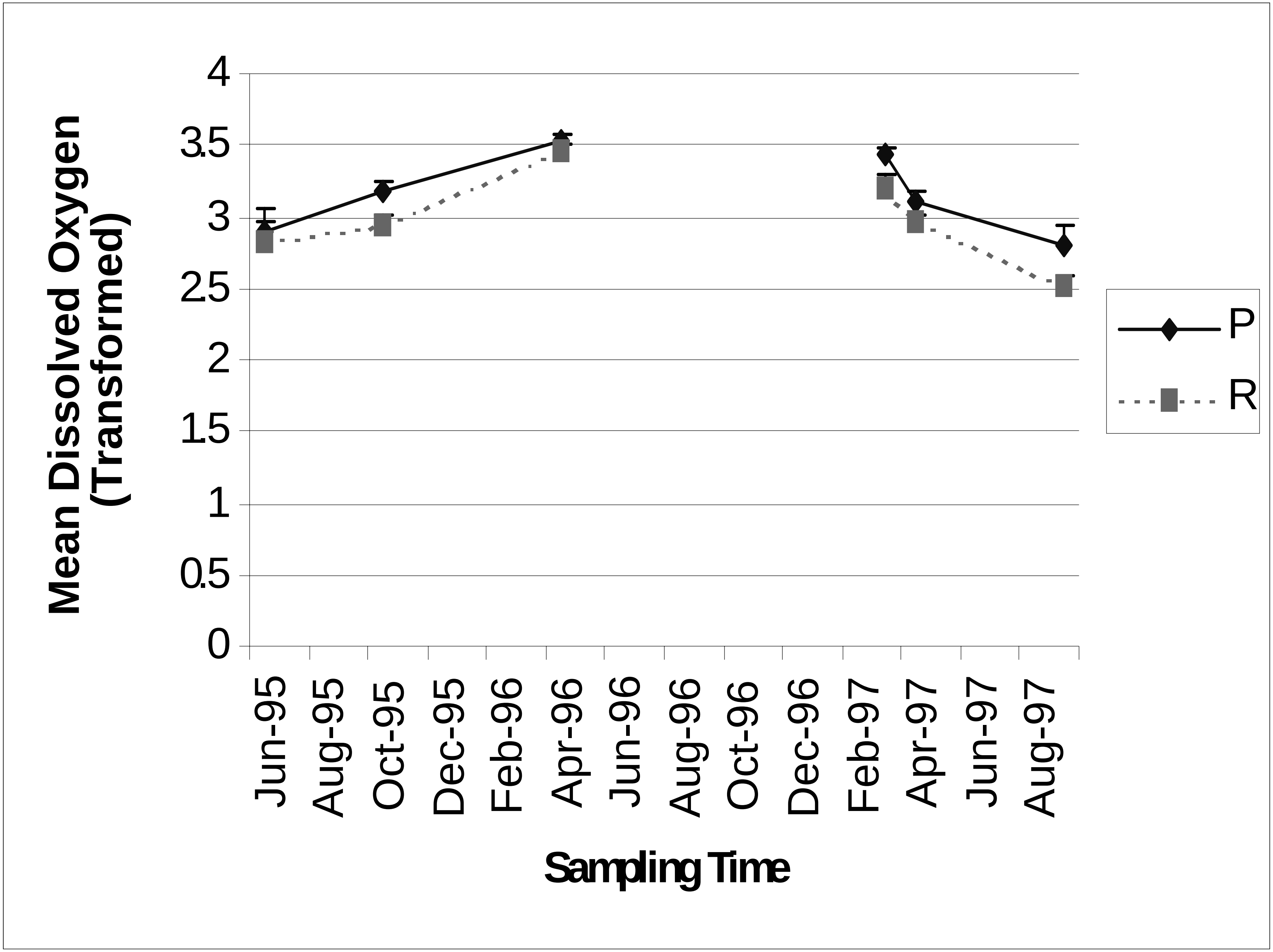


Mean Transient Crustacean Density (Transformed)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R

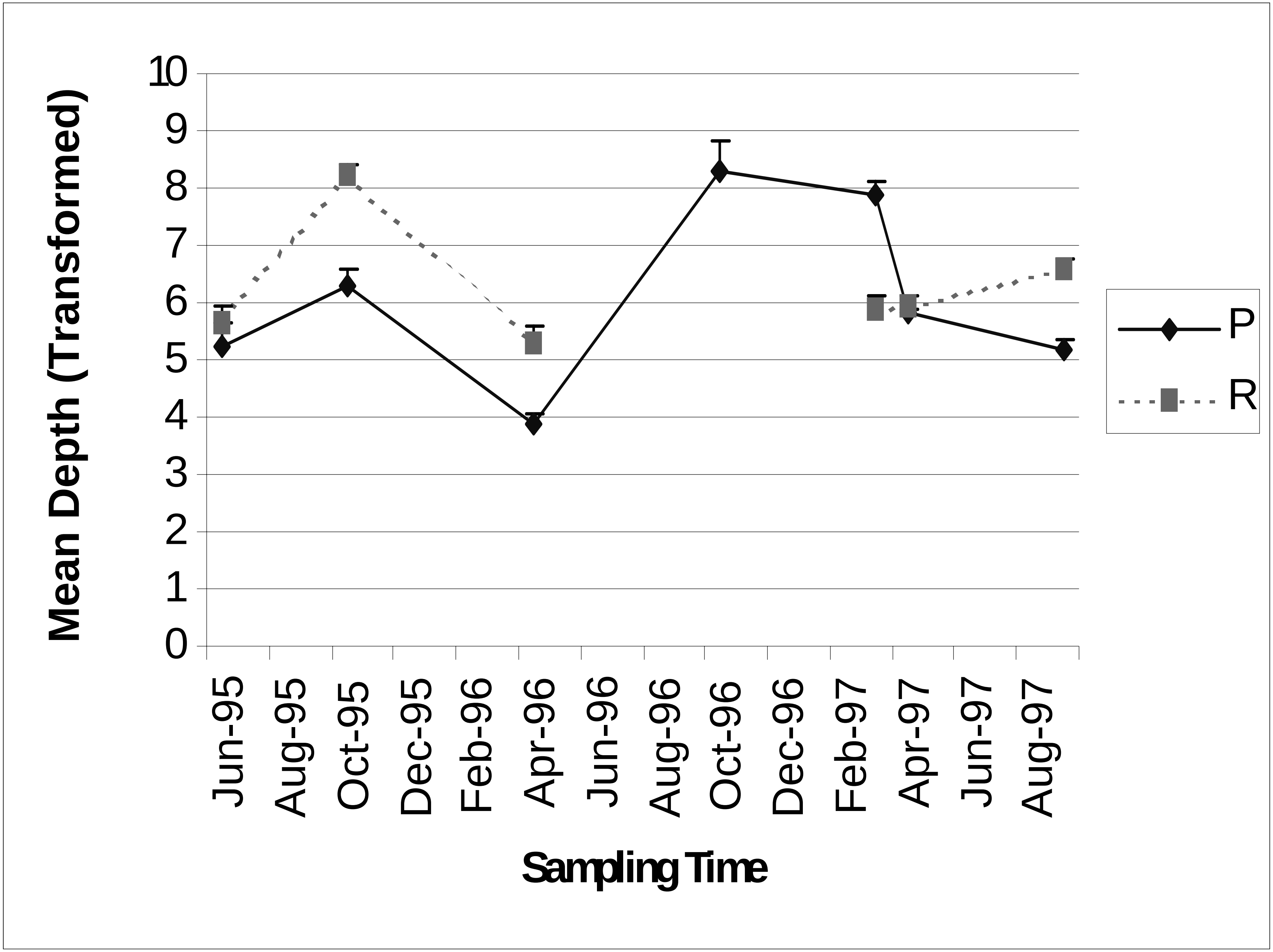

Mean Resident Crustacean Density
(Transformed)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
date
P
R


Mean Salinity (Transformed)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R

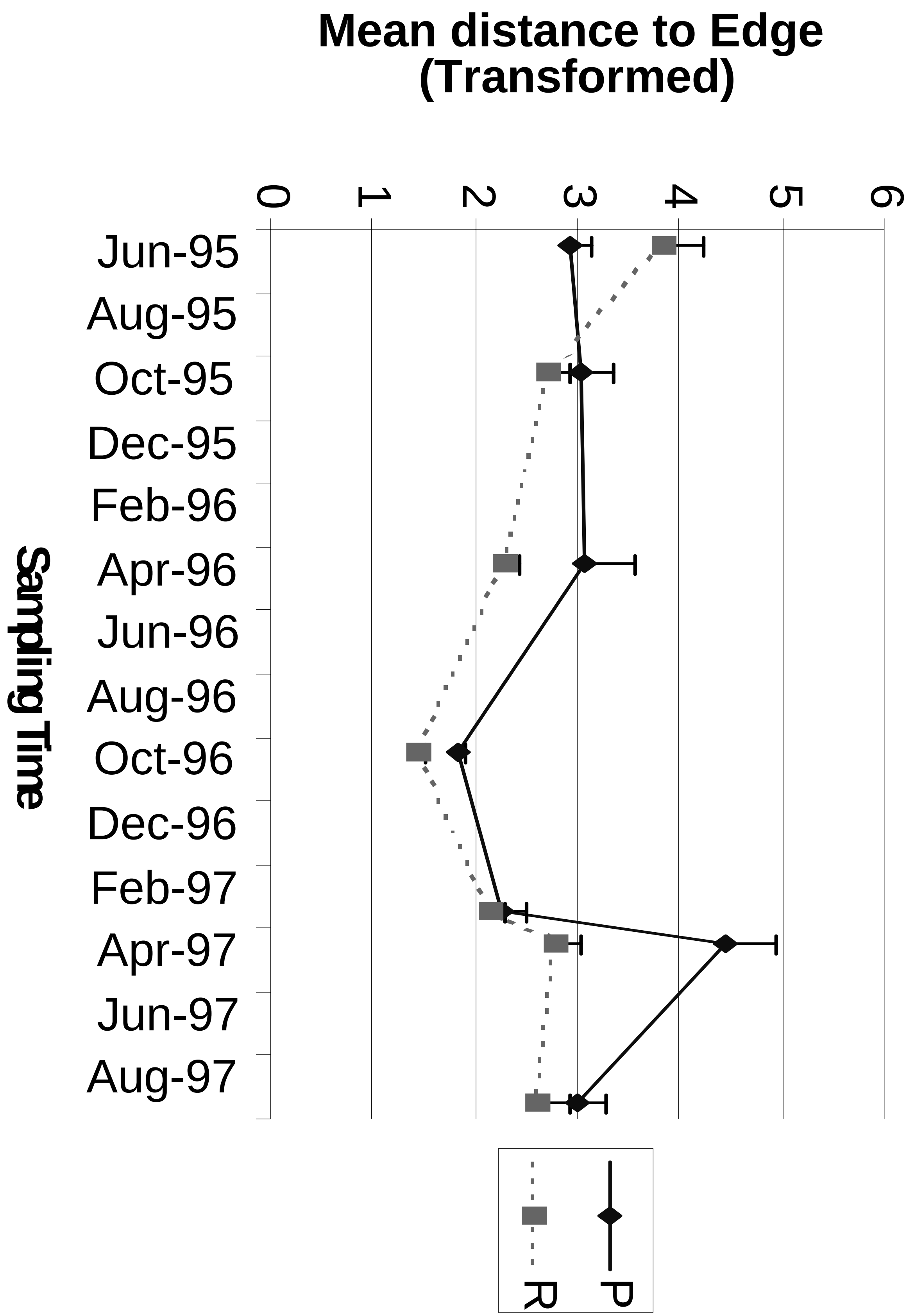

Mean Temperature (Transformed)
0
1
2
3
4
5
6
7
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R



Mean Dissolved Oxygen (Transformed)
4
3.5
3
2.5
2
1.5
1
0.5
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R



Mean Depth (Transformed)
10
9
8
7
6
5
4
3
2
1
0
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R


Mean distance to Edge
(Transformed)
0
1
2
3
4
5
6
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Sampling Time
P
R