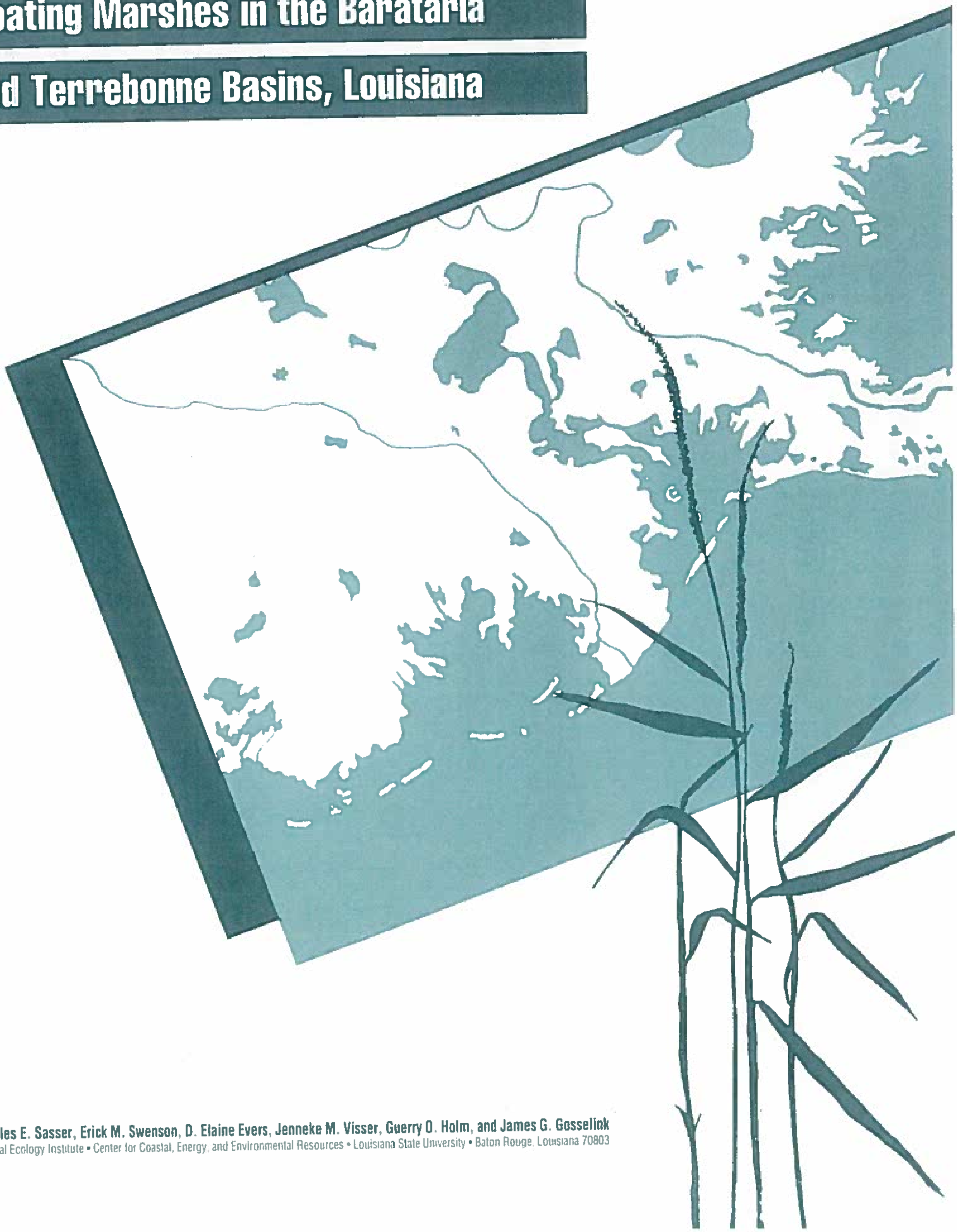
Floating Marshes in the Barataria and Terrebonne Basins, Louisiana



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CONTRIBUTORS

The authors of this report are affiliated with the Coastal Ecology Institute, Center for Coastal, Energy, and Environmental Resources, Louisiana State University, Baton Rouge, Louisiana. Although all authors contributed significantly during both the field portion of this project and preparation of the report, we would like to acknowledge the emphasis of each authors contribution.

Charles E. Sasser: Coordination of all sections in this study.

D. Elaine Evers: Coordination of mapping section.

Erick M. Swenson: Coordination of hydrology section.

Jenneke M. Visser: Coordination of vegetation section.

Guerry O. Holm: Field and laboratory assistance in all sections.

James G. Gosselink: Contributed to all chapters.

CONVERSION FACTORS AND ABBREVIATIONS

multiply English units	by	to obtain metric units
inch (in)	25.4	millimeter (mm)
cubic inch (in^3)	16.39	cubic centimeter (cm^3)
square inch (in^2)	6.452	square cm (cm^2)
foot (ft)	0.3048	meter (m)
square foot (ft^2)	929	square centimeter (cm^2)
square foot (ft^2)	0.0929	square meter (m^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per second(ft^3/sec)	0.02832	cubic meter per second (m^3/sec)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic mile (mi^3)	4.168	cubic kilometer (km^3)
mile per hour (mi/hr)	1.609	kilometer per hour (km/hr)
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
ounce, avoirdupois (oz)	28.35	gram (g)
ounce, fluid (fl oz)	0.02957	liter (L)
pint (pt)	0.4732	liter (L)
quart (qt)	0.9464	liter (L)
gallon (gal)	3.785	liter (L)

Temperature in degrees Celsius (°C) can be converted to degrees Farenheit (°F) as follows:

$°F = 1.8 * °C + 32$

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CHAPTER 1: INTRODUCTION

BACKGROUND

Floating marshes supporting emergent vascular vegetation occur in Louisiana as well as other parts of the world. These marshes have buoyant mats that rise and fall with changes in water level, and are thus seldom or never flooded, unlike the regular tidal or seasonal flooding characteristic of attached (non-floating) marshes.

Large regions of floating marsh dominated by *Cyperus papyrus* occur along rivers and lakes in central and eastern Africa (Gaudet 1976, 1977, 1979). The best known from the literature are the "sudd" swamps (marshes) on the upper Nile River (Migahid 1947, Beadle 1974, Rzoska 1974, Thompson 1985), the *Cyperus papyrus* swamps at Lake Naivasha, Kenya and Lake Victoria, Uganda (Gaudet 1976, 1977), in the Nile and Congo Basins (Gaudet, 1976), and in the inland delta of the Okavango in Botswana (Thompson 1976, 1985, Ellery et al. 1990). In the Danube River Delta in Romania extensive floating mats called "plav" occur, dominated by *Phragmites australis* and covering about 100,000 ha of the region (Rodewald-Rudescu 1974, Pallis 1915). The middle Amazon Basin varzea (floodplain) supports permanent floating meadows associated with the Amazon River in South America (Junk 1970). Smaller areas occur also in The Netherlands (Verhoeven 1992), Australia (Wheeler 1980), Canada (Hogg and Wein 1988a, 1988b), Hawaii, Florida, Georgia, and Arkansas (Cypert 1972, Huffman and Lonard 1983).

Our present knowledge of floating marshes in Louisiana indicate that they are dominated by *Panicum hemitomon, Sagittaria lancifolia*, and *Eleocharis baldwinii*. (Sasser et al., submitted to Vegetatio). We do not include as floating marshes those areas covered by floating aquatic vegetation such as *Eichornia crassipes*, *Alternanthera philoxeroides*, and *Nymphaea* spp., which float without a substantial mat.

In Louisiana it has been nearly five decades since O'Neil (1949) and Russell (1942) made a serious effort to describe and map the state's floating marshes. O'Neil estimated that there were over 100,000 ha of floating marshes in the Mississippi River deltaic plain wetlands (Figure 1.1). These two scientists also proposed quite different hypotheses for the origin of floating marshes. Russell proposed that floating mats formed by the spreading and consolidation of floating aquatic plants into open water. O'Neil thought that subsidence of the underlying substrate eventually caused an attached mat to break free and float.

Since the 1940's little emphasis has been placed on researching the condition and distribution of floating marshes, or the ecological processes important to understanding and managing them. Until the last decade they have received almost no research attention, although our fragmentary evidence from small-scale studies shows that they function quite different from the better-understood attached marshes. This suggests that our management practices, which do not distinguish the two types, need to be tailored for floating marshes. We can do this only if we

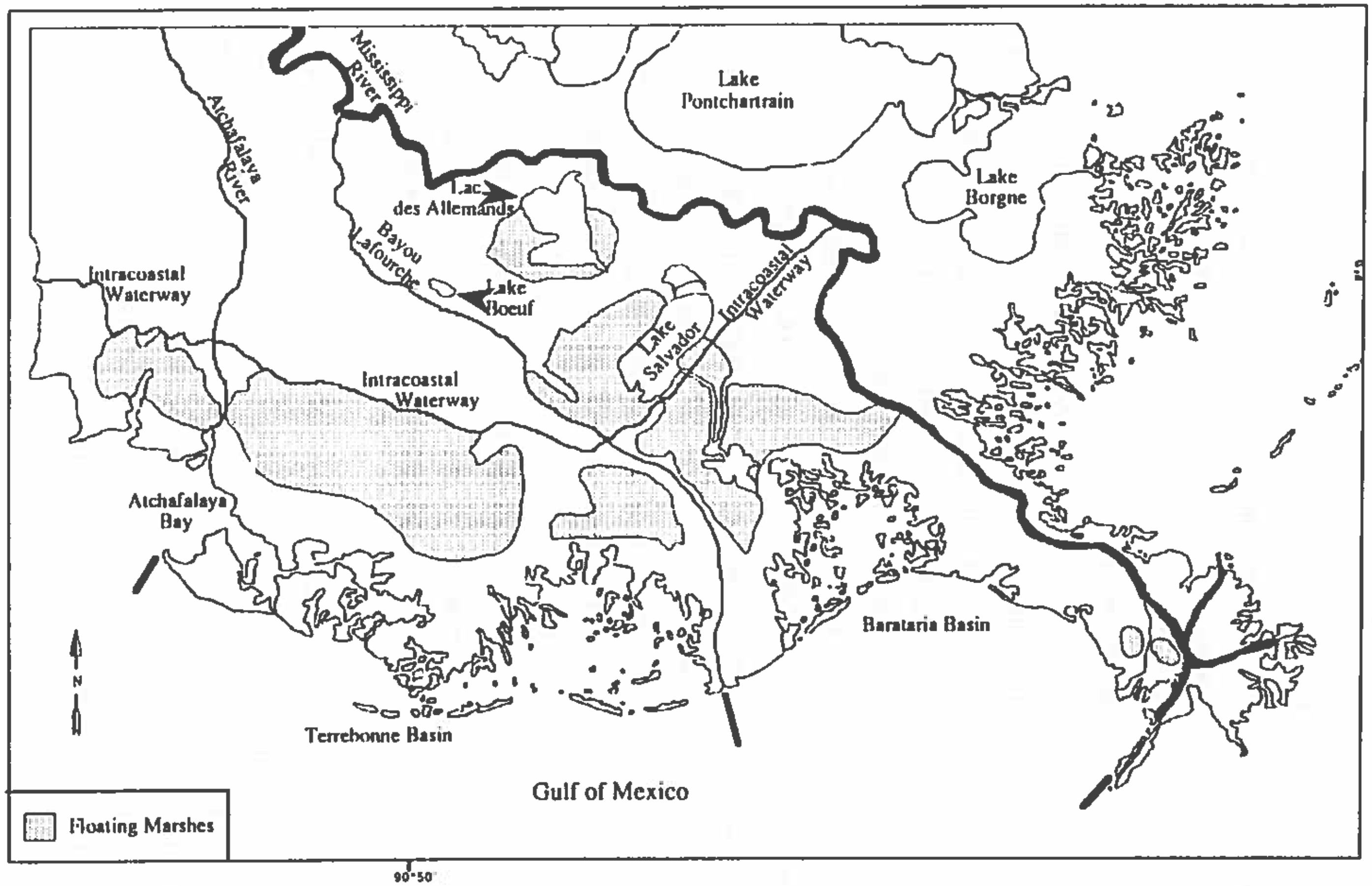


Figure 1.1. Location of floating marshes mapped by O'Neil (1949) in the Mississippi River Delta Plain.

know how widespread these marshes are, understand how they function, and in particular how they react to such human activities as sediment introduction, dredging, and impoundment. Recent work has helped us learn something about the extent and types of floating marshes in localized areas of Barataria and Terrebonne basins (Swarzenski et al. 1991, Sasser et al., in press). Additionally, we have studied plant productivity and nutrient concentrations in a *Panicum hemitomon*-dominated floating marsh surrounding Lake Boeuf in Barataria Basin (Sasser and Gosselink 1984, Sasser et al. 1991), and along Turtle Bayou in Terrebonne Basin (Sasser 1994).

PURPOSE OF THE STUDY

This report describes the vegetation, hydrologic, and substrate characteristics of the floating marshes in Barataria and Terrebonne basins, in the Mississippi River Delta Plain of Louisiana. The primary objectives of this study were:

(1) To classify and map the different types of floating marshes in the Barataria and Terrebonne coastal region. This objective had two parts:

a) To classify floating marshes into broadly different types, based on such characteristics as dominant vegetation, thickness and composition of the mat, soil bulk characteristics, and hydrology.

b) To locate and map floating marshes in Barataria and Terrebonne basins.

Secondary objectives were to determine if possible the conditions that lead to the formation of floating marshes on the Louisiana coast, and identify key ecological questions in floating marshes, in relation to research needs for their intelligent management.

The general approach taken in this study was to map vegetation associations from recent aerial photography, and then investigate the relationship between plant communities and mat buoyancy through a combination of extensive groundtruthing by helicopter and boat, and by intensive analysis of marsh mat movement, ambient water level dynamics, substrate characteristics, and vegetation at a limited number of representative sites.

STUDY AREA DESCRIPTION

General Study Area

The study area of this project includes the freshwater and intermediate marshes in the Barataria and Terrebonne basins of coastal Louisiana (Figure 1.2). These basins are within an area bounded on the west by the Atchafalaya River, on the east by the Mississippi River, and on the south by the Gulf of Mexico. For the purposes of this study the northern boundary is the interface of freshwater marsh with swamp forest, and the southern boundary the interface between intermediate marsh and brackish marsh as defined by Chabreck and Linscombe's 1988 Vegetative Type Map of the Louisiana Coastal Marshes (Chabreck and Linscombe 1988).

A description of the wetland habitats that occur in Barataria and Terrebonne basins can be found in various sources including Penfound and Hathaway (1938), Chabreck (1972), and Gosselink (1984). Both Barataria and Terrebonne basins support extensive marshes that grade from saline at the coast into brackish, intermediate and fresh marshes in a northward (inland) direction (Chabreck 1972). The freshwater and intermediate marshes in the northern parts of the basins have highly organic peat soils, compared to increasingly mineral soils in the brackish and salt marshes of the lower basins.

Description of Primary Study Sites

Thirteen study sites were established at the beginning of this project to intensively monitor marsh mat and water level movement over the period of the study. The sites were selected based on current information regarding the types of vegetated habitats in the study area and their floating status. This information base was supplemented by aerial surveys of the Barataria and Terrebonne basins at the beginning of the project to improve our perspective of the general distribution of the habitats. Study sites were selected that were determined to be representative of the major habitat types identified. These habitat types included:

(1) *Panicum hemitomon*-freshwater marsh (in particular, areas within this habitat along natural levees of major bayous, such as Bayou Penchant and Bayou Des Allemands)

(2) *Panicum hemitomon/Sagittaria lancifolia*-freshwater marsh

(3) *Sagittaria lancifolia*-freshwater marsh

(4) *Eleocharis* sp.-freshwater thin-mat marsh

(5) *Spartina patens*-dominated intermediate marsh

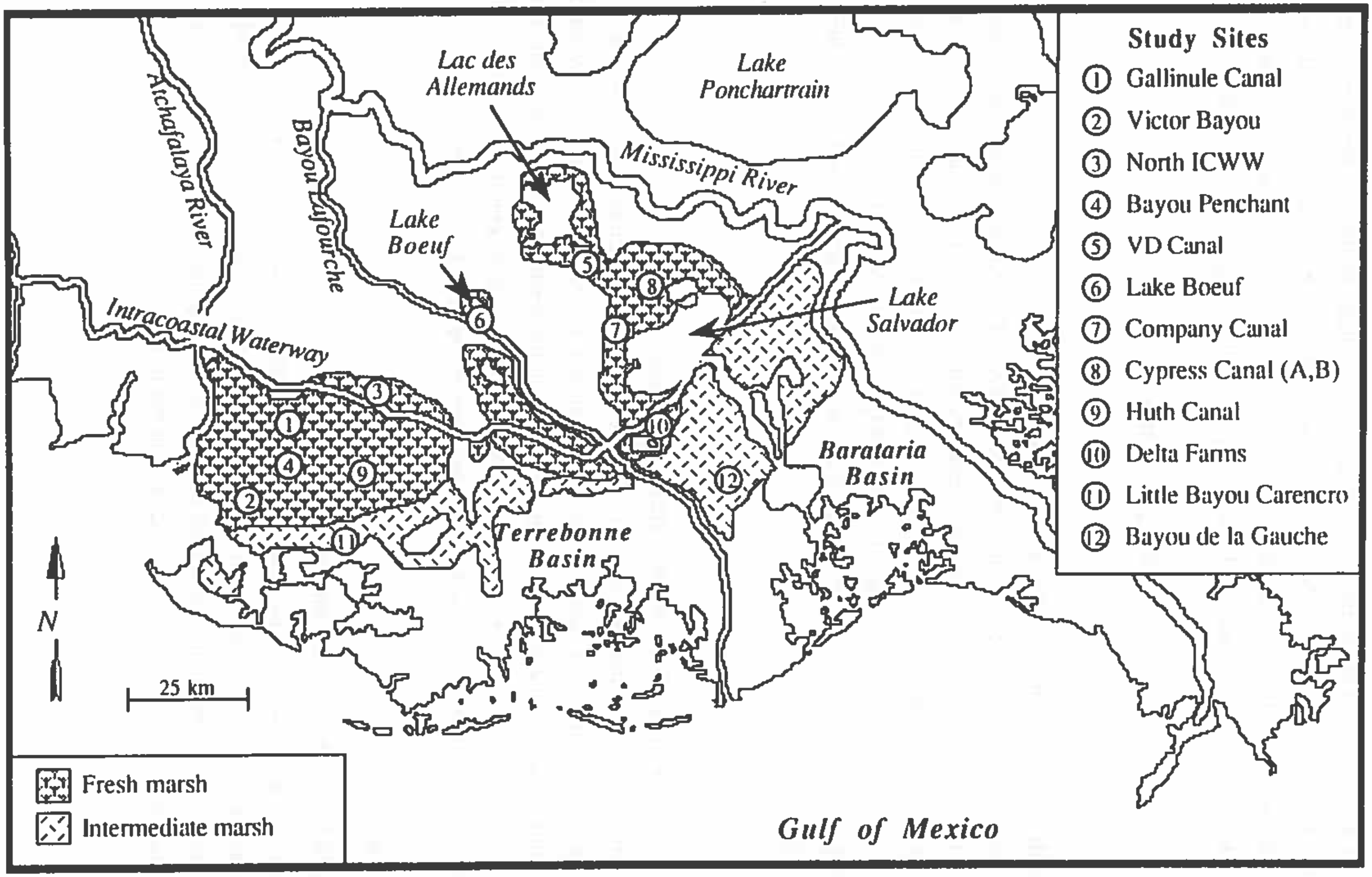


Figure 1.2. Map showing the location of the study area and primary study sites.

In addition to vegetation type, sites were chosen to represent a hydrological gradient from the upper basin to the lower part of the basin. To study the hydrology of the area the sites were divided in four transects (two in each basin) with three stations each (north, middle, and south). The location of the study sites are indicated in Figure 1.2 and the geographical coordinates (lattitude and longitude) are provided in Table 1.1. A brief description of each site follows.

Barataria Basin

VD Canal

Site 5, North Station, Eastern Barataria Transect

The VD canal site is located on the west side of Bayou Des Allemands, approximately 5 km north of the city of Des Allemands. This site is representative of the large natural levee flank marshes along Bayou Des Allemands in Barataria Basin that have been dominated by *Panicum hemitomon* over at least the last 50 years (O'Neil 1949, Chabreck 1972). Other plant species, notably *Typha* sp. and *Sagittaria lancifolia*, occur mixed with the *Panicum hemitomon* in the general vicinity of the gauge.

Cypress Canal A

Site 8a, Middle Station, Eastern Barataria Transect

This site is located in the freshwater area of the upper Barataria Basin, in a thin-mat *Eleocharis baldwinii*-dominated marsh on the south side of Cypress Canal, which runs west from Lake Cataouatche near the interface of a swamp forest with the fresh marsh. This general region is one of mixed fresh marsh vegetation associations, with the fresh marsh grading into intermediate marsh approximately 10 km to the south nearer the north shore of Lake Salvador.

Cypress Canal B

Site 8b, Middle Station, Eastern Barataria Transect

This site is also located on the south side of the Cypress Canal west of Lake Cataouatche (see above), approximately 1 km east of the thin-mat site on that canal. The vegetation at this site is a mixed fresh marsh community dominated by *Sagittaria lancifolia*. The marsh mat is thick. It is of considerable interest that this site is located so near the thin-mat site yet is very different in character.

Table 1.1. Latitude and longitude decimal calculations from USGS quadrangles for each primary study site.

Gauge Number	Gauge Site	7.5 Minute Map (LA)	Latitude	Longitude
1	Gallinule Canal	Morgan City SE	29° 36.59'	91° 00.40'
2	Victor Bayou	Carrencro Bayou	29° 28.52'	91° 07.02'
3	North ICWW	Humphreys	29° 32.39'	90° 51.13'
4	Bayou Penchant	Lake Penchant	29° 29.94'	90° 59.27'
5	VD Canal	Des Allemands	29° 50.44'	90° 29.11'
6	Lake Boeuf	Bayou Boeuf	29° 46.70'	90° 37.31'
7	Company Canal	Gheens	29° 42.02'	90° 22.78'
8A	Cypress Canal A	Lake Cataouatche	29° 51.16'	90° 18.99'
8B	Cypress Canal B	Lake Cataouatche	29° 51.16'	90° 18.66'
9	Huth Canal	Lake Penchant	29° 28.84'	90° 55.24'
10	Delta Farms	Barataria	29° 38.26'	90° 14.52'
11	Little Carencro Bayou	Lake Penchant	29° 24.46'	90° 59.66'
12	Bayou de la Gauche	Cut Off	29° 32.41'	90° 16.13'

Delta Farms

Site 10, South Station, Eastern Barataria Transect

The study site at the Delta Farms area is located south of the Intracoastal Waterway, in the interior marsh between Larose and Bayou Perot. The vegetation at this site is a mixed fresh marsh, dominated by *Panicum hemitomon* and *Sagittaria lancifolia*. The general region of this study site is the interface between fresh and intermediate marsh habitats. The vegetation community in the region is generally diverse and patchy, with high spatial variation in species composition.

Lake Boeuf

Site 6, North Station, Western Barataria Transect

The Lake Boeuf marsh site is in the freshwater region of the upper Barataria Basin. The study site is within the ~3000 ha of fresh marsh dominated by *Panicum hemitomon* that surrounds Lake Boeuf, a freshwater lake covering about 640 ha. This site is represenative of the *Panicum hemitomon* habitat.

Company Canal

Site 7, Middle Station, Western Barataria Transect

The Company Canal site is located in the marsh on the northern side of Company Canal, approximately 5 km west of Bayou Des Allemands. Company Canal runs east to west between Bayou Des Allemands and the Gheens area, west of Lake Salvador. This site is represenative of the mixed *Panicum hemitomon* and *Sagittaria lancifolia* fresh marshes in the Barataria Basin.

Bayou de la Gauche

Site 12, South Station, Western Barataria Transect

The Bayou de la Gauche study site is located in an extensive area of intermediate marsh on the northern side of the bayou, approximately 1 km east of Clovelly Farm. This area has a mixture of several habitats dominated by *Spartina patens* with *Sagittaria lancifolia*, *Eleocharis rostellata*, and other intermediate marsh species.

Terrebonne Basin

North ICWW

Site 3, North Station, Eastern Terrebonne Transect

The North ICWW (Intracoastal Waterway) site is in a thin-mat marsh on the north side of the ICWW southwest of Houma. This is a region of mixed freshwater marsh. Vegetation at this study site is dominated by *Eleocharis baldwinii.*

Huth Canal

Site 9, Middle Station, Eastern Terrebonne Transect

The Huth Canal site is located on the western natural levee of an unamed bayou that connects Huth Canal with Lake Penchant. This site is in a *Panicum hemitomon*-dominated marsh, and is representative of the *Panicum hemitomon*-dominated marsh type in a general area of mixed freshwater vegetation. A large stand of *Typha* sp. occurs west of the site.

Little Bayou Carencro

Site 11, South Station, Eastern Terrebonne Transect

This site is located along the eastern edge of Little Bayou Carencro near its intersection with Brady Canal. This site is in an intermediate marsh, dominated by *Spartina patens*. The vegetation at this site is very clumpy, with relatively large variations in elevation. Species diversity was high and the distribution of species patchy. The vegetated area was interspersed with open water.

Gallinule Canal

Site 1, North Station, Western Terrebonne Transect

The Gallinule Canal site is located on the west side of a canal that runs south from the Intracoastal Waterway to the Turtle Bayou area of the upper Terrebonne Basin. This is an area of thin-mat marsh and open water. The dominant vegetation is *Eleocharis baldwinil*.

Bayou Penchant

Site 4, Middle Station, Western Terrebonne Transect

The Bayou Penchant site is located on the north side of an access canal on the east side of Bayou Penchant in upper Terrebonne Basin. This site is in a *Panicum hemitomon*-dominated freshwater marsh habitat, that is representative of the extensive thick-mat marshes along the flanks of Bayou Penchant.

Victor Bayou

Site 2, South Station, Western Terrebonne Transect

The Victor Bayou site is located on the south side of Victor Canal in an extensive marsh dominated by *Panicum hemitomon* and *Sagittaria lancifolia*. This site is located in the southern portion of the fresh marsh zone in Terrebonne Basin and is influenced by the sediment-rich waters of the nearby Atchafalaya River.

CHAPTER 2: MAPPING THE FLOATING MARSHES IN THE BARATARIA AND TERREBONNE COASTAL REGION OF LOUISIANA

INTRODUCTION

This chapter presents a classification of the present-day floating marshes in the Terrebonne and Barataria basins, Louisiana, into several floating categories, as outlined in Chapter 1, objective 1(b). We also included classifications of other emergent marshes of non-floating character or undetermined buoyancy in our classification scheme. The floating/non-floating differentiation is important because floating and attached (non-floating) marshes react differently to natural and man-induced processes and require different strategies for their best management.

METHODS

Study Area

Previous research indicates that floating marshes are habitat types found in fresh and intermediate marshes (O'Neil 1949, Sasser et al. submitted). In characterizing the marshes of the Barataria and Terrebonne basins, we included the fresh and intermediate areas as determined by Chabreck and Linscombe (1988) in the Mississippi River Delta Plain of the Louisiana coast (Figure 1.2). The brackish and saline marshes have substrates with high mineral density that prevents mats from floating, and are therefore not included in this study. The eastern and western boundaries of the study area are the Mississippi River and Atchafalaya River, respectively.

Photo-interpretation

We visually photo-interpreted 1:63,500-scale color infrared photographic transparencies from December 1990 (source: U.S. Army Corps of Engineers), in conjunction with reconnaissance and ground verification, to determine the different types and amounts of marsh present in the study area, with emphasis on identifying floating marshes. We interpreted imagery using a Bausch and Lomb Zoom Transfer Scope, using USGS 7.5-minute quadrangle sheets as the base and a minimum mapping unit of 1 ha. For cursory examinations of the photography, we used a Bausch and Lomb stereoscope and illumination table. We drafted the interpreted images onto 1-sided matte mylar. Our final product was the accompanying atlas, included with this report, of habitat overlays at a scale of 1:24,000, reflecting the status of the study area as of December 1990.

Color infrared photography displays certain signatures as a key to identification of the vegetative community. For instance, the signature of a robust stand of *Panicum hemitomom* marsh often appears bleached-white and somewhat coarse-grained in texture. Some communities share similar chroma, texture, and pattern. Oftentimes, similar signatures have different species composition, depending on where they are found, such as fresh or brackish and east or west. We therefore took into account the region of the signature. A signature in northern Terrebonne Basin might signify one association, but it might signify a different association in southern Terrebonne Basin. The same property might separate a fresh from a brackish signature. (See Table 2.1 for a description of all the habitat types encountered.)

The most difficult aspect of vegetative mapping is the placement of a line to divide a community or association of vegetation. Some transitions are abrupt, but subtle ecotones are more common. Significant effort was directed toward developing a classification system that dealt with these subtle transitions.

Field Verification

Prior to the beginning of detailed photo-interpretation, reconnaissance flights using a helicopter with fixed floats were made to establish a framework for vegetative classification and identify general photographic signatures. This information was also critical for determining suitable sites for field deployment of continuous-recording water level gauges. We conducted field examinations by helicopter throughout the mapping process to insure accuracy in identification of vegetative communities, visiting a total of 315 sites within the two basins. We evaluated each site in terms of vegetation species composition and general buoyancy of the marsh mat. We separated vegetation into dominant, co-dominant, and other species categories. In addition to site descriptions of vegetation, we conducted extensive low-level aerial documentation of species composition en route to other sites.

When available, we used the water level gauge data as presented in Chapter 3 as a tool in classifying marshes. Once we identified a signature with a marsh that we determined was floating based on the gauge data, we used the information to classify and map that signature wherever else we found it. In areas where no other type of data were available we judged buoyancy qualitatively, because each marsh type exhibits unique characteristics in mat consistency. For example, a true floating marsh will display a waving, fluid motion when a person jumps on it, which indicates buoyancy. Another method that we used to check buoyancy was the helicopter's capacity to "power up and down" and cause a bouncing motion of a floating marsh. In contrast, a non-floating marsh mat will provide very little or no wave motion when pressure is applied. Different grades of buoyancy occur between these two examples.

Table 2.1. Mapping categories as distinguished on the maps in the accompanying atlas.

Category	Habitat Type	Dominant Species	Other Common Species	Description
Thick Mat, Herbaceous, Floating Marshes				
1	*Panicum hemitomon* flotant	*Panicum hemitomon*	*Thelypteris palustris*, *Leersia oryzoides*, *Conoclinium coelestinum*, *Sphagnum* spp.	Freshwater marsh, Floating thick mat
1.1	Broken-up *Panicum hemitomon* flotant	*Panicum hemitomon* with small open water ponds	*Thelypteris palustris*, *Leersia oryzoides*, *Conoclinium coelestinum*	Freshwater marsh, Floating thick mat interspersed with small water bodies
1.2	Clumpy *Panicum hemitomon* flotant	*Panicum hemitomon* occurring in clumps	*Thelypteris palustris*, *Leersia oryzoides*	Freshwater marsh, Sparse clumps of floating thick-mat marsh with more open water than 1.1
2	*Panicum hemitomon /Sagittaria lancifolia* flotant	*Panicum hemitomon* *Sagittaria lancifolia*	*Leersia oryzoides*, *Thelypteris palustris*	Freshwater marsh, Damped floating thick mat
3	*Sagittaria lancifolia* flotant	*Sagittaria lancifolia*	*Eleocharis* spp.	Freshwater/intermediate marsh, Seasonally floating thick mat
3.2	*Spartina patens* flotant	*Spartina patens*	*Eleocharis* spp., *Sagittaria lancifolia*, *Andropogon virginicus*	Intermediate marsh, Floating thick mat
8.2	*Spartina patens* flotant	*Spartina patens*	*Sagittaria lancifolia*, *Vigna luteola*, *Ipomoea sagittata*	Intermediate marsh, Floating thick mat

(continued)

Table 2.1. (Continued)

Category	Habitat Type	Dominant Species	Other Common Species	Description
8.3	*Spartina patens*/ *Scirpus olneyi* flotant	*Spartina patens* *Scirpus olneyi*		Intermediate marsh, Floating thick mat
B.1	*Spartina patens* flotant	*Spartina patens*		Floating thick mat (Note: One small area of *S. patens* was determined to be floating. No other floating *S. patens* sites were detected in the study area.)
Thick Mat, Woody, Floating Marshes				
5	*Myrica cerifera* flotant	*Myrica cerifera*	*Panicum hemitomon*, *Sagittaria lancifolia*, *Solidago sempervirens*	Freshwater marsh, Floating thick mat
5.1	*Myrica cerifera* /*Panicum hemitomon* flotant	*Myrica cerifera* *Panicum hemitomon*	*Sagittaria lancifolia*, *Solidago sempervirens*	Freshwater marsh, Floating thick mat

(continued)

Table 2.1. (Continued)

Category	Habitat Type	Dominant Species	Other Common Species	Description
Thin Mat, Floating Marshes				
4	*Eleocharis baldwinii* /*Hydrocotyle* spp. flotant	*Eleocharis baldwinii*, *Hydrocotyle* spp.	*Ludwigia leptocarpa*, *Bidens laevis*	Freshwater marsh, Seasonally floating thin mat
4.1	*Eleocharis baldwinii* /*Hydrocotyle* spp. flotant + open water	*Eleocharis baldwinii* and open water	*Hydrocotyle* spp.	Freshwater marsh, Seasonally floating thin mat
4.2	*Andropogon virginicus* /*Eupatorium capillifolium* flotant	*Andropogon virginicus*, *Eupatorium capillifolium*	*Solidago sempervirens*	Freshwater marsh, Floating thin mat
Thick Mat Marshes of Undetermined Buoyancy				
3.1	*Sagittaria lancifolia* marsh	*Sagittaria lancifolia*	*Iris* spp., *Typha* spp.	Freshwater marsh, Undetermined buoyancy
3.3	*Sagittaria lancifolia* /*Eleocharis baldwinii* marsh	*Sagittaria lancifolia*, *Eleocharis baldwinii*	*Hydrocotyle* spp., *Ludwigia leptocarpa*	Freshwater marsh, with islands of *Sagittaria lancifolia* of undetermined buoyancy, surrounded by a fringe of thin mat
3.4	*Sagittaria lancifolia* /*Eleocharis* spp. marsh	*Sagittaria lancifolia*, *Eleocharis* spp.	*Sacciolepis striata*	Freshwater marsh, Undetermined buoyancy
8.4	*Spartina patens* marsh	*Spartina patens*		Undetermined buoyancy
U	Concentrations of marsh islands	*Panicum hemitomon* /*Sagittaria latifolia*, *Eleocharis baldwinii*		Freshwater marsh mixture of areas of undetermined buoyancy and thin mat islands

(continued)

Table 2.1. (Continued)

Category	Habitat Type	Dominant Species	Other Common Species	Description
1.4	*Panicum hemitomon /Eleocharis* spp. fresh marsh	*Panicum hemitomon*, *Eleocharis* spp.	*Leersia oryzoides*, *Andropogon virginicus*	Freshwater marsh, Small islands with undetermined buoyanccy
Non-floating Marshes				
8	Non-floating marsh islands	*Typha* spp., *Zizania aquatica*, *Zizaniopsis miliacea*, or *Scirpus validus*	*Hydrocotyle* spp., Iris spp.	Non-floating
8.1	Misecllaneous marsh 1	*Colocasia antiquorum*	*Iris* spp., *Bidens laevis*, *Andropogon virginicus*	Freshwater, Non-floating
8.5	Miscellaneous marsh 2	*Colocasia antiquorum*	*Scirpus olneyi*, *Spartina patens*	Freshwater, Non-floating
Other				
6	Open Water			
7	Forested wetlands			
7.4	Spoilbank			
9	Developed			

A single visit to a site can be misleading because some marshes float only during the summer and fall, and all floating marshes are grounded during low water periods. Therefore we scheduled field verification flights during various times of the year with repeat visits to some areas in order to maximize our ability to identify floating marshes. If a marsh did exhibit some sponginess (possibly indicative of a floating marsh), but we had no conclusive evidence that it was truly floating, the marsh category remained unclassified in this project.

Physical measurements of the mat and water status were conducted at most sites. Depth of water on the marsh mat, approximate thickness of the root mat, and depth to a recognizable firm organic or mineral substrate aided in classification of the marsh types. A global positioning system (Magellan Skynav Model 5000) was used to record each site location in degrees, seconds, and tenths of a second latitude and longitude.

Data summarization

The data generated in this project will be digitized and entered into a geographical information database as a follow-up to this project. In order to obtain summary estimates of marsh area for this report, we analyzed a random sample of approximately one-tenth of the study area. We divided the marsh portion of the study area into 595-ha squares. We numbered each of those squares containing >50% marsh (626 squares) and used a random number generator to select our sample squares. We used the dot matrix method of area determination for each square (Gagliano and van Beek 1970), then summarized the marsh data by basin and for the overall study area.

RESULTS AND DISCUSSION

We identified several different types of floating marshes in our study. The detailed maps of marsh types are presented in the accompanying atlas, which contains a collection of quadrangle maps at a scale of 1:24,000 with clear mylar overlays. The different marsh classes ranged from small pockets surrounded by other marsh categories to large, open expanses.

We first separated the marshes by vegetation and signature, and later by buoyancy. Categories starting with 1 (i.e., 1, 1.1, 1.2, and 1.4) are all dominated by *Panicum hemitomon.* Categories starting with 2 are co-dominated by *P. hemitomon* and *Sagittaria lancifolia.* Categories starting with 3 include *Sagittaria lancifolia. Sagittaria lancifolia* is the dominant species in categories 3, 3.1, and 3.3. It is present, but not dominant, in category 3.2. Categories starting with 4 are thin mat categories, with categories 4 and 4.1 generally dominated by *Eleocharis baldwinii*, and category 4.2 dominated by *Andropogon virginicus* and *Eupatorium capillifolium.*

Categories 5 and 5.1 are dominated by *Myrica cerifera*. Categories starting with 8 identify various other marsh types, which are either attached, floating marshes, or undetermined marshes, and were different enough from the other classes to be separated. Water (category 6), forest (category 7 and 7.4) and developed areas (category 9) were also included in our classification scheme wherever applicable, but are not included in our estimate of areal extent. In the remainder of the discussion we will focus only on the marsh areas (categories 1 through 5, and category 8).

After the separation of marshes by dominant species, we further divided them by buoyancy. The flotant categories comprise thick mat types (categories 1, 1.1, 1.2, 2, 3, 3.2, 5, 5.1, 8.2, and 8.3) and thin mat (categories 4, 4.1, 4.2) (Tables 2.1 and 2.2). Based on our estimates from sub-sampling the mapping data base, we estimate that flotant covers over one-half of the total marsh area within the study area, with 65% in Barataria Basin and 60% in Terrebonne Basin (Figure 2.1).

We also determined a number of attached (non-floating) marsh types (categories 8, 8.1, and 8.5). These marshes were firm to walk on, exhibiting no "bounce" or movement. These marshes cover approximately 7% of the study area.

Further research is needed in some areas (categories 1.4, 3.1, and 3.4), where the buoyancy is still undetermined. These marshes were not solid, as were the marshes categorized as attached, but were "spongy", or with some movement, indicating possible buoyancy. Some areas had mixed buoyancy, along with mixed species composition, and were noted as U (undetermined).

Floating Marshes

Thick Mat, Herbaceous Flotant

The thick flotant with *Panicum hemitomon* as the dominant species (categories 1, 1.1, and 1.2) comprises one of the largest groups in the study area (16%). This habitat was described by O'Neil (1949) as extensive in coastal Louisiana in the 1940's. Interestingly, it is the only fresh marsh flotant he described. *Leersia oryzoides* and *Thelypteris palustris* are also commonly present (Table 2.1). Categories 1.1 and 1.2 are variations of 1 (Table 2.1), but are increasingly more broken up into open water ponds, respectively. Category 1 is generally found in large expanses of marsh, especially along the flanks of natural levees of large bayous in the freshwater marshes of Barataria and Terrebonne basins.

Category 2 flotant, with *P. hemitomon* and *Sagittaria lancifolia* as co-dominants, is found in both basins (see Atlas). Other species that commonly occur in this marsh type are *T. palustris*

Table 2.2. Estimates of the marsh areas as determined from random subsampling using the dot matrix method of area determination for each classification, as described in the methods section. Results of the estimates are given for the study area and for each basin.

Marsh Category	Flotant Type*	Habitat Type	Study Area	Terrebonne Basin	Barataria Basin
		Estimated Total Marsh Area	166,343 ha	87,119 ha	79,214 ha
Thick-mat, Herbaceous Floating Marshes					
1	I	*Panicum hemitomon* Flotant	10%	10%	10%
1.1	I	*Panicum hemitomon* Flotant	5%	6%	4%
1.2	I	Broken-up*Panicum hemitomon* Flotant	1%	2%	
2	II	Island clumps of*Panicum hemitomon /Sagittaria lancifolia* Flotant	7%	<1%	14%
3	III	*Sagittaria lancifolia* Flotant	6%	<1%	12%
3.2		*Sagittaria lancifolia* intermediate marsh	6%	2%	12%
8.3		*Spartina patens/Scirpus olneyi* marsh	3%	5%	
Thick-mat, Woody, Floating Marshes					
5	V	*Myrica cerifera* Flotant	11%	14%	7%
5.1	V	*Myrica cerifera /Panicum hemitomon* Flotant	<1%	<1%	<1%

* Based on Sasser *et al.* 1994

(continued)

Table 2.2. Continued.

Marsh Category	Flotant Type*	Habitat Type	Study Area	Terrebonne Basin	Barataria Basin
Thin-mat, Herbaceous Floating Marshes					
4	IV	*Eleocharis baldwinii* /*Hydrocotyle* spp Flotant	16%	22%	8%
4.1	IV	*Eleocharis baldwinii* /*Hydrocotyle* spp.Flotant + open water	2%	<1%	3%
4.2	IV	*Andropogon virginicus* /*Eupatorium capillifolium* Flotant	2%	3%	
Thick-mat Marshes of Undetermined Buoyancy					
1.4		*Panicum hemitomon* /*Eleocharis* spp. marsh	<1%	2%	
3.1		*Sagittaria lancifolia* fresh marsh	15%	6%	25%
3.3		*Sagittaria lancifolia* /*Eleocharis baldwinii* marsh	1%	2%	
3.4			< 1%		
8.2		*Spartina patens*/*Eleocharis* spp	7%	11%	2%
U		Undetermined islands	1%	2%	<1%
Attached Marshes					
8		Attached fresh marsh islands		<1%	<1%
8.1		Miscellaneous attached fresh marsh	7%	11%	<1%
8.5			< 1%		

* Based on Sasser *et al.* 1994

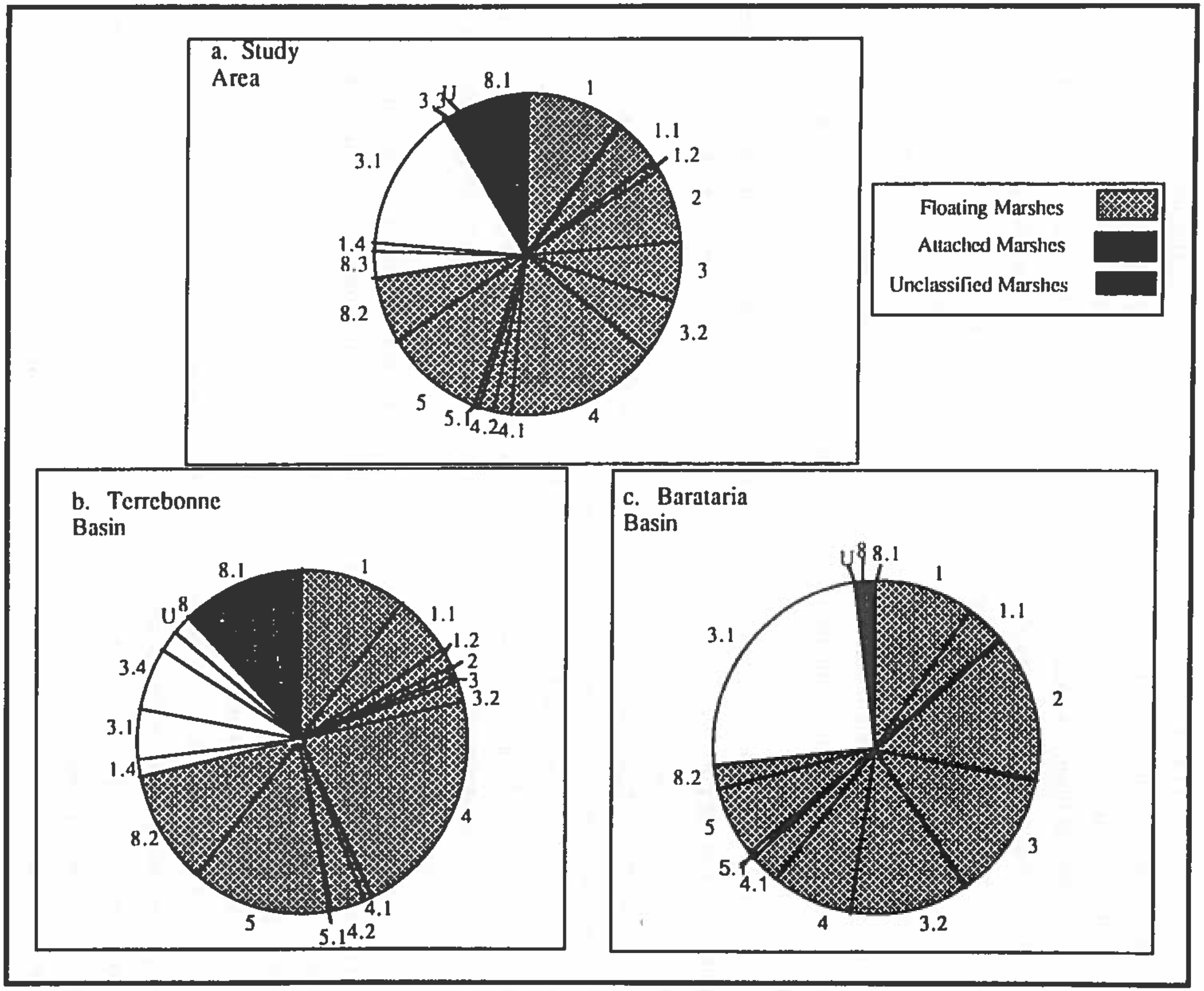


Figure 2.1. Estimated areas of different marsh classes in the study area .

and *Leersia oryzoides* (Table 2.2). It is a thick mat flotant with a damped floating character, as described by Sasser et al. (in press). These marshes are estimated to account for approximately 7% over the total study area (Figure 2.1a). It is estimated to account for a small part (1%, Figure 2.1b) of Terrebonne Basin. As seen in the atlas, it is found in the southwestern region of the freshwater marshes between the area of *P. hemitomon* flotant and the Atchafalaya River. An estimated 14% of the Barataria Basin marshes (Figure 2.1c) are this type, and are found mostly in the northern portion of the basin (atlas), between Lake Salvador and the swamp forest to the north.

Category 3 is a *Sagittaria lancifolia*-dominated, thick-mat intermediate marsh (Tables 2.1, 2.2) mostly confined to Barataria Basin. It is estimated to cover approximately 6% of the study area (Figure 2.1a), 12% of Barataria Basin, and small areas totaling <1% in Terrebonne Basin (Figures 2.1b and 2.1c).

Category 3.2 is dominated by *S. patens*, and covers an estimated 6% of the total study area (Figure 2.1). The category is an intermediate marsh and includes other species such as *S. lancifolia*, *Eleocharis* spp., and *Andropogon virginicus*.

Category 8.2 represents an intermediate marsh type and is estimated to be approximately 11% of the study area. It is found mostly in the southern portion of the study area in the intermediate marsh as determined by Chabreck and Linscombe (1988) (Table 2.2, Figure 2.1b). It contains a dominant mixture of *S. patens* along with other species, including *S. lancifolia*, *Vignea luteola*, *Ipomoea sagittata*, *Eleocharis* spp., *Eupatorium coelestinum*, *Andropogon glomeratus*, *T. palustris*, and *Kosteletzkia* sp. (Table 2.1).

Category 8.3 represents an intermediate marsh type and is estimated to be approximately 5% of the study area. The category is a co-dominant mixture of *S. patens* and *Scirpus olneyi* (Table 2.1). These marshes usually followed Chabreck and Linscombe's (1988) intermediate/brackish boundary line (atlas).

A floating *Spartina patens* marsh (category B.1, Table 2.1) was identified in Barataria Basin (Figure 2.1c) in the Bayou Perot area. This site was located near the border between the intermediate and brackish marshes as determined by Chabreck and Linscombe (1988). Although previous data indicate that *S. patens* brackish marshes do not float, this site demonstrates that some brackish marshes do float. This site confounds the flotant issue. The high buoyancy of this site may be due to its association with the seaward line of the current intermediate marsh.

Thick Mat, Woody Flotant

Because of the problems associated with helicopter landings in shrub communities, it was not possible to determine buoyancy of the *M. cerifera* categories. Our assumption of the buoyancy of this habitat type is based upon previous work by Williamson et al. (1984) and Sasser et al. (submitted), which indicates that *M. cerifera* stands associated with *Panicum* flotant are buoyant.

Category 5 includes large stands of wax myrtle and accounted for an estimated 10% of the study area, with an estimated 14% and 7% in Terrebonne and Barataria basins, respectively (Figure 2.1). Category 5.1 is a mixture of randomly-spaced individual *M. cerifera* shrubs in *Panicum* flotant (Table 2.1) and is estimated to account for less than 1% in either of the basin study areas (Figures 2.1b and 2.1c).

Thin Mat Flotant

Thin-mat categories (4, 4.1, 4.2) are characteristic of much of the study area (Table 2.2, Figure 2.1a). Category 4 is the most common thin mat type, found in extensive areas, and is estimated to be 22% of the marsh area in Terrebonne Basin (Table 2.2, Figure 2.1b), and 11% of Barataria (Table 2.2, Figure 2.1c). Category 4.1 is a variation of category 4, but associated with more small, open water bodies. Categories 4 and 4.1 are found in areas adjacent to swamp forests, which are located mostly in the northern part of the study area.

Areas of category 4.2 are usually linear features within open water and are dominated by *Andropogon virginicus and Eupatorium capillifolium* (Table 2.1). Category 4.2 comprises an estimated 3% of Terrebonne Basin (Table 2.2, Figure 2.1b) and is found in the same general areas as the other category 4 marshes.

Non-floating (Attached) Marshes

In addition to the floating marshes, we characterized attached marshes. One such marsh exhibited a signature with a circular pattern. Our field investigations found this pattern was indicative of species found to grow in attached marshes such as *Typha* sp., *Scirpus validus* sp., and *Zizaniopsis* sp. (Table 2.1). It is represented by category 8, and accounts for an estimated 1% overall and in each marsh type (Table 2.2, Figure 2.1). This category was found throughout the study area, usually near the marsh/water interface in interior marshes.

Categories 8.1 and 8.5 represent attached fresh and intermediate marshes, respectively, that occur mostly within the sediment shadow of the Atchafalaya River edge of the study area (atlas). Both categories are dominated by *Colocasia esculenta* and include a variety of other species, as seen in Table 2.2. Fresh marsh category 8.1 also includes *Iris* spp., *Bidens laevis,* and *Andropogon virginicus*. The intermediate marsh category 8.5 may also include *Scirpus olneyi* and *Spartina patens*. Category 8.5 is a minor type overall, while category 8.1 accounts for an estimated 11% in Terrebonne Basin (Figure 2.1b), but only 1% of Barataria Basin (Figure 2.1c).

Marshes with Undetermined Buoyancy

The mapping categories included under this heading were identified in the mapping portion of this study, but no gauge data were available for determining the buoyancy of these marshes. They were spongy underfoot, but a complete characterization of these marshes was not possible within the scope of this project. More research is necessary in these areas.

Category 3.1, dominated by *S. lancifolia*, covers an estimated 15% of the total study area (Figure 2.1). Category 3.1 is fresh marsh including species such as Iris spp. and *Typha* sp. Categories 3.3 and 3.4 are co-dominated by *S. lancifolia* and *E. baldwinii*. Category 3.3 may also include *Hydrocotyle* spp. and *Ludwigia leptocarpa*, while category 3.4 may also contain *Sacciolepis striata* (Table 2.1).

We found several areas that comprised islands of *P. hemitomon*, *S. lancifolia*, and thin mat intermingled in shallow open water lakes (Table 2.1, category U). We estimate that these islands account for approximately 2% of the marsh area (Table 2.2, Figure 2.1). These areas were most often found on the eastern side of the Terrebonne Basin. *Eleocharis baldwinii* was usually associated with these areas, and *S. lancifolia* was sometimes present.

Category 1.4 includes *P. hemitomon* as a dominant, with *Eleocharis* sp. also commonly occurring (Table 2.1). It is found in the western part of Terrebonne Basin.

Category 8.4 is a *S. patens*-dominated marsh (Table 2.1) whose floating character was not determined in this study. It constituted a minor portion of the area in our study.

CHAPTER 3: HYDROLOGY

INTRODUCTION

This section of the project involved collecting water level and marsh mat level time series data from the sites discussed in chapter one. The primary goal of the water level and mat level data collection was to determine the buoyancy characteristics of examples of the major vegetated habitats in the basins, with particular focus on the seasonal dynamics of mat movement. To this end, the following three parameters were measured at each of the sites:

1. Open water (bayou or canal)
2. Inland Marsh water level (~60 meters inland)
3. Inland marsh mat vertical movement (~65 meters inland)

This chapter describes the methods used and presents examples of the time series data collected, along with a discussion of the major hydrologic characteristics observed. The data set is quite large, thus only selected examples of the data are shown. The examples shown are however, typical for each of the sites studied.

METHODS

Gauge Description

Data were collected using a multi-channel data logger (Stevens Multiloggers®, Leupold and Stevens Inc., Beaverton, Oregon) which was located on a platform ~60 meters inland. The marsh water levels were measured at this point. The bayou (or canal) water levels were measured with a pressure sensor deployed along the water's edge and connected to the data logger by an armored signal cable. The pressure sensor measured water levels (in feet) above the base of the sensor. The marsh mat was measured at a point ~5 meters inland from the data logger platform. An armored cable connected the mat sensor to the data logger. The gauge deployment scheme is shown in Figure 3.1. The inland water levels were measured using a stilling well with a float and counterweight system. The cable attached to the float goes over the sensor pulley and was attached to a weight. Thus, as the float moved vertically (with the water), it moved the cable, which in turn rotated the sensor pulley attached to the digital shaft encoder. The rotation of the encoder shaft was converted to a digital signal which was recorded by the data logger. The mat levels were monitored by using a float-counterweight encoder, but without the float. The sensor was deployed on a single pipe (to minimize friction effects) with the counterweight located inside the pipe. The cable attached to the weight was placed over the sensor pulley and then attached to a dog leash anchor that had been augured into the mat. Thus, as the mat moved vertically, it moved the cable, which in turn rotated the sensor pulley attached to the digital shaft encoder. As with the mat water, the rotation of the encoder shaft was converted to a digital signal which was recorded by the data logger.

Water Level Gauge Calibration

The data from the gauges was recorded onto solid state memory modules. Upon initial receipt of the gauges, all of them were unpacked, checked for damage, then calibrated in the laboratory. Laboratory calibration consisted of checking the pressure transducers (which were used for open water measurements), in a calibration tank, at water levels ranging from 0 to 2.0 feet at 0.25 foot increments. A regression analysis was performed using the actual water level in the tank as the independent variable and the gauge reading as the dependent variable. All of the pressure transducers performed quite well, as the results shown in Table 3.1 indicate. In addition to the level calibration, the pressure sensors were placed in a tank at a constant water level of 1.5 feet for 7 days to check for drift. The sensor outputs were sampled every 30 minutes during this stability test. The results indicated that the pressure sensors appear to be stable to about 1 to 2%.

The shaft encoders, which were used for measuring the mat movement and the marsh water movement were also calibrated. In this instance the encoders were set up in the lab on a stand with a float and counterweight. The float was them moved over a distance from 0 to 1.0 meters at 0.20 meter intervals. A regression analysis was performed using the actual reading as the independent variable and the encoder reading as the dependent variable. As was the case with the pressure sensors, all of the encoders functioned well, within the manufacturers' specifications as can be seen by the calibration data listed in Table 3.1. The data indicate that the encoders have accuracies better then 1 centimeter. In addition, the encoders are a digital measuring device and did not have a potential drift problem as did the pressure sensors.

Data Logger Configuration

After all of the sensors were calibrated, the data loggers were configured. The data logger configuration consisted of:

1. verifying all of the switch settings on the factory installed interface boards,
2. setting the clocks on each of the loggers,
3. Setting the sampling interval for each of the loggers, and
4. setting the channel identification for each of the three channels that was used on each logger.

Table 3.1. Calibration results for the sensors used during the study. Indicated, for each sensor, are the results of a regression analysis in which the actual water level was the independent variable and the sensor reading was the dependent variable. Results for both the pressure sensors and the shaft encoders are listed.

Pressure Sensor Number	Intercept (ft)	Slope (ft/ft)	R-Square
1	0.009	0.962	1.0
2	0.007	0.969	1.0
3	0.014	0.955	1.0
4	0.008	0.965	1.0
5	0.006	0.985	1.0
6	0.005	0.997	1.0
7	0.005	0.964	1.0
8	0.013	0.953	1.0
9	0.017	0.934	1.0
10	0.008	0.959	1.0
11	0.001	0.947	1.0
12	0.008	0.975	1.0
Encoder Number	**Intercept (m)**	**Slope (m/m)**	**R-Square**
1	0.0001	0.986	1.0
2	0.001	1.001	1.0
3	-0.001	1.000	1.0
4	0.001	0.985	1.0
5	-0.001	1.001	1.0
6	-0.0001	1.000	1.0
7	-0.001	0.999	1.0
8	0.001	1.001	1.0
9	-0.001	1.000	1.0
10	0.001	1.001	1.0
11	-0.001	1.000	1.0
12	0.001	1.001	1.0
13	-0.001	1.000	1.0
14	0.001	1.000	1.0
15	-0.003	0.993	1.0
16	0.003	0.997	1.0
17	-0.001	1.000	1.0
18	0.001	1.001	1.0
19	-0.001	1.000	1.0
20	0.001	1.001	1.0
21	-0.0002	1.000	1.0
22	0.001	1.000	1.0
23	0.001	1.002	1.0
24	0.0004	1.000	1.0

The multi-channel loggers were assigned numbers ranging from 9301 through 9312 (93 = year purchased, 01-12 = consecutive ID number). Each channel ID then consisted of the logger ID plus a 2 digit code for the channel number (01 through 03). In all cases, channel 1 was the pressure sensor in the open water (bayou or canal); channel 2 was the marsh mat sensor and channel 3 was the marsh water sensor. Thus, each data series had a unique ID code which was recorded as part of the data, eliminating the possibility of mixing up data if a data file was named incorrectly during processing. The consecutive ID number was set to correspond to the sample site locations indicated on Figure 3.1. The only exception was the second gauge located at the Cypress Canal sample site (location 8 on Figure 3.1) which was assigned the number 13 for data processing purposes, but is referred to in this report as Cypress Canal B.

Gauge Deployment

After all of the gauges were set-up and their operation was verified, field deployment began. The gauges were deployed in the following manner:

1. The pressure sensor was installed on a post in the adjacent water body.
2. A staff gauge was installed on the pressure sensor post.
3. A platform to hold the data logger and batteries was installed on the marsh surface ~60 meters inland from the pressure sensor. This platform also had a float and counterweight well for measurement of marsh water levels.
3. The mat sensor was installed ~5 meters inland from the gauge platform.
4. The pressure sensor and the mat sensor were connected to the data logger using armored (PVC coated flexible steel) conduit.

After all connections were made and checked, the batteries were attached, the data cards were installed, and the gauges were set up to start recording. The open water sensor was checked during installation and servicing by recording the reading of a staff gauge deployed in the bayou next to the pressure sensor, set so as to give the same reading as the gauge. The marsh water and marsh mat sensors were also checked by using the top of the mounting platform as a reference level (Figure 3.1). During installation the distance from the top of the data logger (or mat sensor) platform to the water (or mat) surface was measured. The gauges were set so that the top of the platform would correspond to a reading of 2.0 meters. Thus, if the distance from the platform to the water (or mat) was 1.50 meters, then the gauge should be reading 0.50 meters. This distance was measured on each servicing trip, and compared to the actual gauge reading. The reference

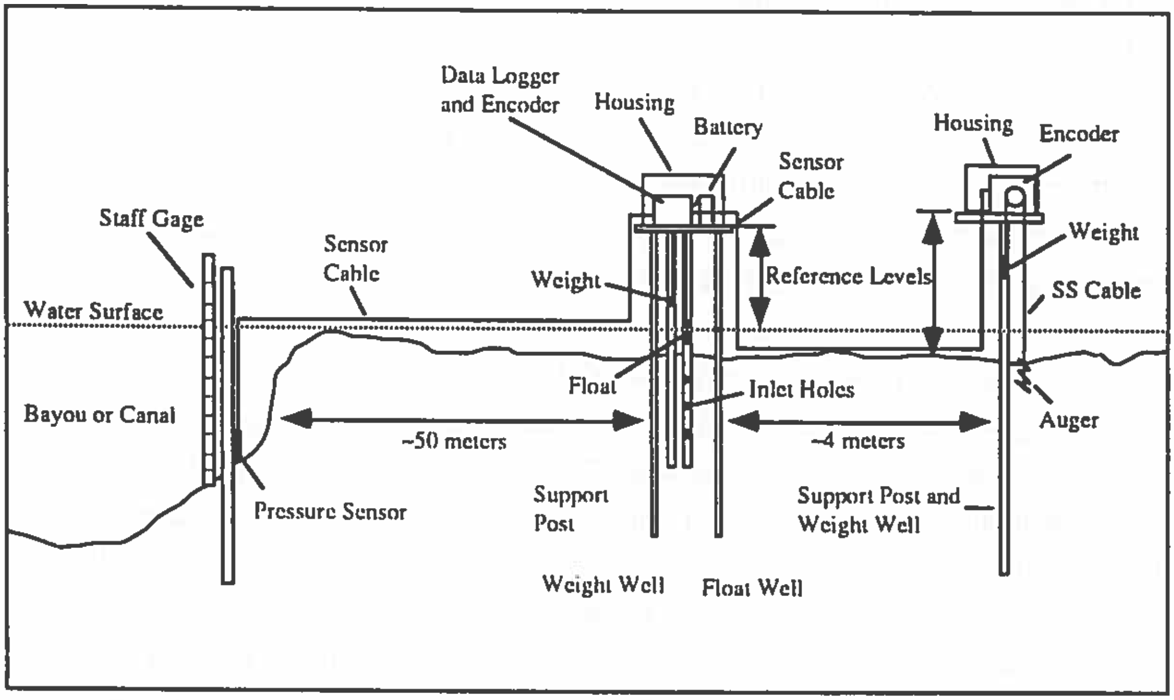


Figure 3.1. Sketch of a typical gauge installation. The open water is measured with a pressure sensor, the marsh water is measured with a float-counterweight system connected to a digital shaft encoder, and the marsh mat fluctuations are measured with a digital shaft encoder activated by an auger placed into the marsh mat.

level checks indicated that the marsh water and marsh mat were both measured with an accuracy of ±2.5 centimeters. The open water pressure sensors had an accuracy of ±0.07 feet (± 2.1 cm).

It was discovered during the initial deployments, that the length of the sensor cable between the logger and the mat sensor was too long. This excess length resulted in missed counts by the data logger due to resistance and capacitance effects of the cable. This discovery resulted in the necessity to re-design the deployment scheme. The result was that the field deployment schedule had to be lengthened and several previously deployed gauges had to be modified. Deployment started in March 1993, with most of the gauges placed in the field by May, 1993.

Data Retrieval

The memory modules (in which data were stored) could either be exchanged in the field (and the data retrieved upon return to the Laboratory) or the data could be retrieved in the field, using a portable computer. The original intent was to always swap out data cards and do the processing back at LSU. However, during several servicing trips, there were no data on the cartridge upon return to LSU, although the field check indicated that there were data on the cartridge when it was removed from the gauge. The cartridges were shipped to the manufacturer for replacement. We were informed by the manufacturer that these cartridges were from a batch of faulty cartridges, and that the new cartridges would not experience the same data loss problem. In spite of these reassurances, we decided to transfer the data in the field with a portable computer. The new data cards did perform to specifications and we did not experience any further loss of data on the new memory cards (the memory cards were always checked upon return to LSU even though the data had already been recovered in the field).

The gauges were serviced every two to three months at which time the data were retrieved, the memory cartridges and the batteries replaced. Figure 3.2 presents a time line showing the months, for each sample site, during which valid data were obtained. The water and mat level measurement program was quite successful, with time series data sets being collected at all marsh sites. There was some data loss due to memory cartridge failure (discussed above), battery failure and deployment error (excessive cable length - discussed above). The total data loss was ~16% with half of this loss due to the failure of the memory modules. However, 48% of the sites had data losses of less then 10%, and ~75% of the sites had data losses less then 20%. The resulting time series ranged in length from 184 days to 461 days, with a mean length of 356 days.

Data Analysis

The water level data were retrieved in the field using a Zenith® portable computer. The resulting field data files were converted into time series format (using the manufacturers supplied software) upon return to LSU. The time series data files were transferred to the LSU mainframe computer for analysis using "Statistical Analysis System" (SAS 1990 a, b, c, d, e). Since all of the data were in time series format, the same techniques were used for all sites. After the data were transferred, a preliminary analysis, to check the data for missing data points and/or outliers was performed. During this check any needed correction factors (for calibration or drift) were applied. The data were then ready for final analysis. Data analyzed in this report covered the period March 1993 through May 1994. Daily means, computed from the 30 minute data, were transferred to a Macintosh computer to produce the plots in this report. The final analysis consisted of the following:

Sample site	Mar-93	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93
1	X	X	X	X			X	X	X	X
2	X	X	X	X	X	X	X	X	X	X
3	X	X	X	X			X	X	X	X
4	X	X	X	X			X	X	X	X
5		X	X	X	X					
6				X	X	X	X	X		
7		X	X	X	X		X	X	X	X
8A			X	X	X	X	X	X	X	X
8B				X	X		X	X	X	X
9			X	X	X	X	X	X		
10						X	X	X	X	X
11						X	X	X	X	X
12		X	X	X	X	X	X	X	X	X

Sample Site	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94
1	X	X	X	X	X					
2	X	X	X	X	X					
3	X	X	X	X	X					
4	X	X	X	X	X					
5		X	X	X	X					
6		X	X	X	X					
7	X	X	X	X	X					
8A	X	X	X	X	X					
8B	X	X	X	X						
9		X	X	X	X					
10	X	X	X	X	X					
11	X	X	X	X	X					
12	X	X	X	X	X					

Figure 3.2. Data series time line. An X indicates that valid data is available from the gauge installed at the indicated sample site(1–12) for the indicated month.

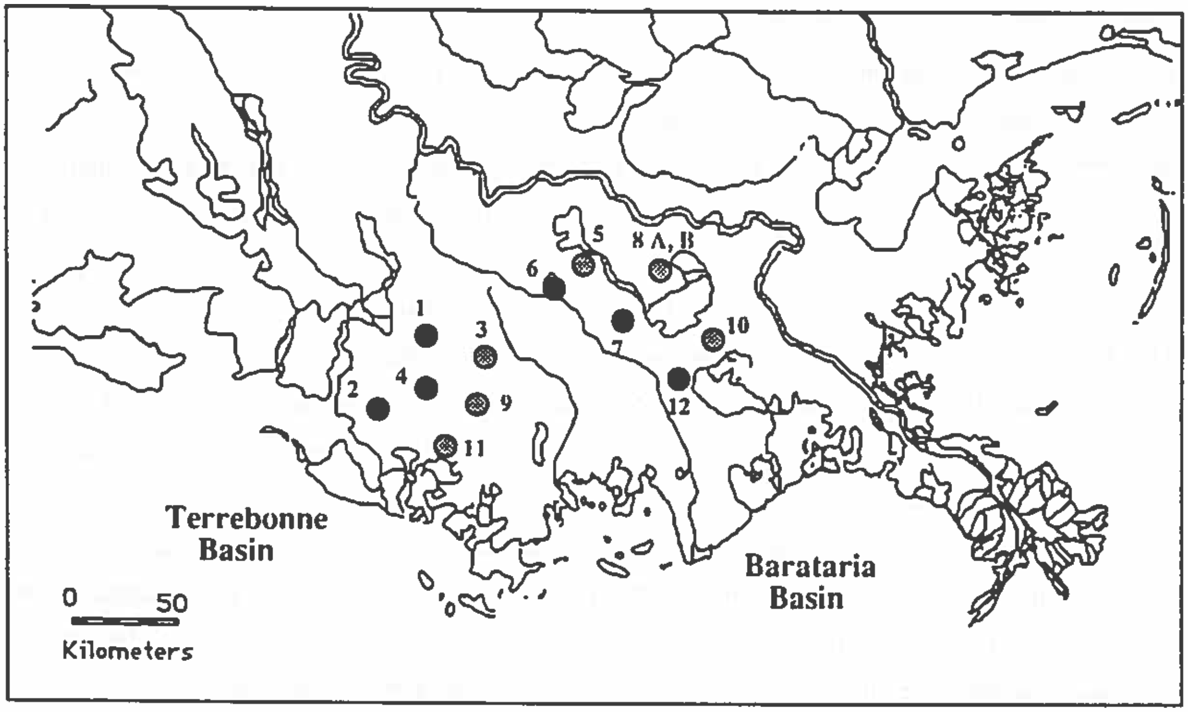
1. Time series plots of the data
    a. Daily means for the entire record to investigate variation at long term (seasonal) time scales.
    b. Three hour means for selected months to investigate variation at short term (tidal) time scales.
2. Comparison of the marsh water to the marsh mat at each site
3. Comparison of the open water to the marsh mat at each site
4. Spatial pattern of water levels within basins.

The main goal of the water and mat level program was to investigate the seasonal floating characteristics of the sites. In this regard, we were interested in the fluctuations occurring on time scales of weeks to months as opposed to hourly. Thus we used the daily mean values (computed from the half-hour time series data) for most of the analysis. However, time series plots of three-hour means were also inspected in order to evaluate the possible importance of tidally-induced water level fluctuations, particularly at the southern stations.

RESULTS AND DISCUSSION

The study sites can be loosely grouped into an east and west longitudinal transect within each of the two basins studied, with a north, middle and south site (Figure 3.3). Plots of the daily mean open water levels (in meters), the marsh water levels (in meters) and the marsh mat levels (in meters) for each of the thirteen (the Cypress Canal Site had gauges at two locations) gauge sites are shown in Figures 3.4[1] through 3.16. In all cases the horizontal axis is elapsed time, in days, since March 1, 1993 and the vertical axis is water (or mat) level, in meters. The vertical axis for all plots covers a range of one meter to allow for ease in visual comparison among sites. Figures 3.4 through 3.6 present the data from the west longitudinal transect in Terrebonne Basin, Figures 3.7 through 3.9 present the data from the east longitudinal transect in Terrebonne Basin, Figures 3.10 through 3.12 present the data from the west longitudinal transect in Barataria Basin, and Figures 3.13 through 3.16 present the data from the east longitudinal transect in Barataria Basin. In general, the data from all sites appear to be reasonable with the exception of the mat data from Little Carencro Bayou (Figure 3.9), VD Canal (Figure 3.13) and Delta Farms (Figure 3.16). The Little Carencro data show very little mat fluctuation. During field servicing however, it was obvious (from walking on the marsh) that it was buoyant (while standing in one position for a few minutes, the mat would become submerged under ~25 cm of water). In addition, the reference level

[1] Figures 3.4 through 3.33 are found at the end of this chapter



Station Key	
● West Longitudinal Transect	
Terrebonne	**Barataria**
North: 1 - Gallinule Canal	North: 6 - Lake Boeuf
Middle: 4 - Bayou Penchant	Middle: 7 - Company Canal
South: 2 - Victor Bayou	South: 12 - Bayou de la Gauche
◍ East Longitudinal Transect	
Terrebonne	**Barataria**
North: 3 - North ICWW	North: 5 - VD Canal
Middle: 9 - Huth Canal	Middle: 8 - Cypress Canal (A, B)
South: 11 - Little Carencro Bayou	South: 10 - Delta Farms

Figure 3.3. Map of central Louisiana coastal zone, showing the locations of the water level gauge longitudinal transects in the Barataria and Terrebonne Basins.

measurements indicate that it should have moved ~25 cm. The data from VD Canal show some movement which appears to mimic the marsh water however the movement is less than 5.0 cm (the reference readings indicate that it only moved ~3 cm). The data from Delta Farms shows a straight line for the mat data due to a failure of the mat sensor for this gauge. The field reference level measurements indicate that this mat moved ~7 cm. Cursory examination of the record collected after May 1994 from this gauge (site 10) indicated that this mat shows small fluctuations in mat level that mimic marsh water level.

Figures 3.17 and 3.18 present the three-hour mean data for the open water for February through April 1994. All of the daily data show the same basic signal in which there is greater variation at the southernmost stations in each of the basins. This is most noticeable with the open water data. This greater amount of variability is due to the tidal forcing occurring at the south portion of the basins. The 25-hour diurnal tidal signal is a large portion of the water level signal at the southern stations (Figure 3.17 gauge 2, gauge11; Figure 3.18 gauge 2). This tidal signal is also evident, but to a lesser extent, at some of the other stations. The tidal signal is superimposed upon other longer-term fluctuations. This type of water level signal has been shown to be typical for the Louisiana brackish and salt marshes (Byrne et al. 1976, Adams and Baumann 1980, Chuang and Swenson, 1981, Swenson and Turner 1987). The data from this project indicate that a similar pattern also exists in the intermediate marshes, at least at their southernmost boundary. Swenson and Chuang (1983) demonstrated for the Lake Pontchartrain Basin that subtidal events (these are events with durations on the order of several days) may explain up to 50% of the variation in volume exchange in a salt marsh system. Spectral analysis conducted on the three-hourly data from the open water were used to determine the dominant time scale at which the fluctuations were occurring for the fresh and intermediate marshes studied for this project. The results indicated that the water level fluctuations occurred at time scales on the order of three days (or longer) for most of the sites. The only sites which showed a strong spectral density peak at the diurnal tidal period were Victor Bayou (gauge 2), Bayou de la Gauche (gauge 12) and Little Bayou Carencro (gauge 11). However, the height of the tidal energy peak compared to the longer-period fluctuations, indicated that the tidal signal was less than 50% of the total fluctuations. Thus, the daily means are sufficient to describe the floating dynamics of these marshes.

The three-hour means for the marsh mat fluctuations for February through April 1994 are presented in Figures 3.19 and 3.20. This time period was used since it represents a period during which the water levels are influenced by tides, frontal passages and increased fresh water input due to spring flooding. In addition this was also a time period during which there was consistent data from most of the gauge locations. In general, for the marshes which float, the marsh mat fluctuations follow the longer term water level fluctuations. It should be pointed out that the data from gauge 11 (Bayou Carencro, Figure 3.19), gauge 10 (Delta Farms, Figure 3.19) and gauge 4

(Bayou Penchant) all show a flat line for the mat movement during this time period. This is due to failure of the mat sensor at these three stations during this time period. Data collected from station gauge 11 (Little Bayou Carencro) at times when the sensor was functioning, indicated mat fluctuations of about 15 cm (field check, discussed above, indicated it should have been able to move ~25 cm). Data collected from the other two stations at times when the sensor was functioning measured mat fluctuations less than 5 cm for station gauge 10 (Delta Farms), and about 25 cm for station gauge 4 (Bayou Penchant). Appendix A presents plots of the complete data record (three-hour means) for all stations and all sensors (open water, marsh water, and marsh mat).

The relationships between the marsh mat, the open water, and the marsh water fluctuations, using the daily mean values, are presented in Figures 3.21 through 3.33. The data from the West Terrebonne longitudinal transect is presented in Figures 3.21 through 3.23, the data from the East Terrebonne longitudinal transect is presented in Figures 3.24 through 3.26, the data from the West Barataria longitudinal transect is presented in Figures 3.27 through 3.29, and the data from the East Barataria longitudinal transect is presented in Figures 3.30 through 3.33. The format is the same for all figures, with the top plot presenting the relationship between the marsh mat and the marsh water, the middle plot presenting the relationship between the marsh mat and the open water, and the bottom plot presenting the relationship between the marsh water and the open water. The results of a regression analysis are indicated on each of the plots. In all cases, the axes have a range of one meter to allow for easy visual comparison of the plots from each site.

The hydrological information for each of the sites are summarized in Tables 3.2 and 3.3. Table 3.2 presents the regression results (between open water, marsh water, marsh mat) and Table 3.3 presents the amplitudes of the fluctuations observed at each site. Both the total fluctuations as well as the tidally induced fluctuations are presented. The tidal fluctuations are estimates of the mean tidally-induced signal as determined from inspection of the three-hourly data plots of all data measured during the study. The total fluctuations is the total range (using all of the three-hourly data) of movement measured at each location. There is excellent agreement (r^2 range from 0.73 to 0.99) between the open water and the marsh water at all of the north and middle sites, except the Sagittaria mat at the middle station on the East Barataria transect (Cypress Canal B), indicating that these sites have an open connection between the marsh and the adjacent water body. The southern stations for both Terrebonne (Victor Bayou and Little Carencro Bayou) and Barataria (Bayou de la Gauche and Delta Farms) do not show as strong a relationship. In the case of the Terrebonne West (Victor Bayou) and the Barataria West (Bayou de la Gauche) there is evidence of an impoundment effect, with the open water and the marsh water tracking each other at high water levels, but not at lower water levels. This is also the same type of signal seen at the middle station on the East Barataria transect (Cypress Canal). This effect can be seen on Figures 3.23, 3.29 and 3.32, and

Table 3.2. Summary of the relationships among open water (OW), marsh water (MW) and marsh mat (MM) for the study sites. Indicated for each site are the results (r^2 and the slope) obtained from a regression between the daily means of; open water and marsh water; marsh mat and marsh water; and marsh mat and open water. The sites are grouped by location within each of the basins (east side, west side) the listing of stations within each group starts with the northern station and ends with the southern station. Boldface numbers refer to stations where there was evidence of some sort of "impounding effect" (marsh water to open water appears to show a better relationship at higher water levels).

Station ID	MM:MW		MW:OW		MM:OW	
	r-square	Slope	r-square	Slope	r-square	Slope
TERREBONNE WEST						
Gallinule Canal	0.832	1.059	0.991	1.004	0.936	1.785
Bayou Penchant	0.974	0.798	0.765	1.127	0.902	0.890
Victor Bayou	0.936	0.871	**0.260**	0.294	0.399	0.345
TERREBONNE EAST						
North ICWW	0.825	0.509	0.939	0.994	0.774	0.455
Huth Canal	0.837	0.879	0.818	1.162	0.898	1.171
Little Bayou Carencro	0.902	0.459	0.402	0.709	0.415	0.225
BARATARIA WEST						
Lake Boeuf	0.984	0.897	0.991	1.026	0.990	0.928
Company Canal	0.759	0.126	0.907	0.886	0.327	0.102
Bayou de la Gauche	0.845	0.276	**0.589**	0.469	0.746	0.155
BARATARIA EAST						
VD Canal	0.000		**0.773**	0.624	0.000	
Cypress Canal A	0.872	0.912	0.726	0.618	0.797	0.709
Cypress Canal B	0.246	0.047	0.432	0.322	0.120	0.013
Delta Farms	nd	nd	0.370	0.381	nd	nd

nd = not determined (no data available)

Table 3.3. Summary of the water and mat level fluctuations observed at each of the sites. The amplitudes (total and tidal induced only) of the fluctuations occurring at each site (in centimeters) are listed. The sites are grouped by location within each of the basins (east side, west side) the listing of stations within each group starts with the northern station and ends with the southern station.

Station ID	Measured Fluctuations (cm)					
	Open Water		Marsh Water		Marsh Mat	
	Total	Tidal	Total	Tidal	Total	Tidal
TERREBONNE WEST						
Gallinule Canal	40	<5	40	<5	40	<5
Bayou Penchant	60	10	60	<5	25	<5
Victor Bayou	90	30	90	15	30	<5
TERREBONNE EAST						
North ICWW	45	10	45	<5	45	5
Huth Canal	50	5	50	0	40	5
Little Bayou Carencro	100	30	60	30	25[a]	nd
BARATARIA WEST						
Lake Boeuf	55	<5	55	<5	50	<5
Company Canal	50	10	50	10	5	nd
Bayou de la Gauche	60	25	60	25	20	12
BARATARIA EAST						
VD Canal	45	<5	45	<5	5	5
Cypress Canal A	70	10	60	<5	40	5
Cypress Canal B	70	10	40	<5	<5	0
Delta Farms	50	15	50	<5	7[a]	0

nd = not determined (no data available)
a = based upon field reference checks

is quite similar to results obtained by Swenson and Turner (1987) when they analyzed water levels in a partially impounded brackish marsh site near Catfish Lake, Louisiana. The east Terrebonne south site (Little Carencro Bayou) showed no evidence of an impoundment effect, however the marsh water data (Figure 3.9) had a lot of spikiness to it, indicating a possible sensor problem. The East Barataria Southern Site (Delta Farms, Figure 3.16) shows more of an attenuation effect as opposed to an impoundment effect, in which a great deal of the open water fluctuations are not transmitted to the marsh water. This type of behavior may be a result of a fairly solid edge (old spoil bank) at this site, which may serve as a impediment to lateral flow through the marsh substrate at lower water levels. Thus, at this type of site, the marsh is only flooded when water levels are high enough to top the natural levees and/or the canal spoil banks.

The regression analysis between marsh mat movement and the marsh water movement indicated that of the thirteen locations studied, ten showed relationships in which the water movement explained at least 75% of the mat movement, indicating a fairly freely floating mat. Of the remaining three sites, two showed weak relationships between marsh water and marsh mat, and were on the East Barataria Basin transect. The third site (Delta Farms) had a failure of the mat sensor, thus we are not able to characterize the relationship with the available data (the gauge has been repaired and is currently operating). Only one site (Cypress Canal A) on the Barataria East Transect was floating, and exhibited a seasonal pattern in which it did not float during the winter. Similar results were found by Swarzenski et al. (1991) for an intermediate marsh site in near Lake Salvador (also in Barataria Basin). Of the sites that exhibited a strong relationship between the marsh mat and the marsh water, three of them [Barataria West Middle (Company Canal) and Terrebonne East South (Little Carencro Bayou) and Terrebonne East North (North ICWW)] had slopes (between marsh mat and marsh water) which were less then 0.5. The North ICWW and the Company Canal sites also showed a high correlation between the marsh water and the open water (r^2 ~0.9) with slopes of almost 1.0, indicating that there is free water exchange in and out of the marsh at thes sites. In the case of Company Canal the low slope (0.13) is most likely due to a limited range (~5 cm) to the vertical movement of this mat ("micro-floating"). In the case of the North ICWW station, the low slope (0.51) may be due to a limited range of mat movement (but with a range closer to 40 cm), or the mat may be floating submerged during some parts of the year. The marsh water data from Little Carenceo Bayou appeared to have a sensor problem (as discussed previously) and thus inferences made from the regression analysis are somewhat suspect. Based upon our field experience at this site however, it appears to be a freely floating marsh mat.

SUMMARY

Time series measurements of open water, marsh water and marsh mat fluctuations collected at thirteen sites within the Barataria and Terrebonne Basins were analyzed to determine the buoyancy characteristics of examples of the major vegetated habitats in the basins, with particular focus on the seasonal dynamics of mat movement. The gauges were deployed over the time period from March, 1993 through April, 1994 with data being collected at one hour intervals. The resulting time series ranged in length from 184 days to 461 days, with a mean length of 356 days. The data were reduced to three hour means and analyzed to determine the dominant signals in the data. The results can be summarized as follows:

1. The open water levels measured in these systems were characterized by a diurnal tidal signal superimposed upon other, longer period signals. This type of signal is typical for Louisiana salt and brackish marshes (Byrne et al. 1976, Adams and Baumann 1980, Chuang and Swenson, 1981, Swenson and Turner 1987).
2. The longer period events (three days and greater) were the dominant time scales for the measured fluctuations. At sites where there was a noticeable diurnal tidal signal (three sites), it was responsible for less than 50% of the fluctuations.
3. The daily means of the fluctuations are adequate to characterize the dynamics of the systems measured.

Based upon the above, daily means were used in regression analysis between (1) open water and marsh water, (2) open water and marsh mat, and (3) marsh water and marsh mat. The regression results were used along with the time series data plots, to characterize the sites as:

1. Floating: These are sites in which there is a high r-square between the marsh mat and marsh water. This type of marsh has three sub-categories:
   a. Freely Floating: These are sites in which there is free connection between the open water and the marsh water as evidenced by a high r-square and a slope close to 1.
   b. Damped Floating: These are very similar to the free floating sites but the mat sometimes floats while submerged.
   c. Impounded Floating: These are sites in which there is a low r-square between the marsh mat and the open water. This may be due either to (1) impoundment of the marsh water levels due to the presence of canal spoil banks and/or high natural levees and/or (2) limited exchange due to substrate charactistics (e.g.. low porosity).

2. Micro-floating: These are sites in which there is a high r-square between the marsh water and the marsh mat but the mat movement is only on the order of 5 cm. These may be sites at which (1) the mat sensor is measuring expansion and contraction of the mat as opposed to actual floating, or (2) the mat is able to float but the vertical movement is physically constrained (the live roots are growing into a firm substrate). This type of mat would be one that could potentially break free and become fully floating under extremely high water levels for an extended period of time. Expansion of the mat should not explain this behavior, since the mat level gauge is anchored in the top 30 cm of the mat.
3. Non-floating: The mat data shows no evidence of mat movement.

A summary of the results for each of the gauge sites are listed below:

Site 1 (Gallinule Canal):
The mat at this site exhibited freely floating behavior throughout the year, with a total vertical movement of ~40 cm.

Site 2 (Victor Bayou):
The mat at this site exhibited damped-floating behavior, with a total vertical movement of ~30 cm.

This site also showed restricted exchange between the marsh and open water.

Site 3 (North ICWW):
The mat at this site exhibited damped-floating behavior, with a total vertical movement of ~45 cm.

Site 4 (Bayou Penchant):
The mat at this site exhibited freely-floating behavior throughout the year, with a total vertical movement of ~25 cm.

Site 5 (VD Canal)
The mat at this site exhibited micro-floating behavior, with a total vertical movement of ~5 cm. the mat appeared to float throughout the year (there were gaps in the mat data record).

This site also showed restricted exchange between the marsh and open water.

Site 6 (Lake Boeuf):
The mat at this site exhibited freely-floating behavior throughout the year, with a total vertical movement of ~50 cm.

Site 7 (Company Canal):
The mat at this site exhibited micro-floating behavior, with a total vertical movement of ~5 cm. the mat appeared to float throughout the year (there were gaps in the mat data record).

Site 8 (Cypress Canal A):
This site is the only site to show a seasonal floating pattern.

The mat at this site exhibited freely-floating behavior during late spring through late fall, with a total vertical movement of ~40 cm.

The mat at this site exhibited non-floating and/or micro-floating behavior during late fall through early spring, with a total vertical movement of <5 cm.

Site 8 (Cypress Canal B):

The mat at this site exhibited micro-floating behavior, with a total vertical movement of <5 cm. the mat appeared to float throughout the year (there were gaps in the mat data record).

Site 9 (Huth Canal):

The mat at this site exhibited freely-floating behavior throughout the year, with a total vertical movement of ~40 cm.

Site 10 (Delta Farms)

The mat at this site exhibited micro-floating behavior, with a total vertical movement of ~5 cm.

This site also showed restricted exchange between the marsh and open water.

Site 11 (Little Bayou Carencro)

The mat at this site exhibited freely-floating behavior during the ~2 months that the mat sensor functioned properly, with a total vertical movement of ~10 cm.

Field visits indicated that the mat should be capable of moving ~25 cm.

Site 12 (Bayou de la Gauche)

The mat at this site exhibited freely-floating behavior throughout the year, with a total vertical movement of ~20 cm.

This site also showed restricted exchange between the marsh and open water.

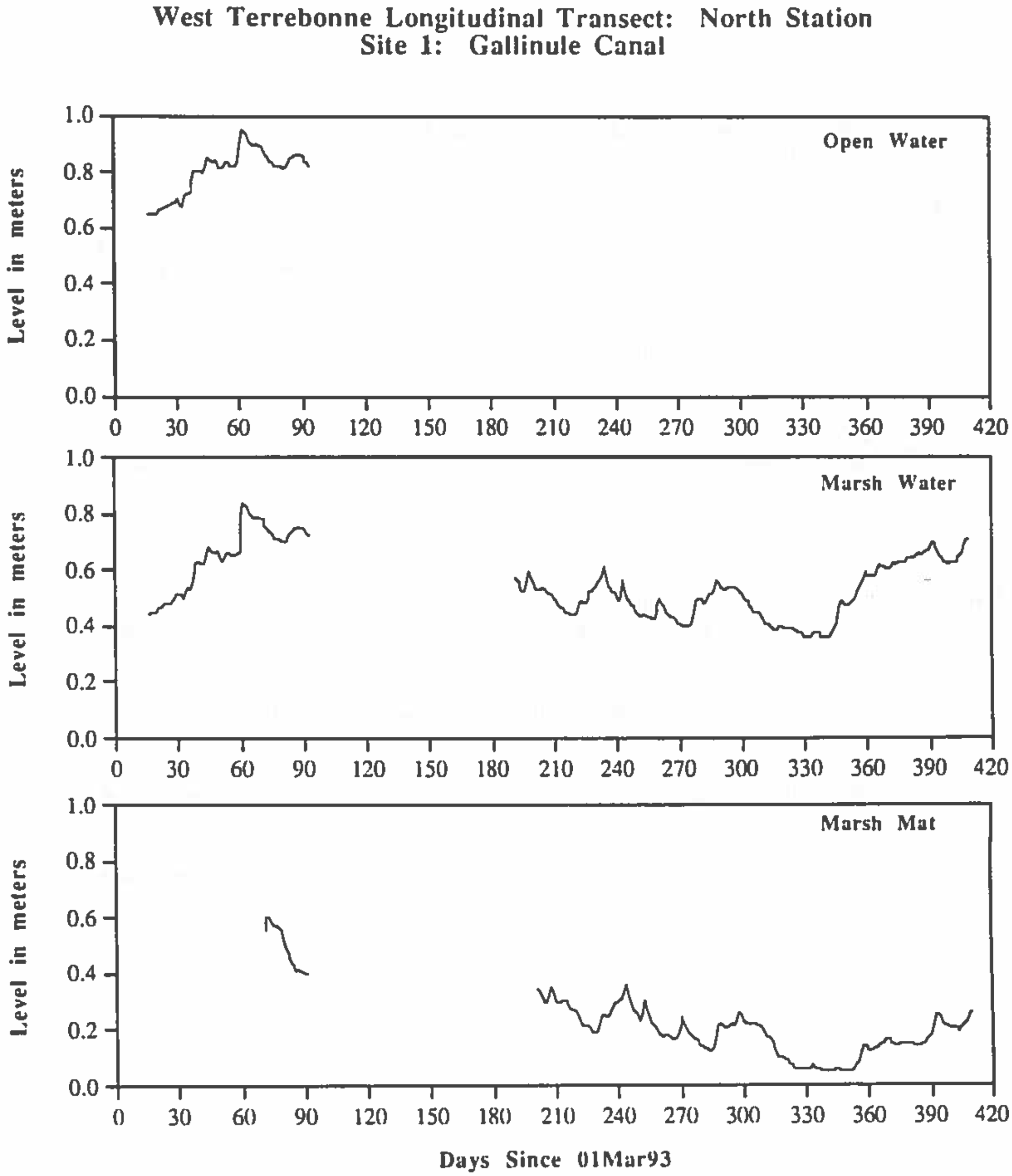


Figure 3.4. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 1 (Gallinule Canal), the north gauge site on the west Terrebonne longitudinal transect.

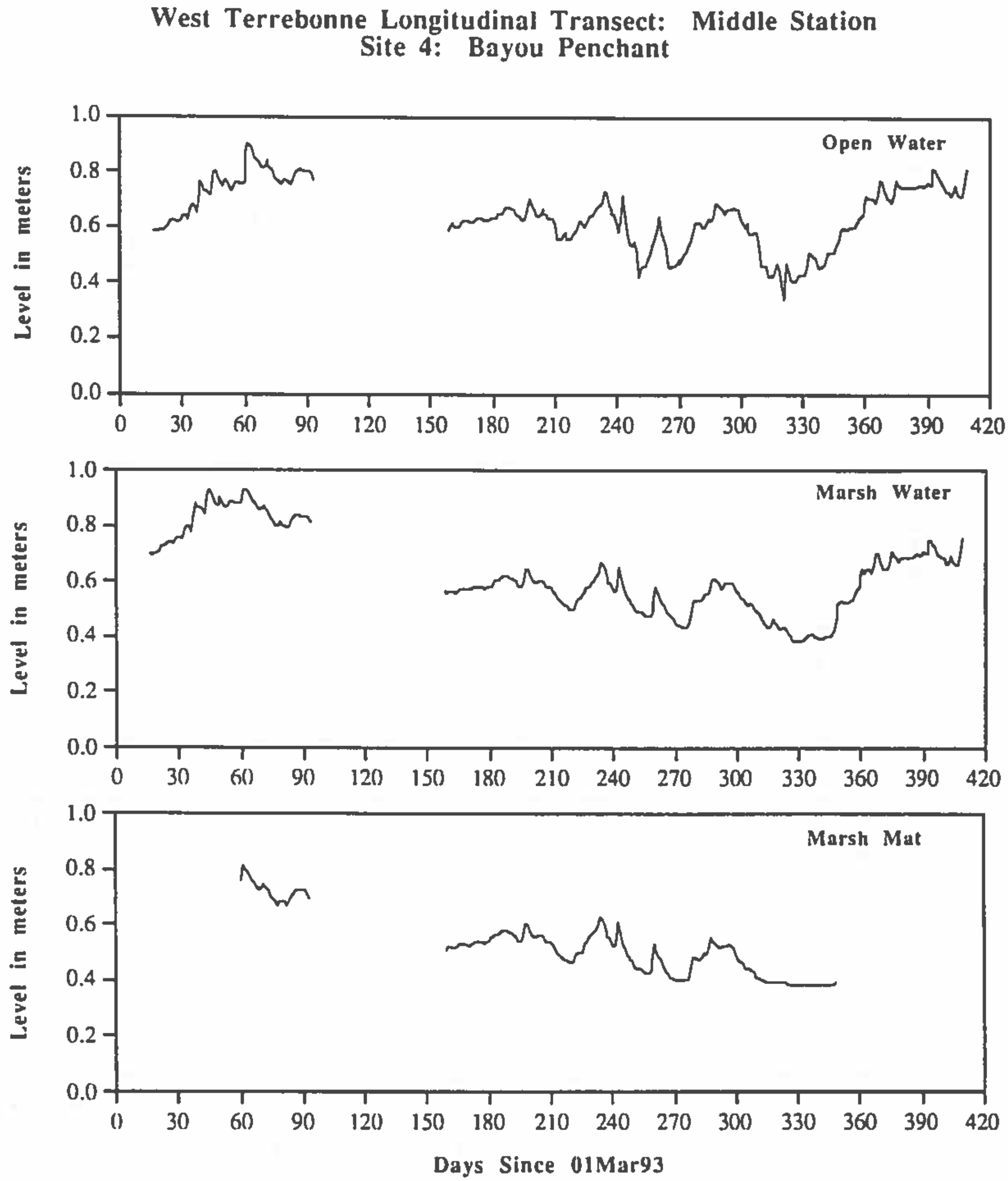


Figure 3.5. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 4 (Bayou Penchant), the middle gauge site on the west Terrebonne longitudinal transect.

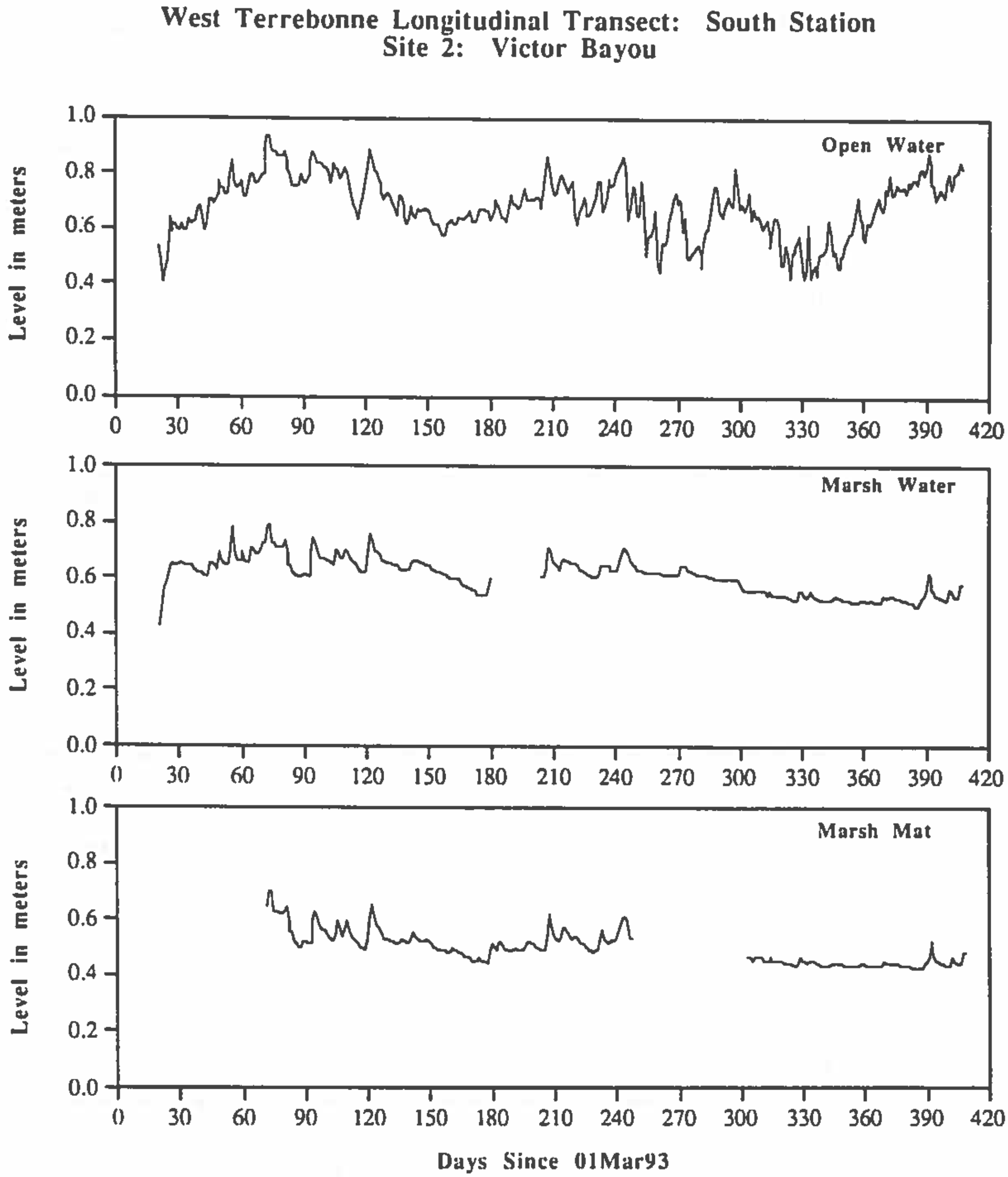


Figure 3.6. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 2 (Victor Bayou), the south gauge site on the west Terrebonne longitudinal transect.

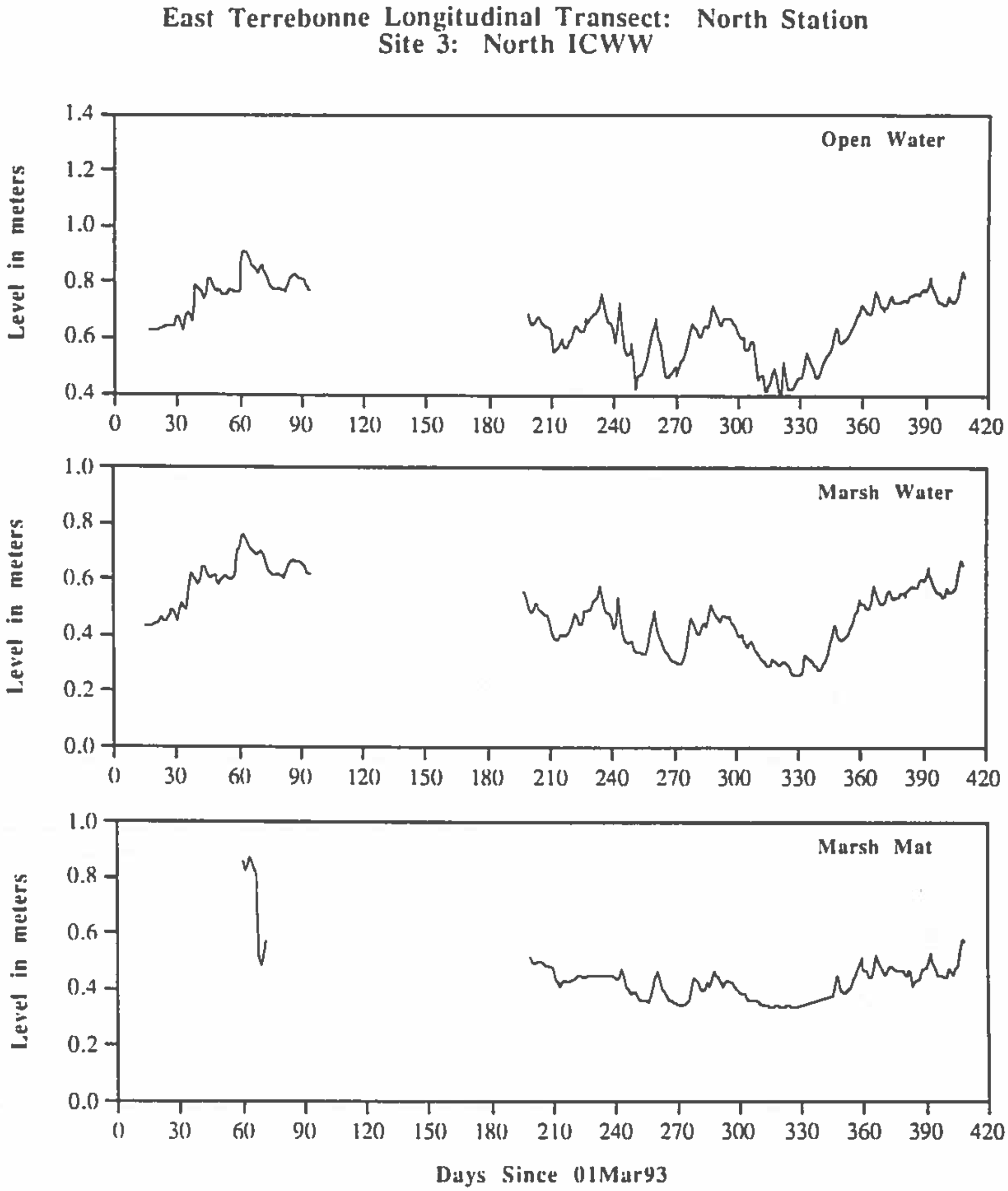


Figure 3.7. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 3 (North ICWW, the north gauge site on the east Terrebonne longitudinal transect.

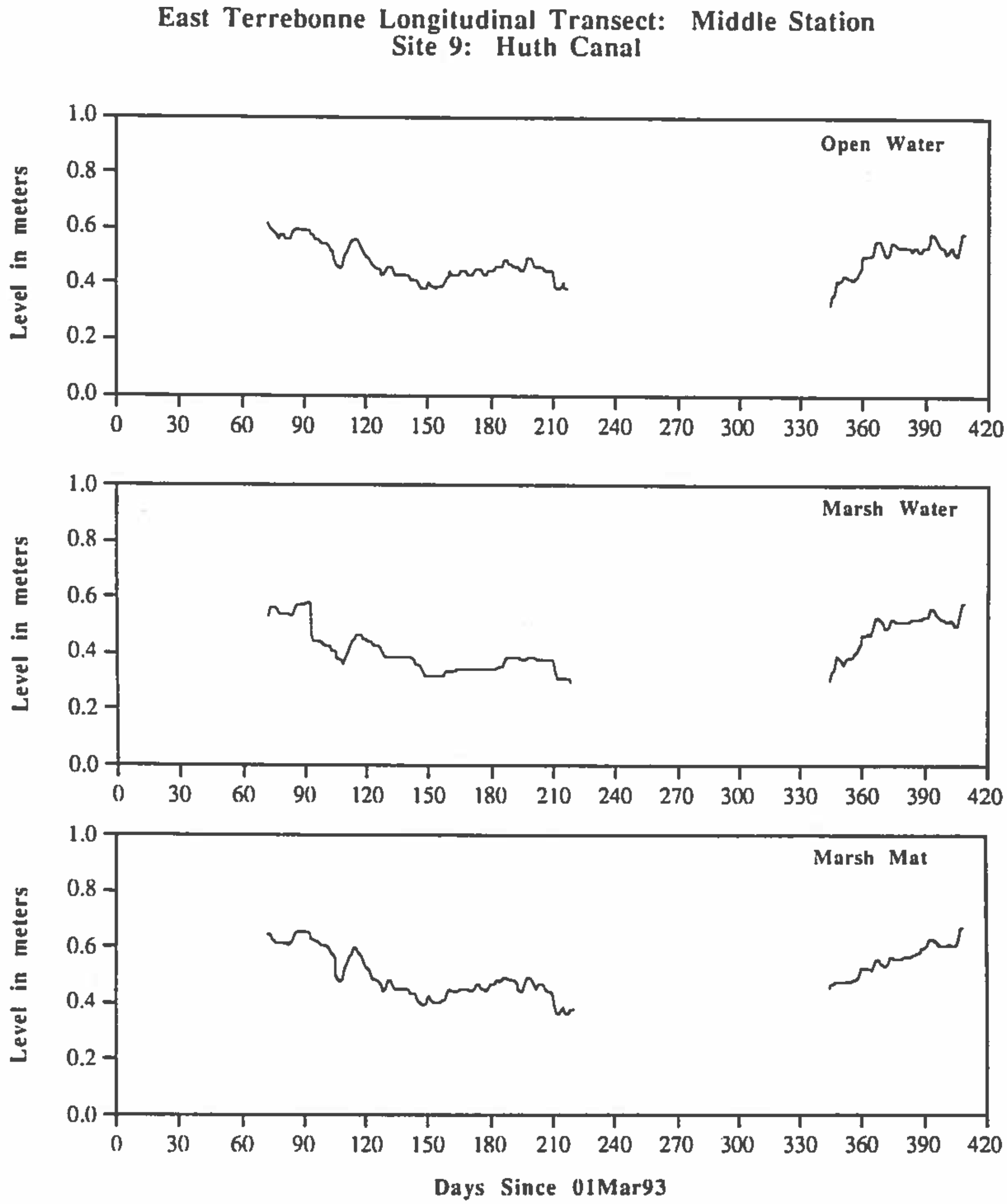


Figure 3.8. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 9 (Huth Canal), the middle gauge site on the east Terrebonne longitudinal transect.

East Terrebonne Longitudinal Transect: South Station
Site 11: Little Bayou Carencro

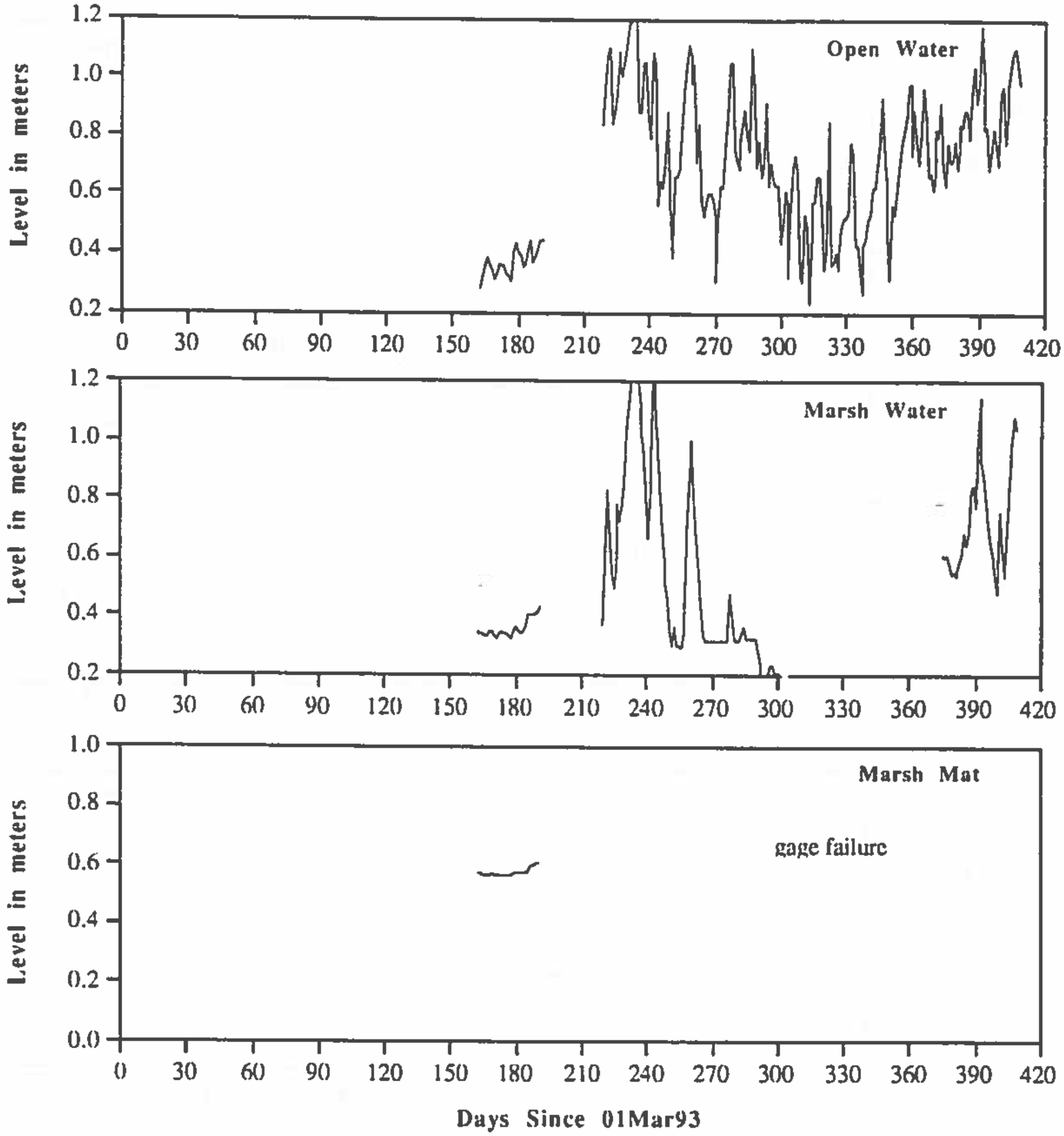


Figure 3.9. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 11 (Little Bayou Carencro), the south gauge site on the east Terrebonne longitudinal transect.

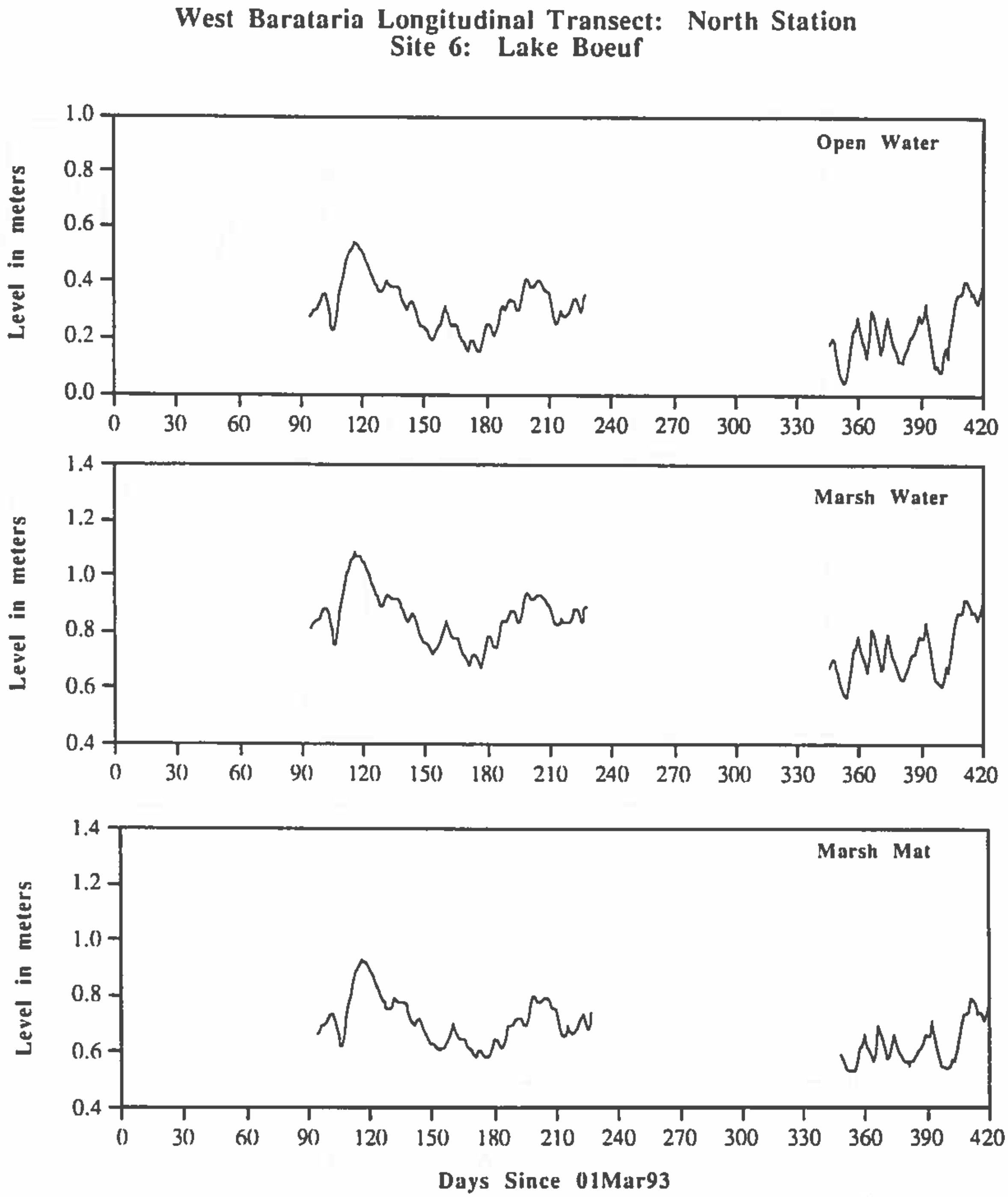


Figure 3.10. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 6 (Lake Boeuf), the north gauge site on the west Barataria longitudinal transect.

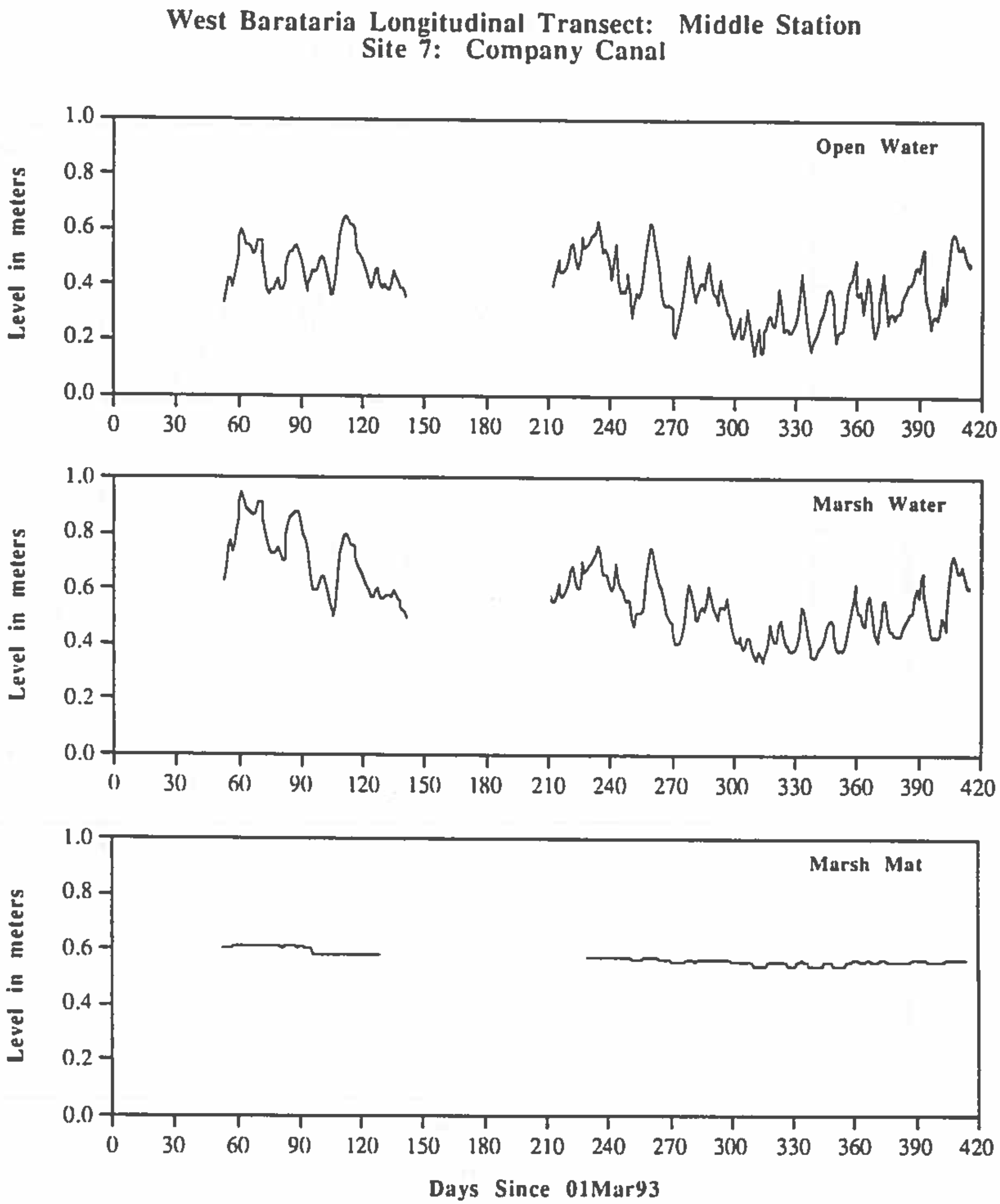


Figure 3.11. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 7 (Company Canal), the middle gauge site on the west Barataria longitudinal transect.

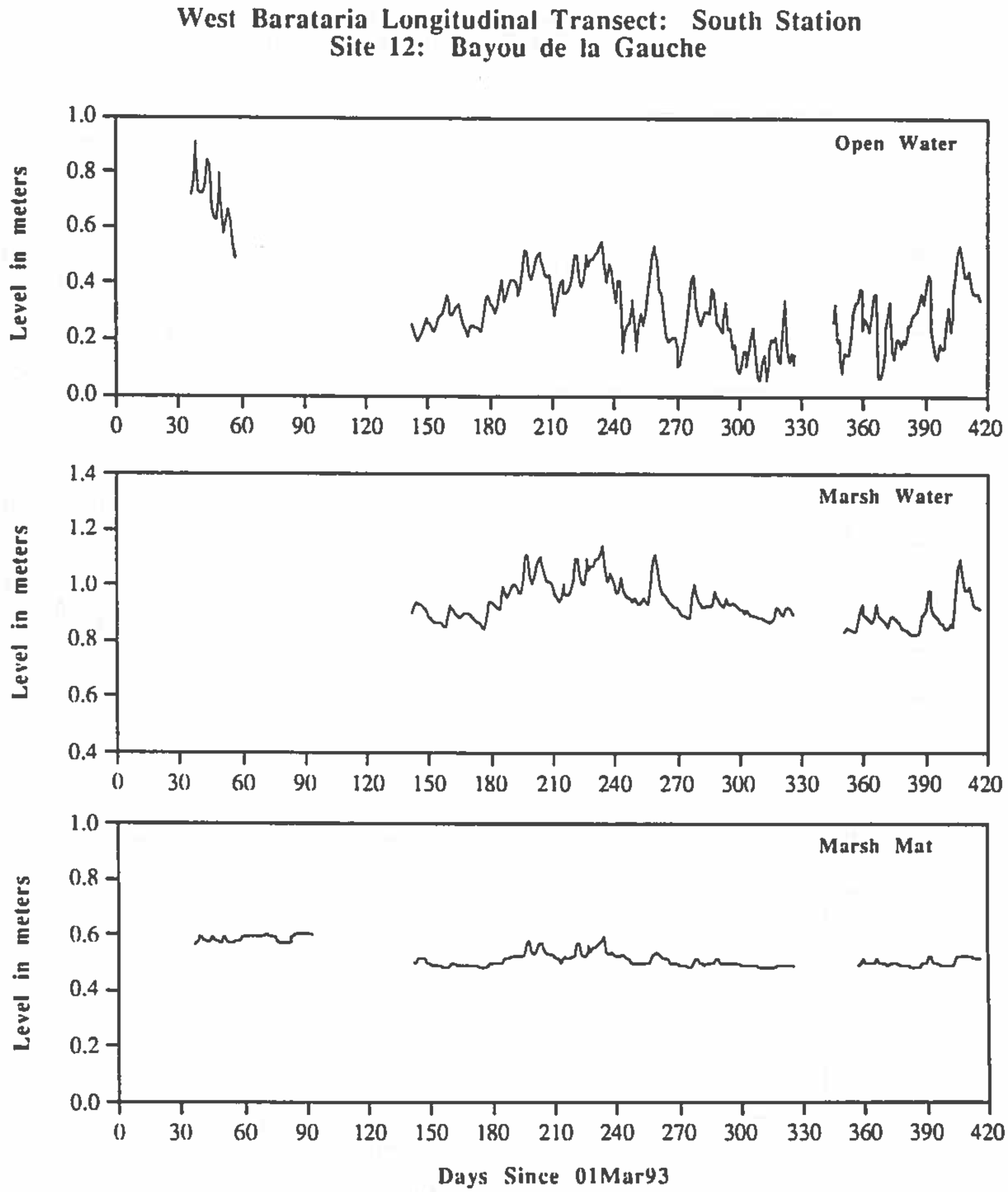


Figure 3.12. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 12 (Bayou de la Gauche), the south gauge site on the west Barataria longitudinal transect.

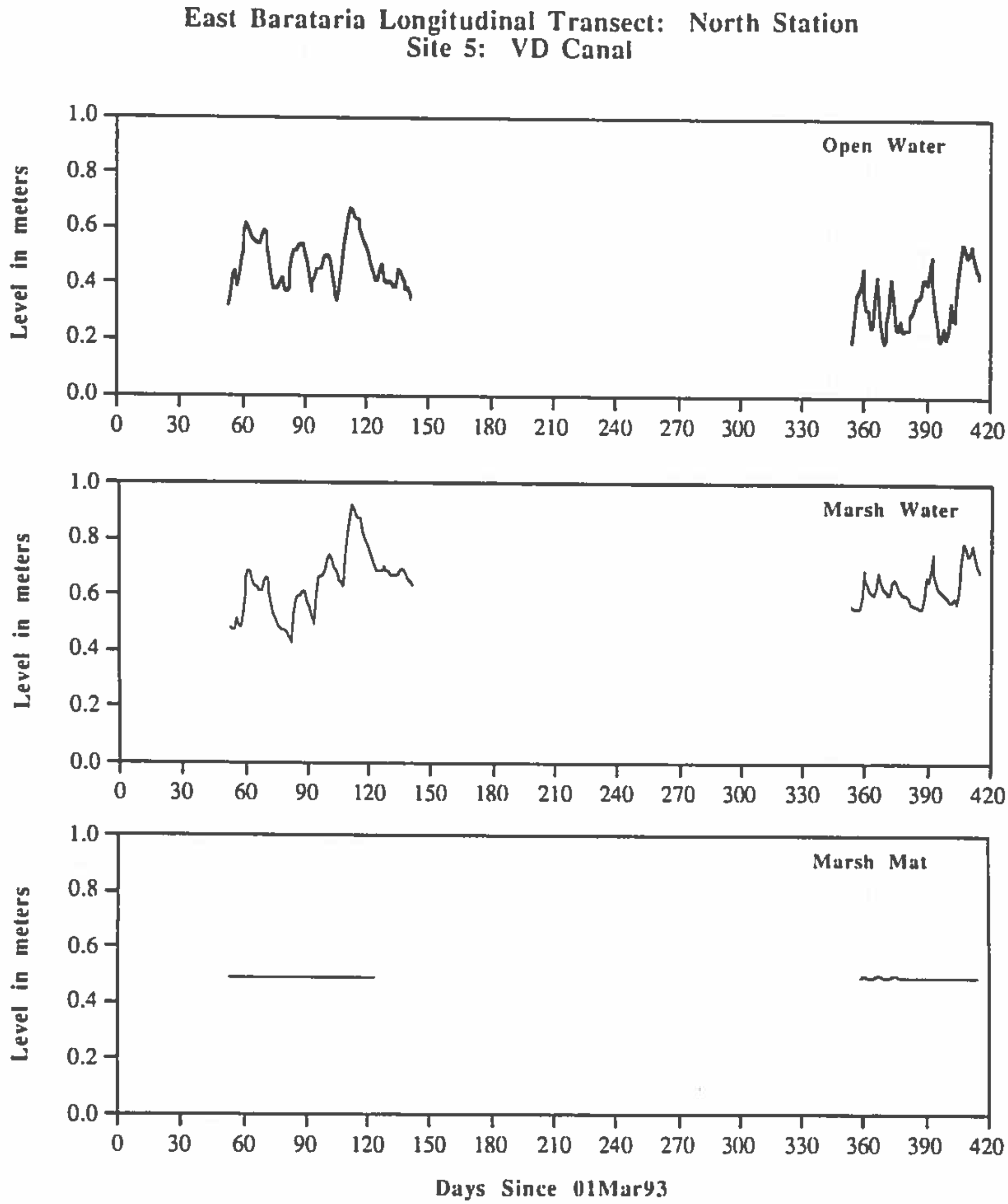


Figure 3.13. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 5 (VD Canal), the north gauge site on the east Barataria longitudinal transect.

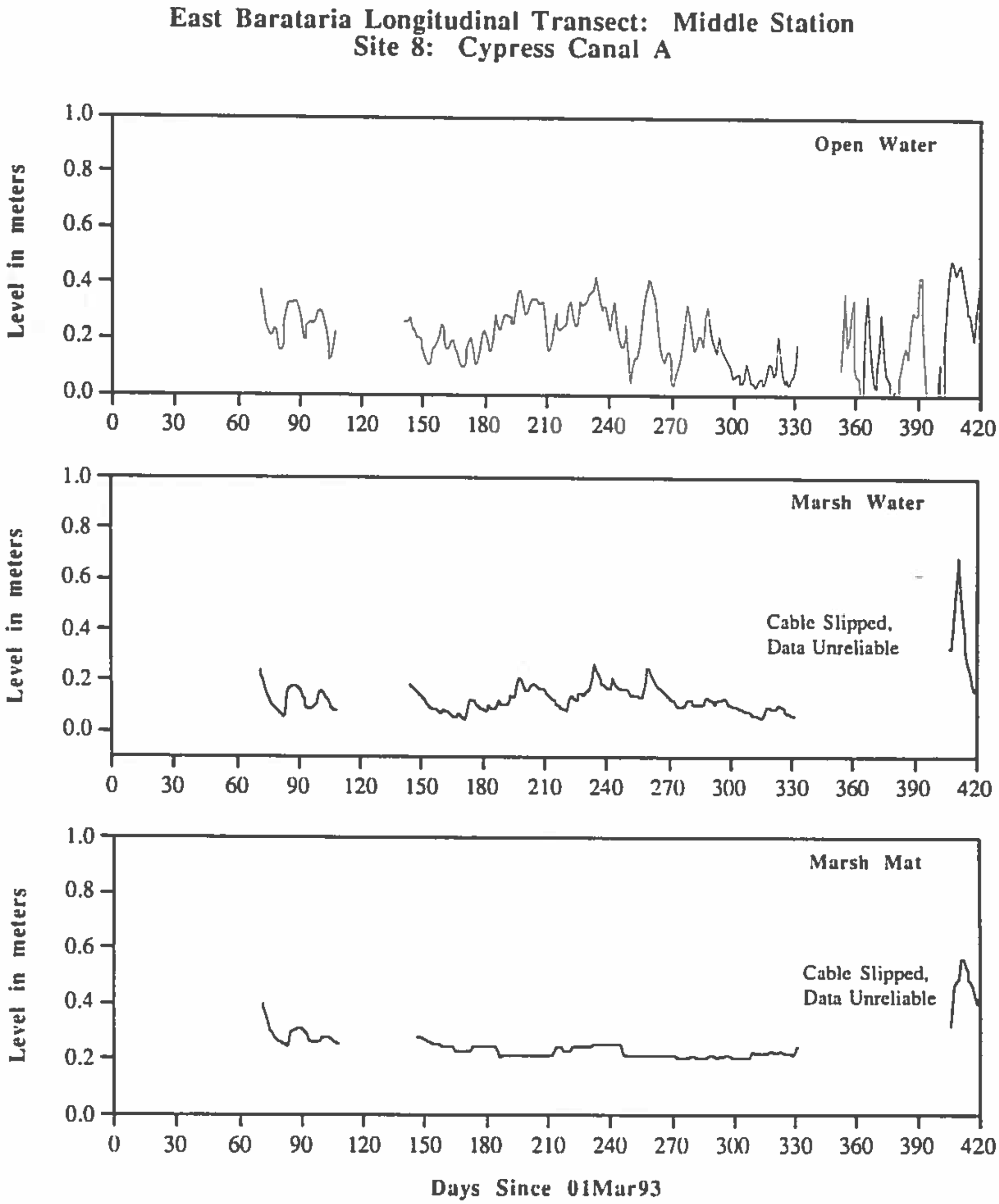


Figure 3.14. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 8 (Cypress Canal A), the middle gauge site on the east Barataria longitudinal transect.

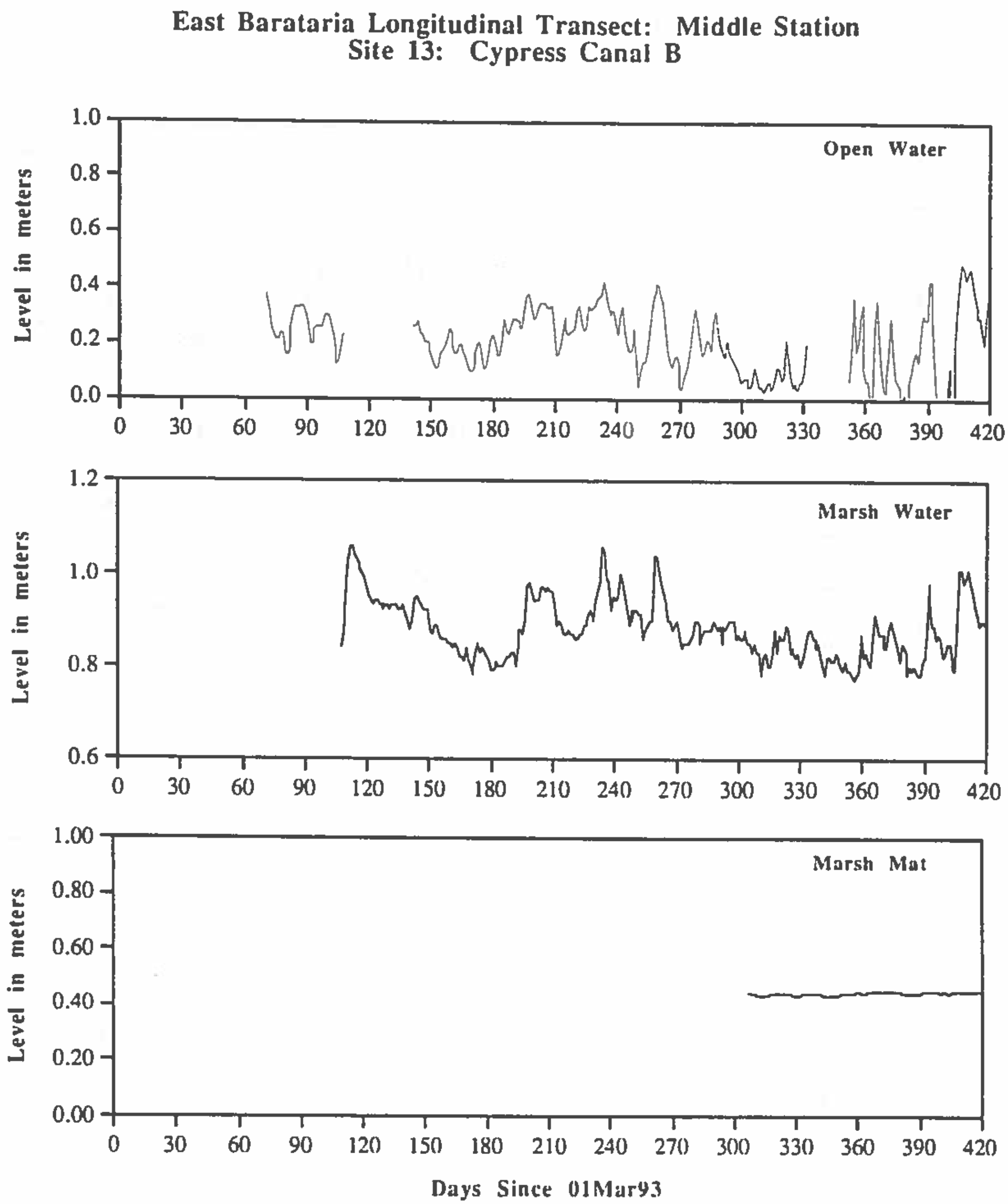


Figure 3.15. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 13 (Cypress Canal B), the middle gauge site on the east Barataria longitudinal transect.

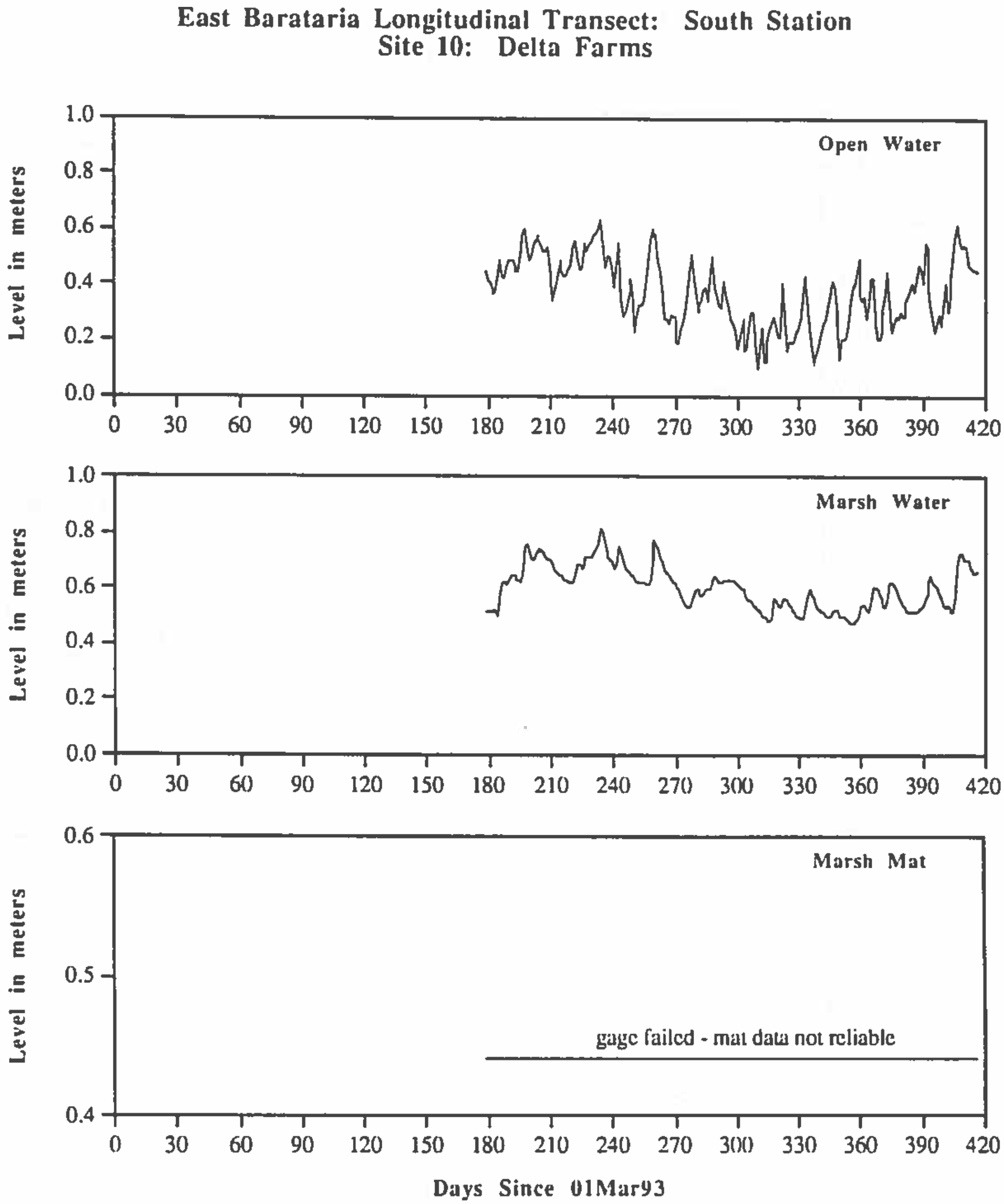


Figure 3.16. Time series plots of daily mean values of (top to bottom) open water, marsh water, and marsh mat. The horizontal axis is elapsed time (in days) with zero corresponding to 01Mar93. The vertical axis is water (or mat) level in meters. This data is from gauge Site 10 (Delta Farms) the south gauge site on the east Barataria longitudinal transect.

Terrebonne Basin Open Water Data: February 1994 through April 1994

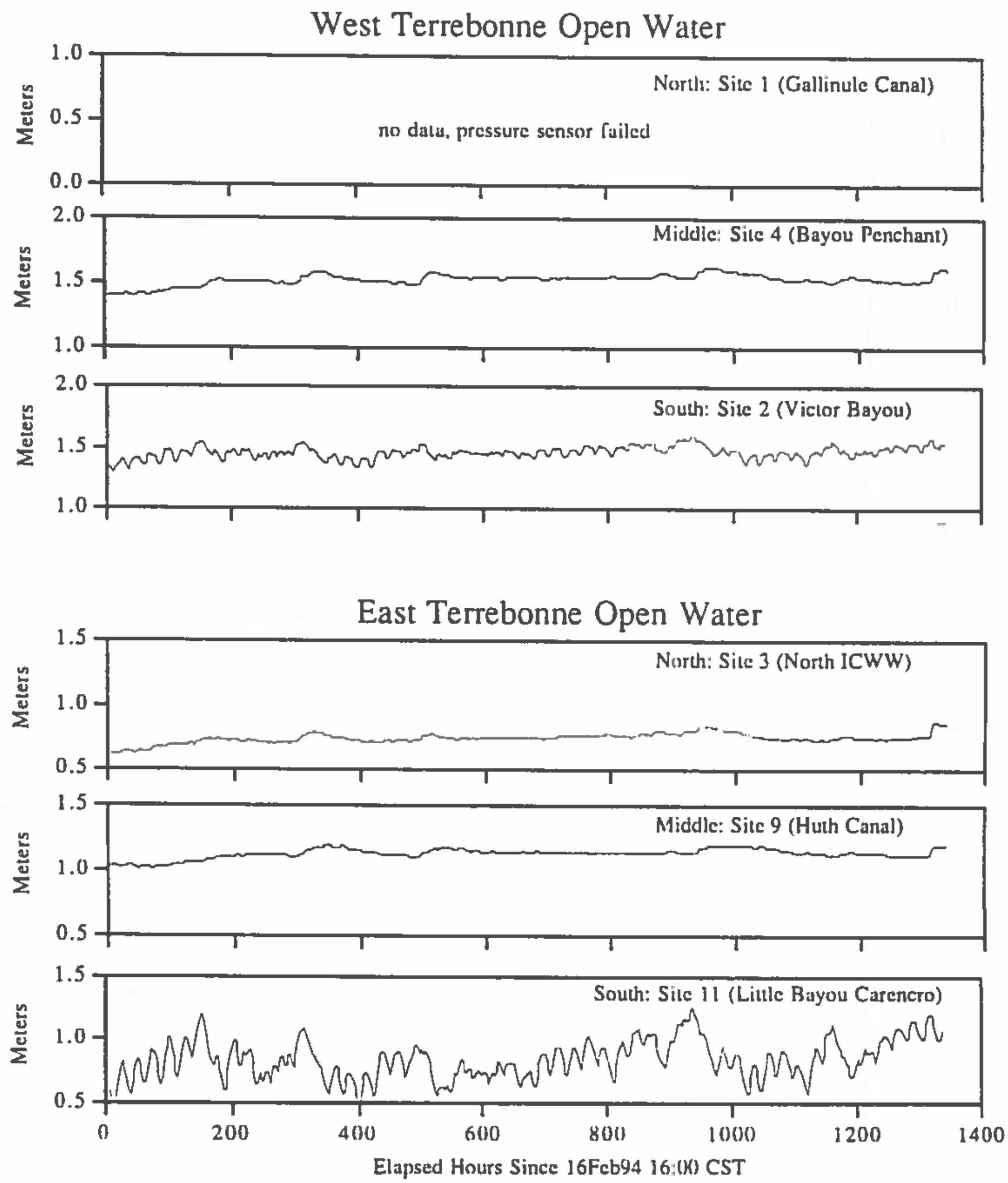


Figure 3.17. Time series plots of three hour mean values of open water fluctuations for the west Terrebonne Basin transects. The horizontal axis is elapsed time (in hours) with zero corresponding to 16Feb94:16:00 CST. The vertical axis is open water level in meters. The top group of three stations are from the west transect and the bottom group of three stations are from the east transect.

Barataria Basin Open Water Data: February 1994 through April 1994

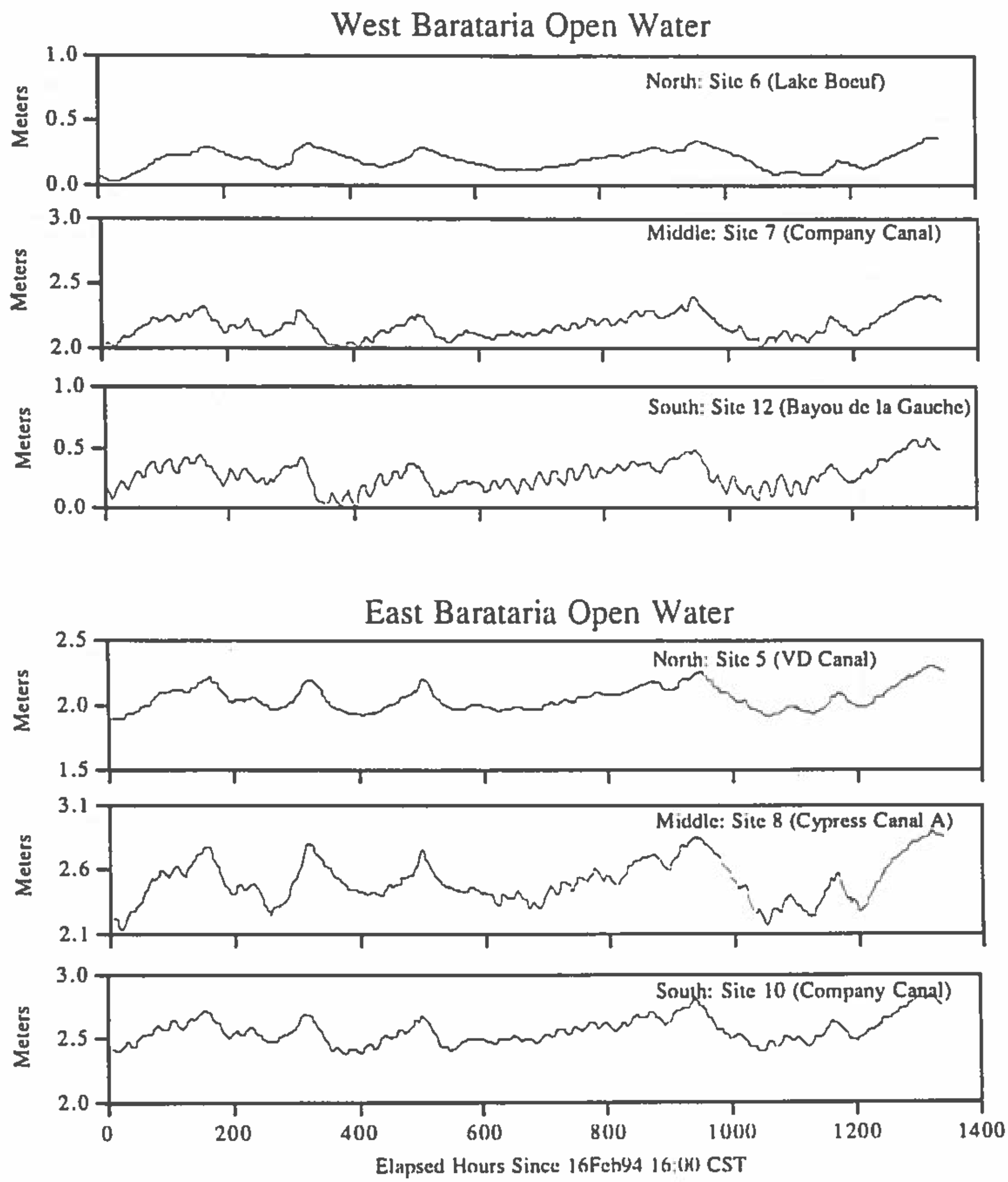


Figure 3.18. Time series plots of three hour mean values of open water fluctuations for the Barataria Basin transects. The horizontal axis is elapsed time (in hours) with zero corresponding to 16Feb94:16:00 CST. The vertical axis is open water level in meters. The top group of three stations are from the west transect and the bottom group of three stations are from the east transect.

Terrebonne Basin Marsh Mat Data: February 1994 through April 1994

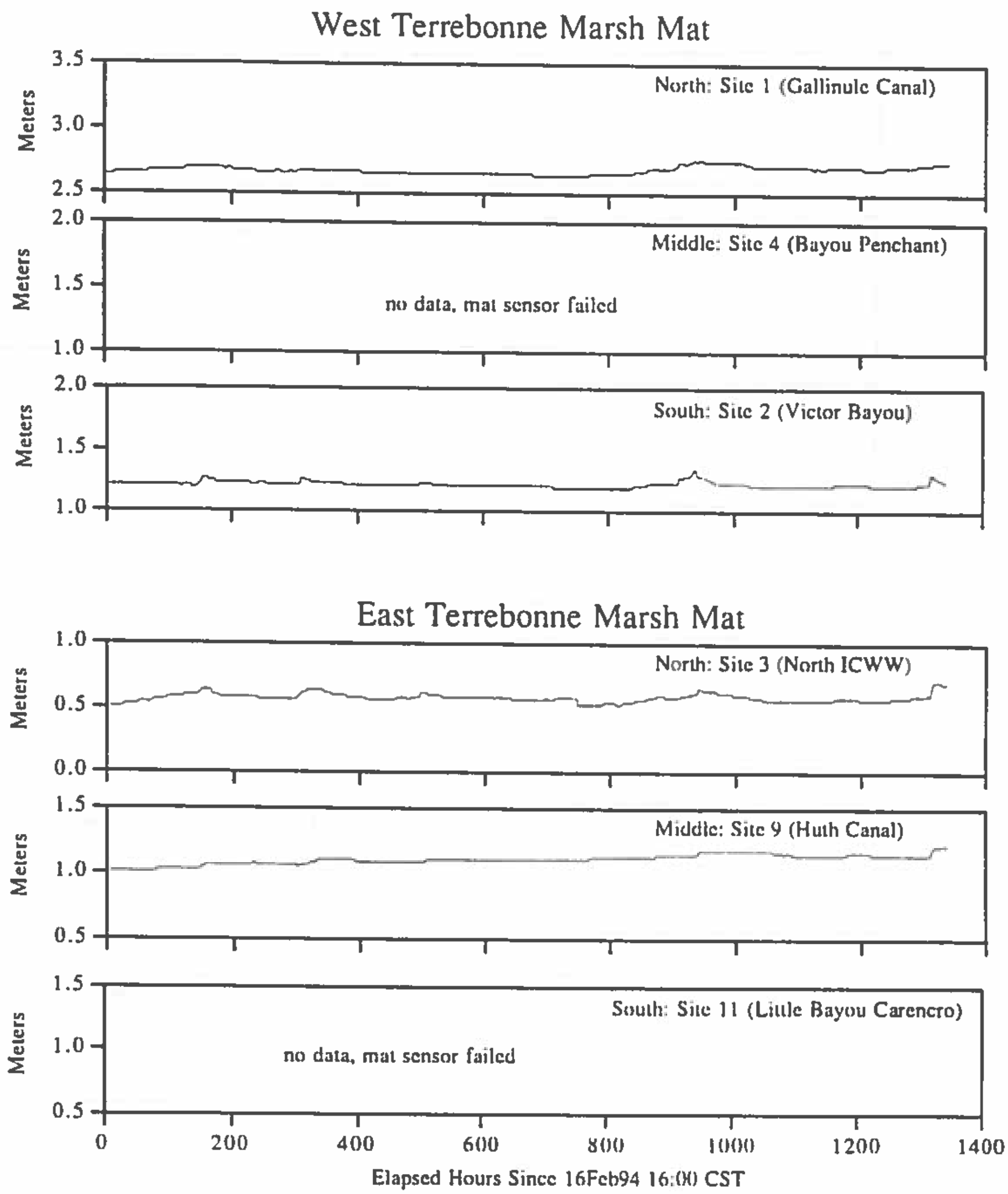


Figure 3.19. Time series plots of three hour mean values of marsh mat fluctuations for the Terrebonne Basin transects. The horizontal axis is elapsed time (in hours) with zero corresponding to 16Feb94:16:00 CST. The vertical axis is open water level in meters. The top group of three stations are from the west transect and the bottom group of three stations are from the east transect.

Barataria Basin Marsh Mat Data: February 1994 through April 1994

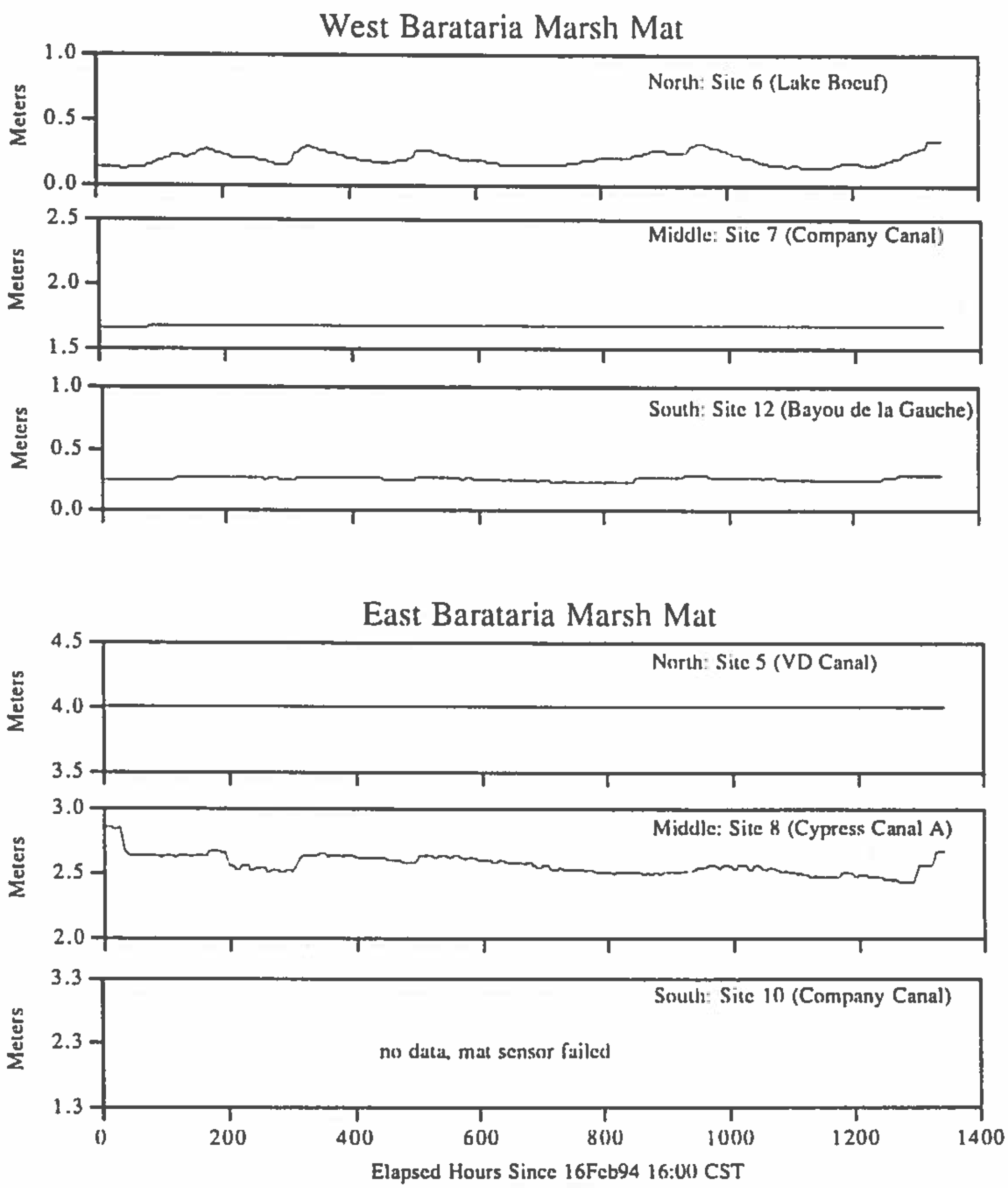


Figure 3.20. Time series plots of three hour mean values of marsh mat fluctuations for the Barataria Basin transects. The horizontal axis is elapsed time (in hours) with zero corresponding to 16Feb94:16:00 CST. The vertical axis is open water level in meters. The top group of three stations are from the west transect and the bottom group of three stations are from the east transect.

Station Site 1: Galinule Canal

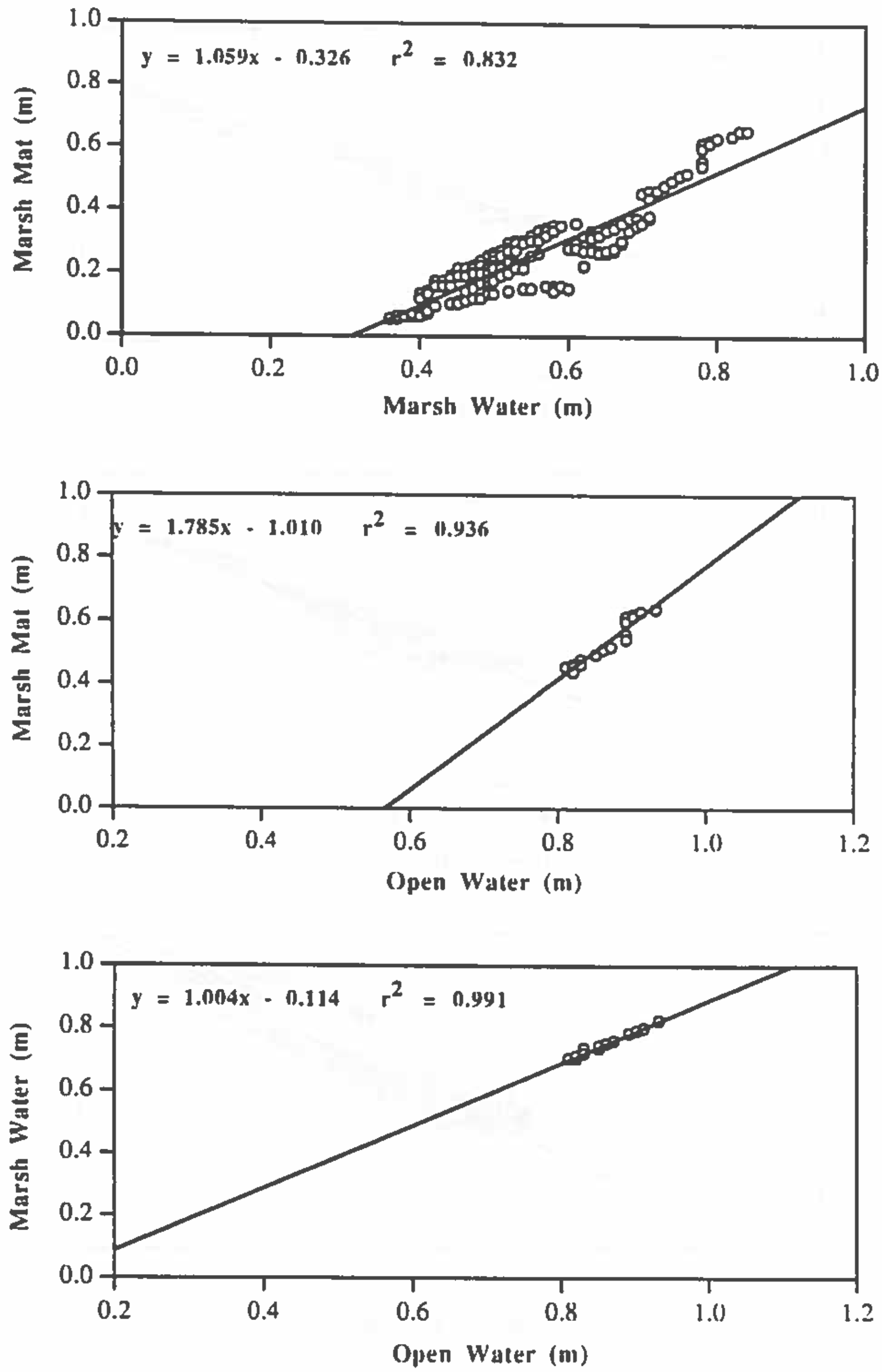


Figure 3.21. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the north station (Gallinule Canal - Site 1) on the West Terrebonne longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 4: Bayou Penchant

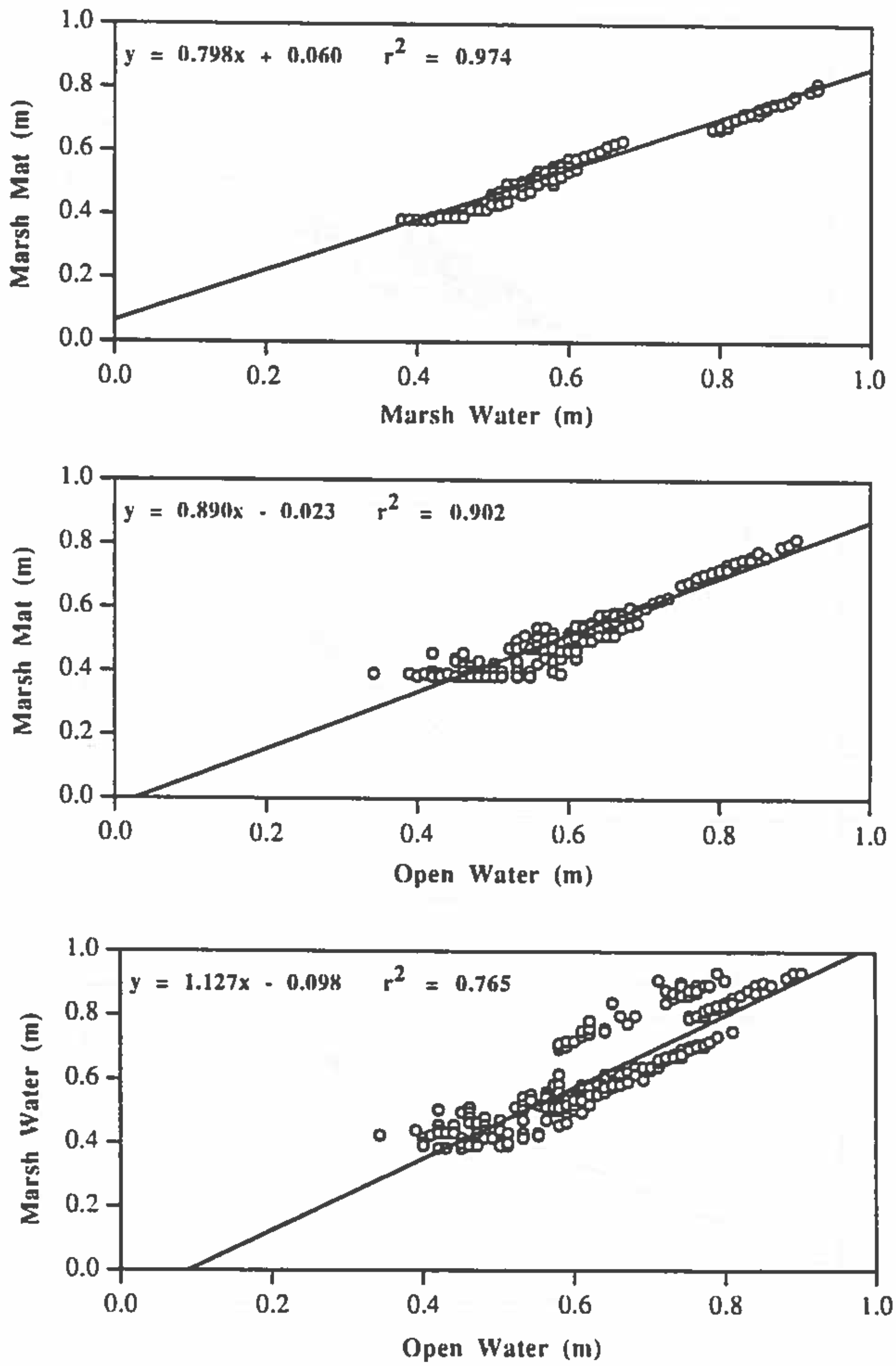


Figure 3.22. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the middle station (Bayou Penchant - Site 4) on the West Terrebonne longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

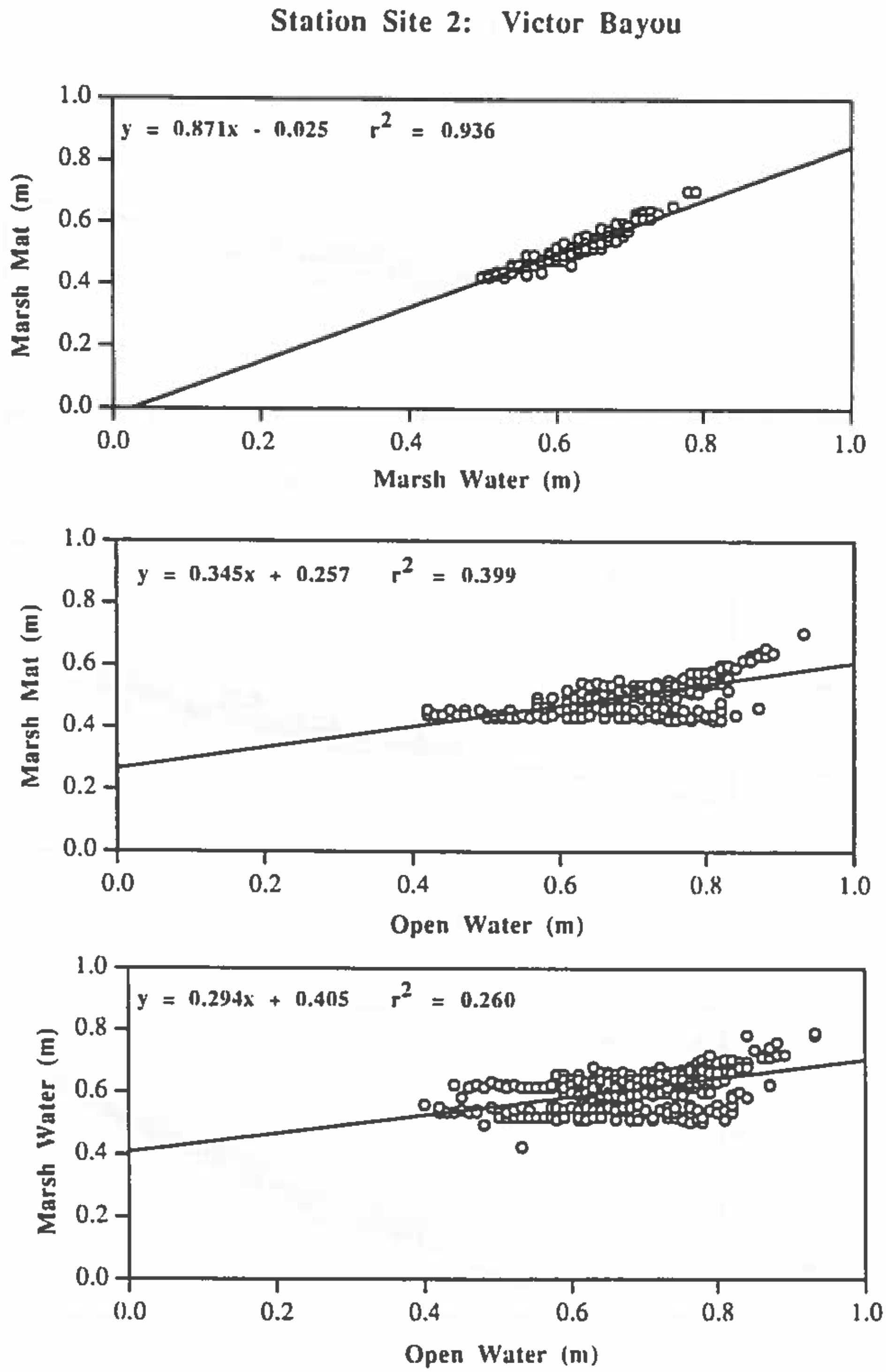


Figure 3.23. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the south station (Victor Bayou - Site 2) on the West Terrebonne longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 3: North ICWW

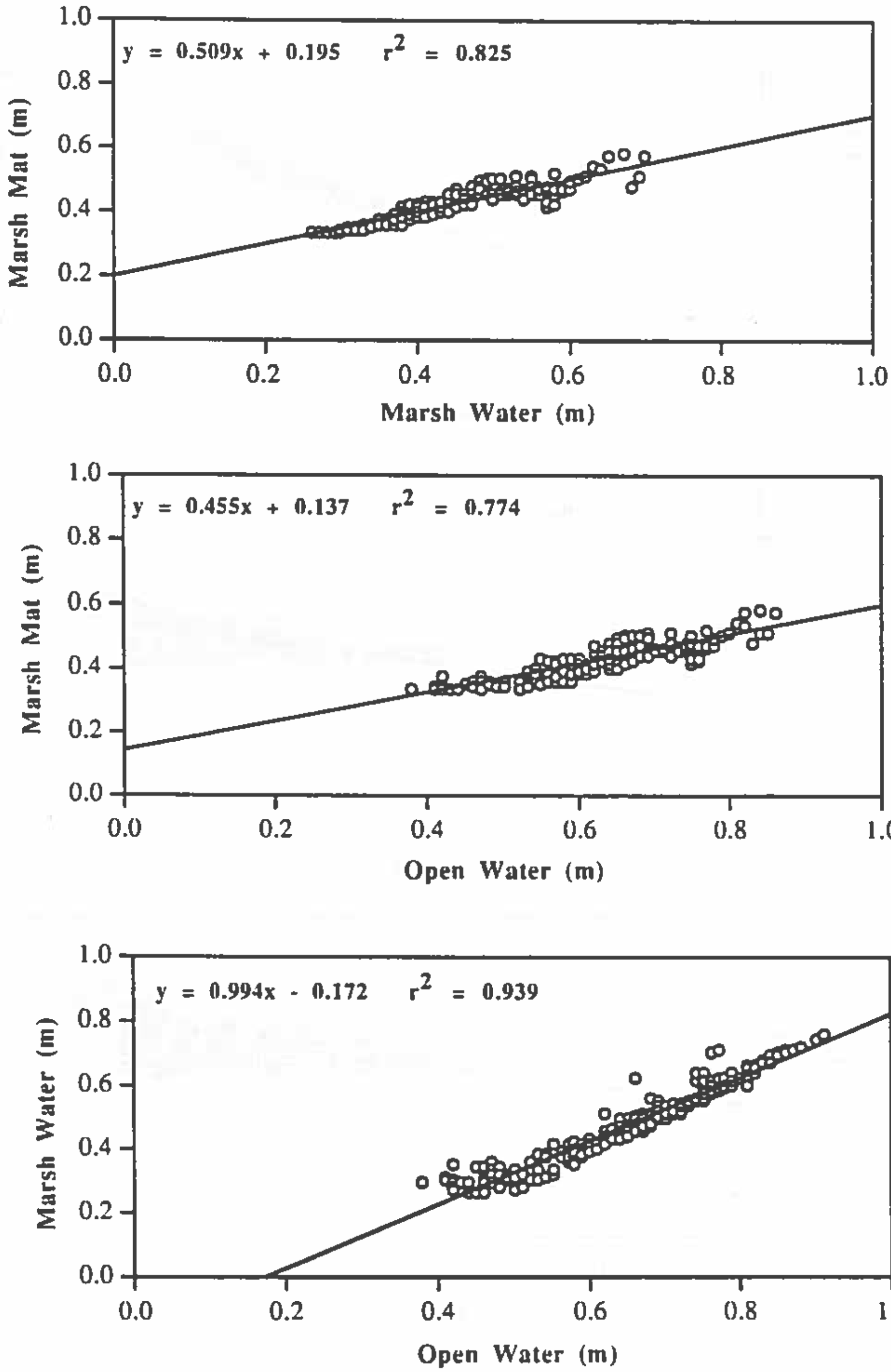


Figure 3.24. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the north station (North ICWW - Site 3) on the East Terrebonne longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 9: Huth Canal

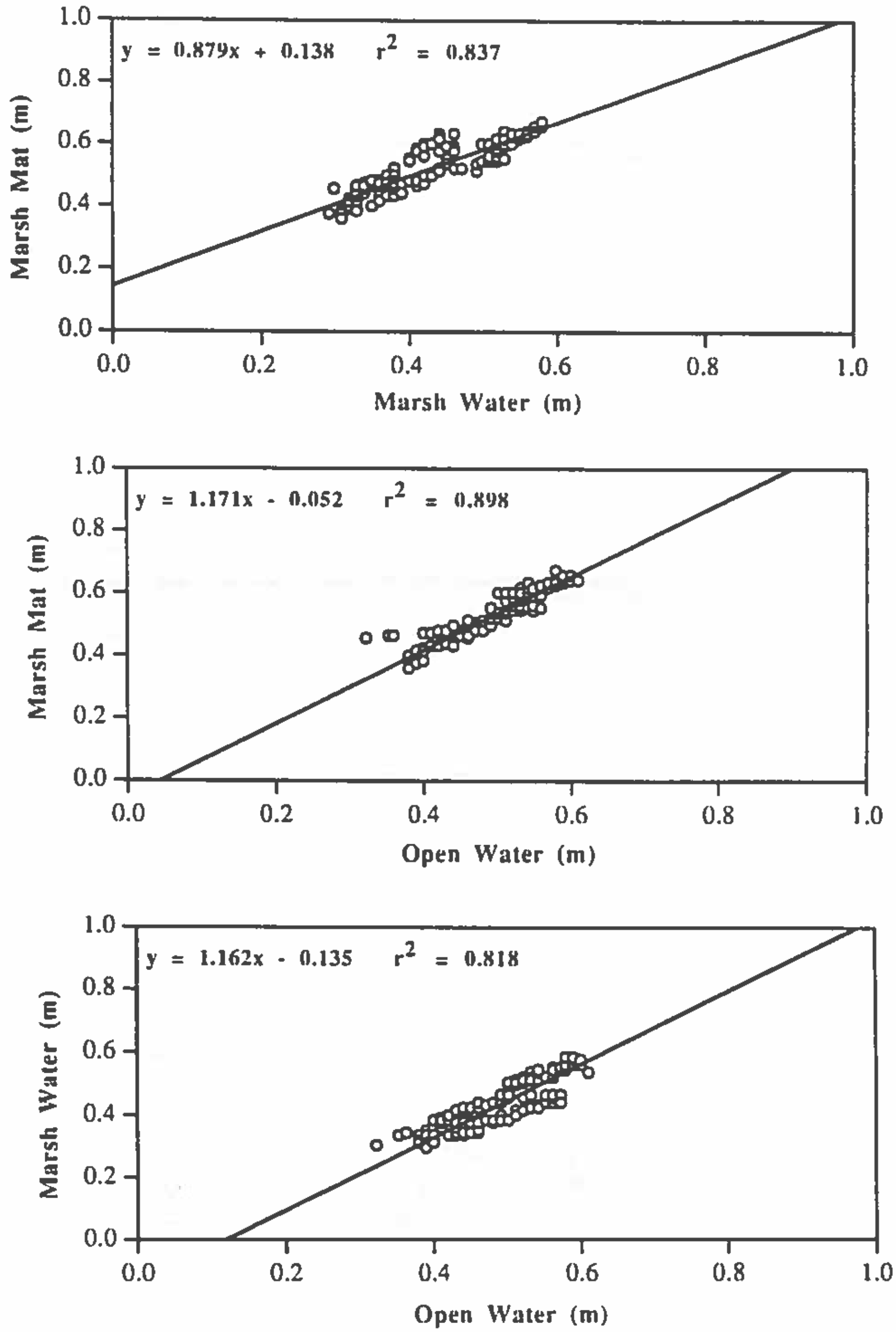


Figure 3.25. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the middle station (Huth Canal - Site 9) on the East Terrebonne longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 11: Little Bayou Carencro

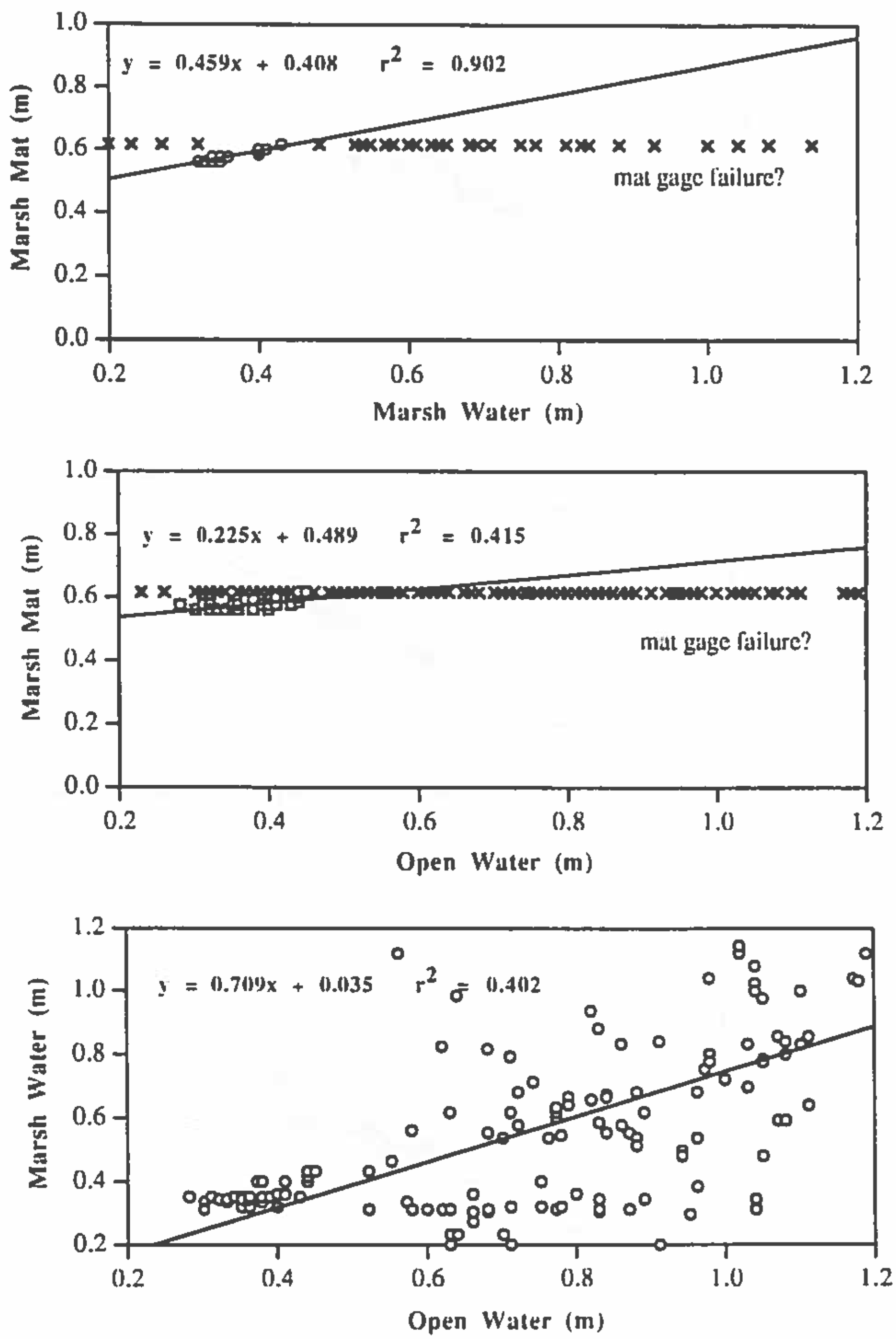


Figure 3.26. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the south station (Little Bayou Carencro - Site 11) on the East Terrebonne longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 6: Lake Boeuf

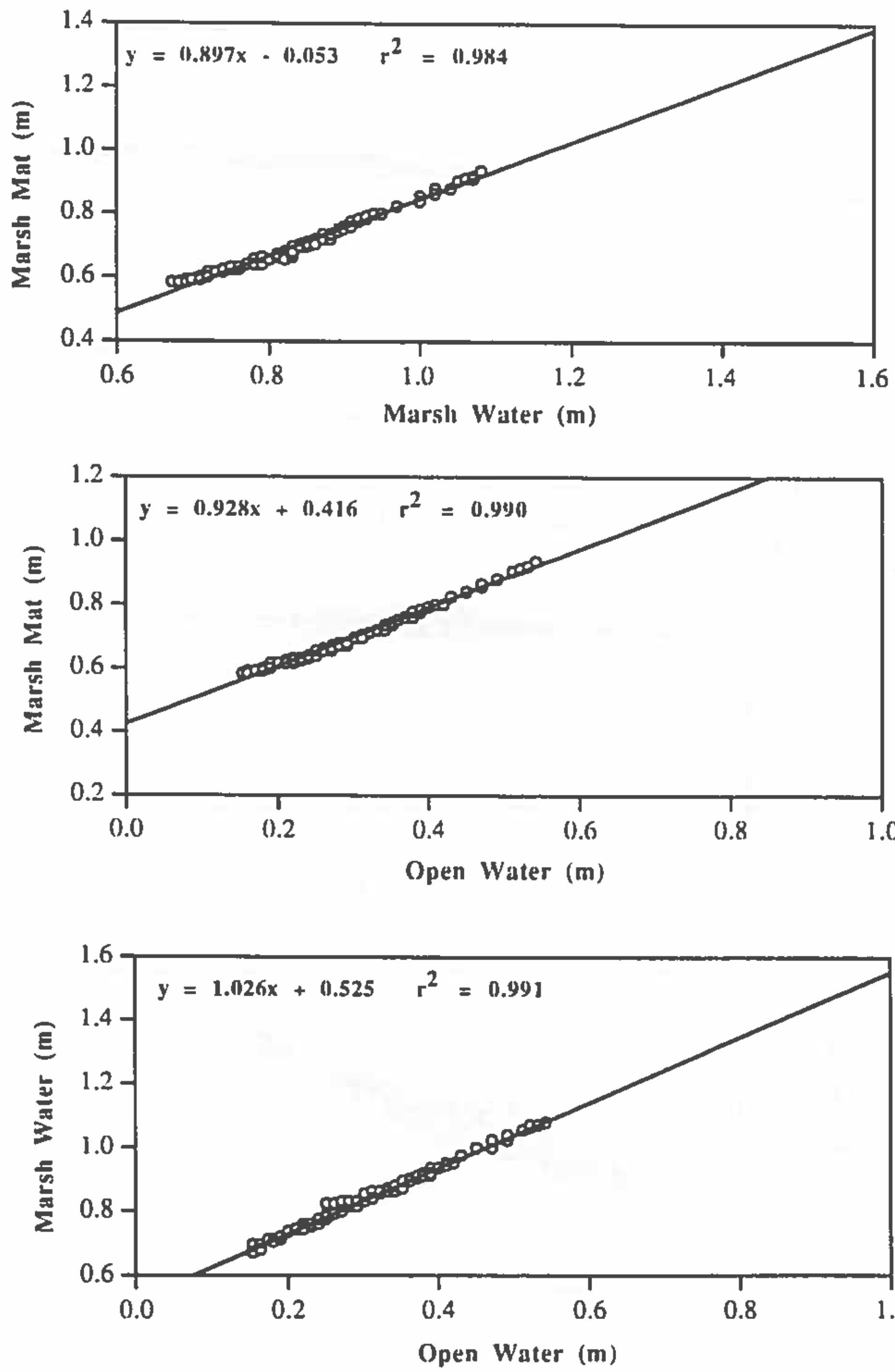


Figure 3.27. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the north station (Lake Boeuf - Site 6) on the West Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 7: Company Canal

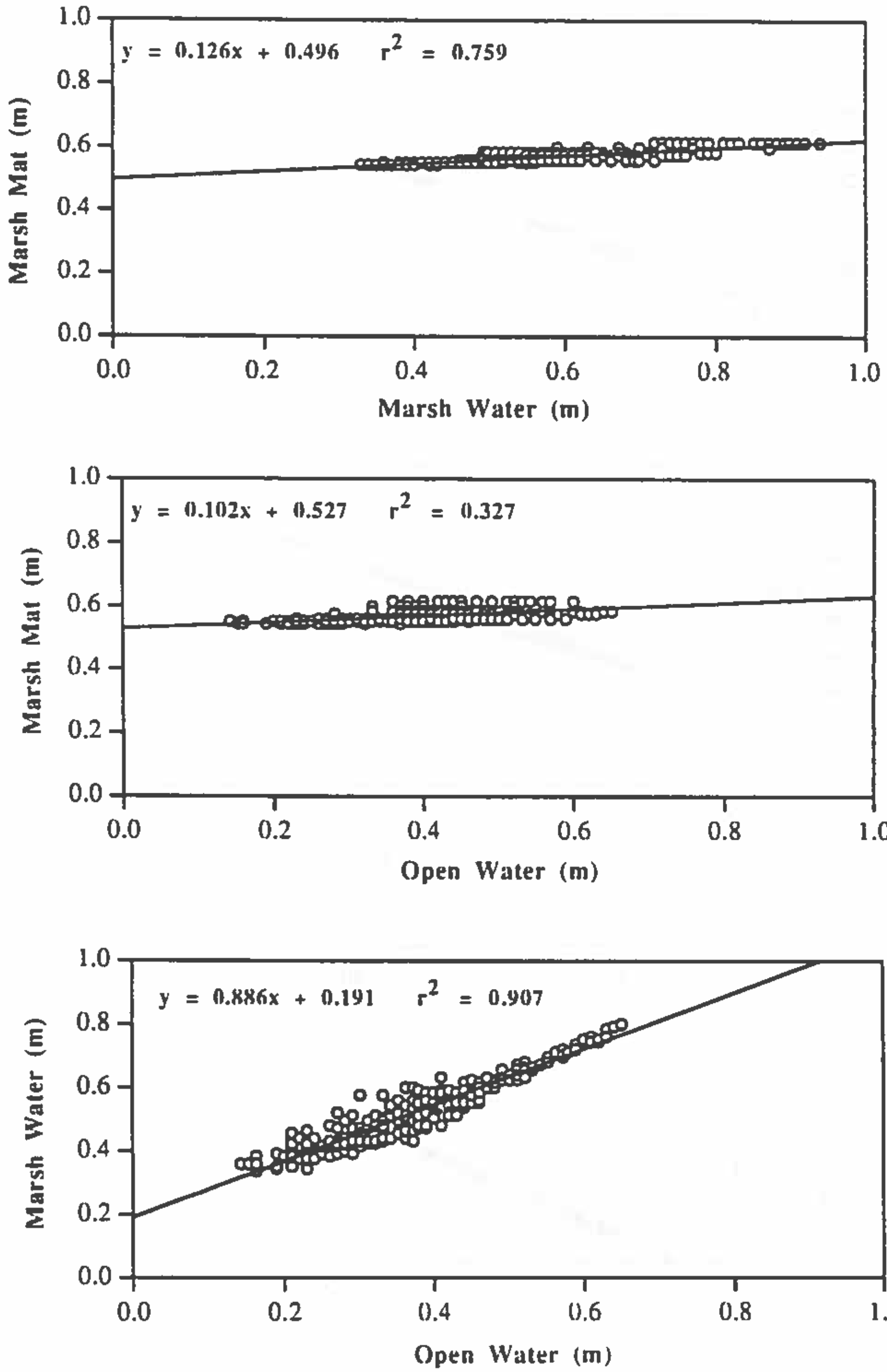
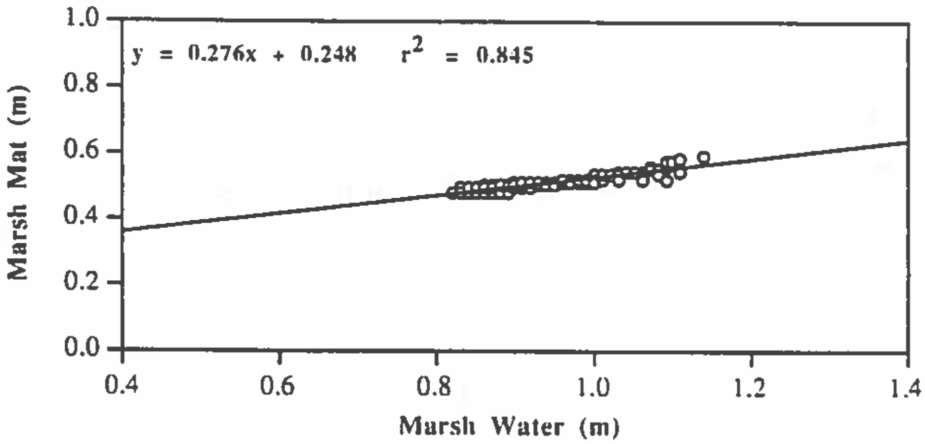
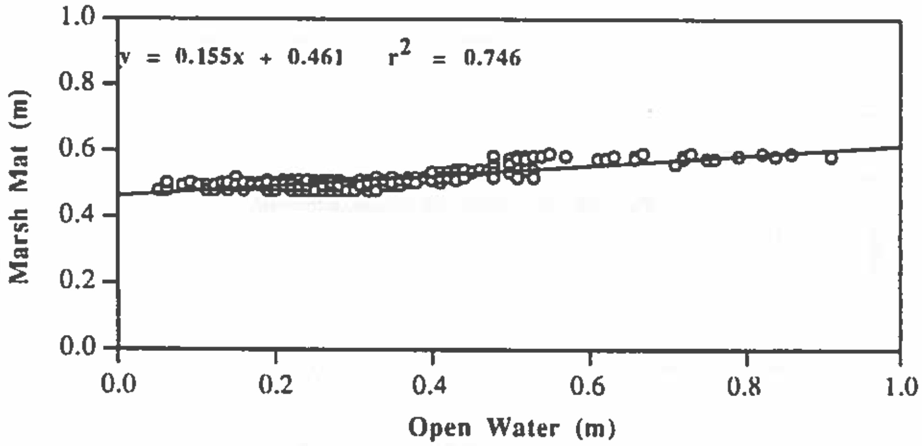


Figure 3.28. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the middle station (Company Canal - Site 7) on the West Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 12: Bayou de la Gauche





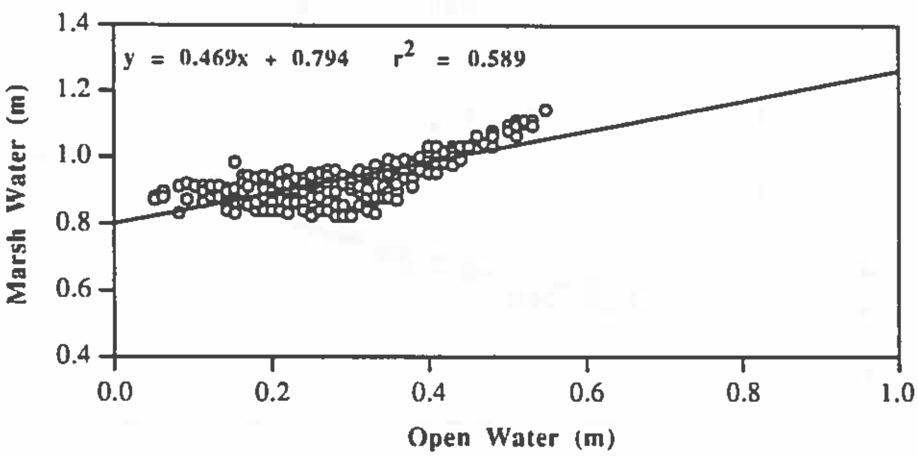


Figure 3.29. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the south station (Bayou de la Gauche - Site 12) on the West Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 5: VD Canal

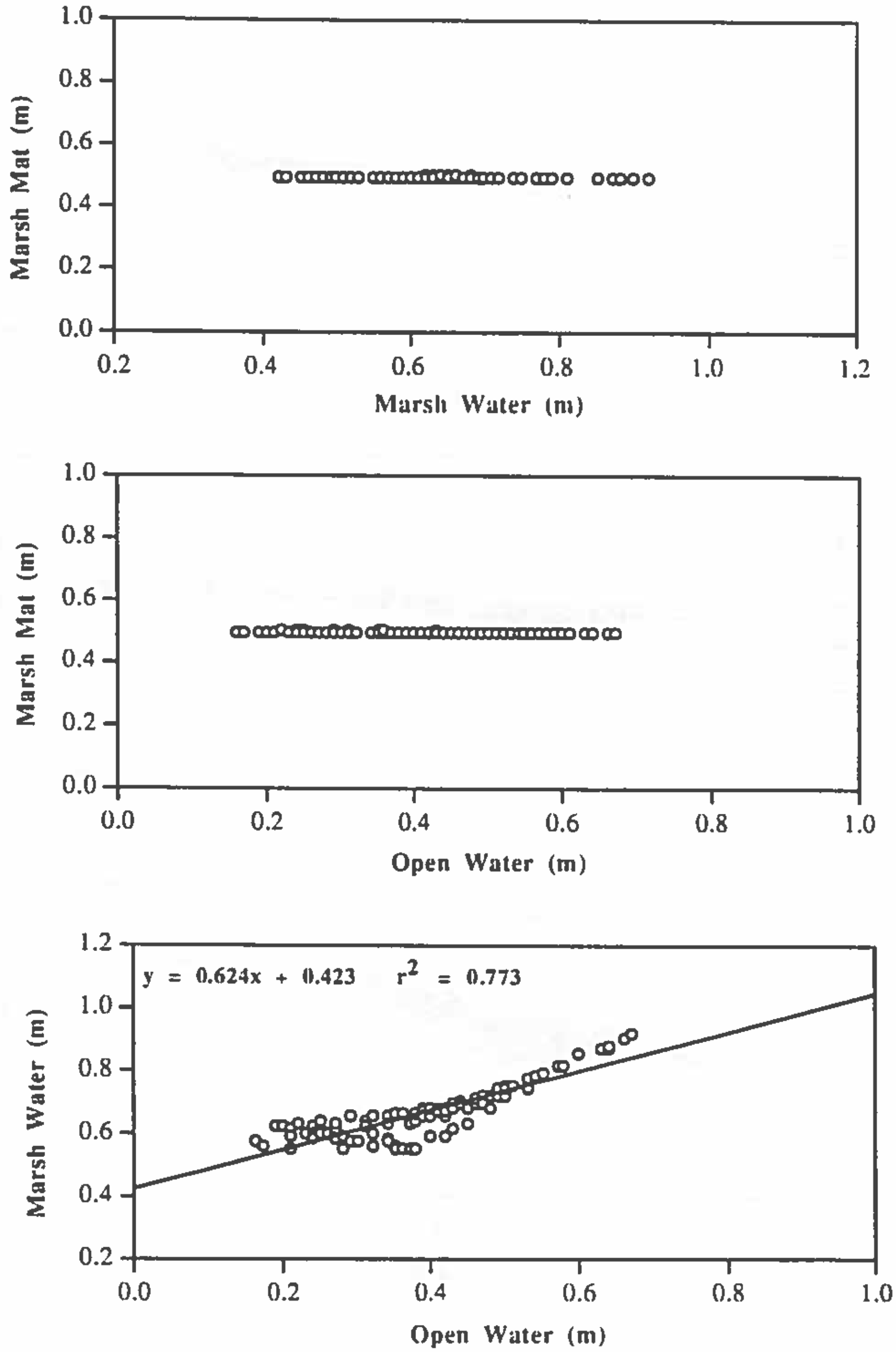
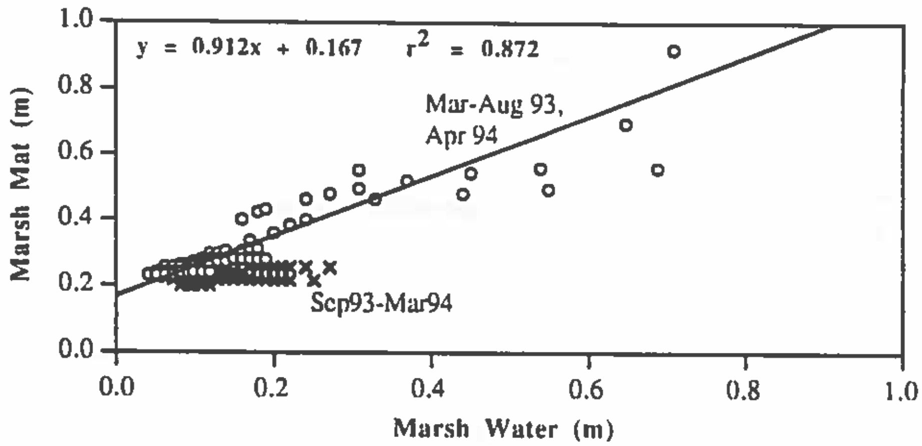
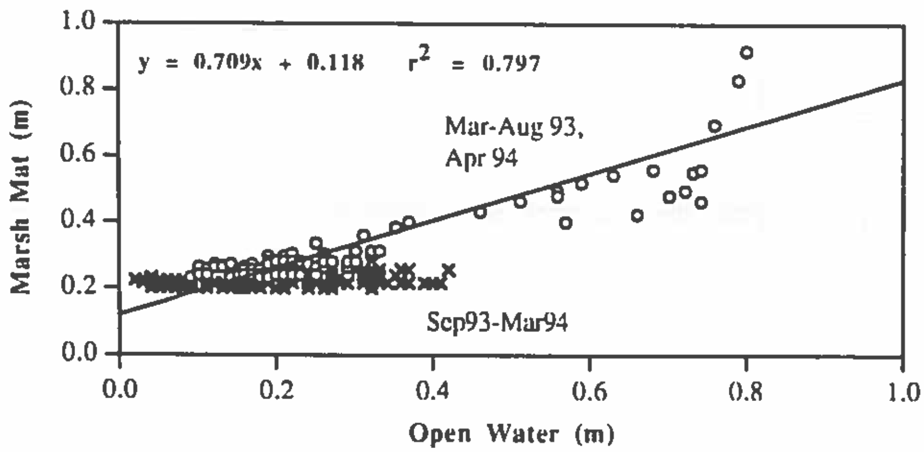


Figure 3.30. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the north station (VD Canal - Site 5) on the East Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 8: Cypress Canal A





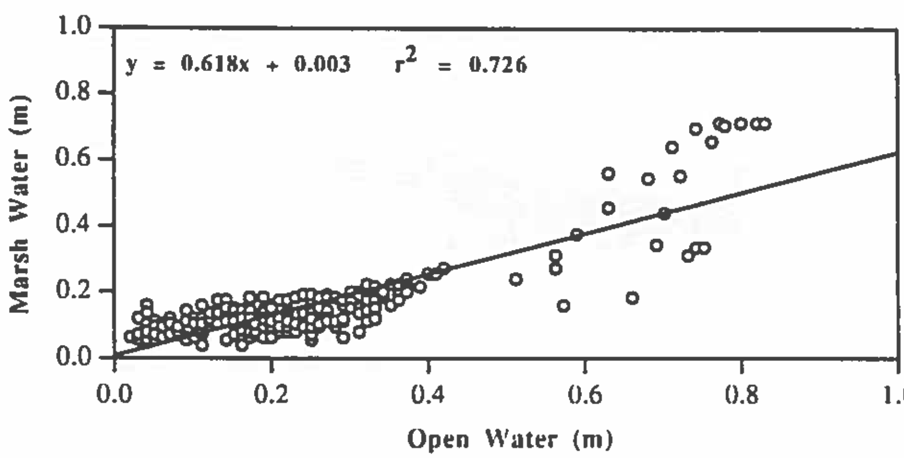


Figure 3.31. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the middle station (Cypress Canal A - Site 8) on the East Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

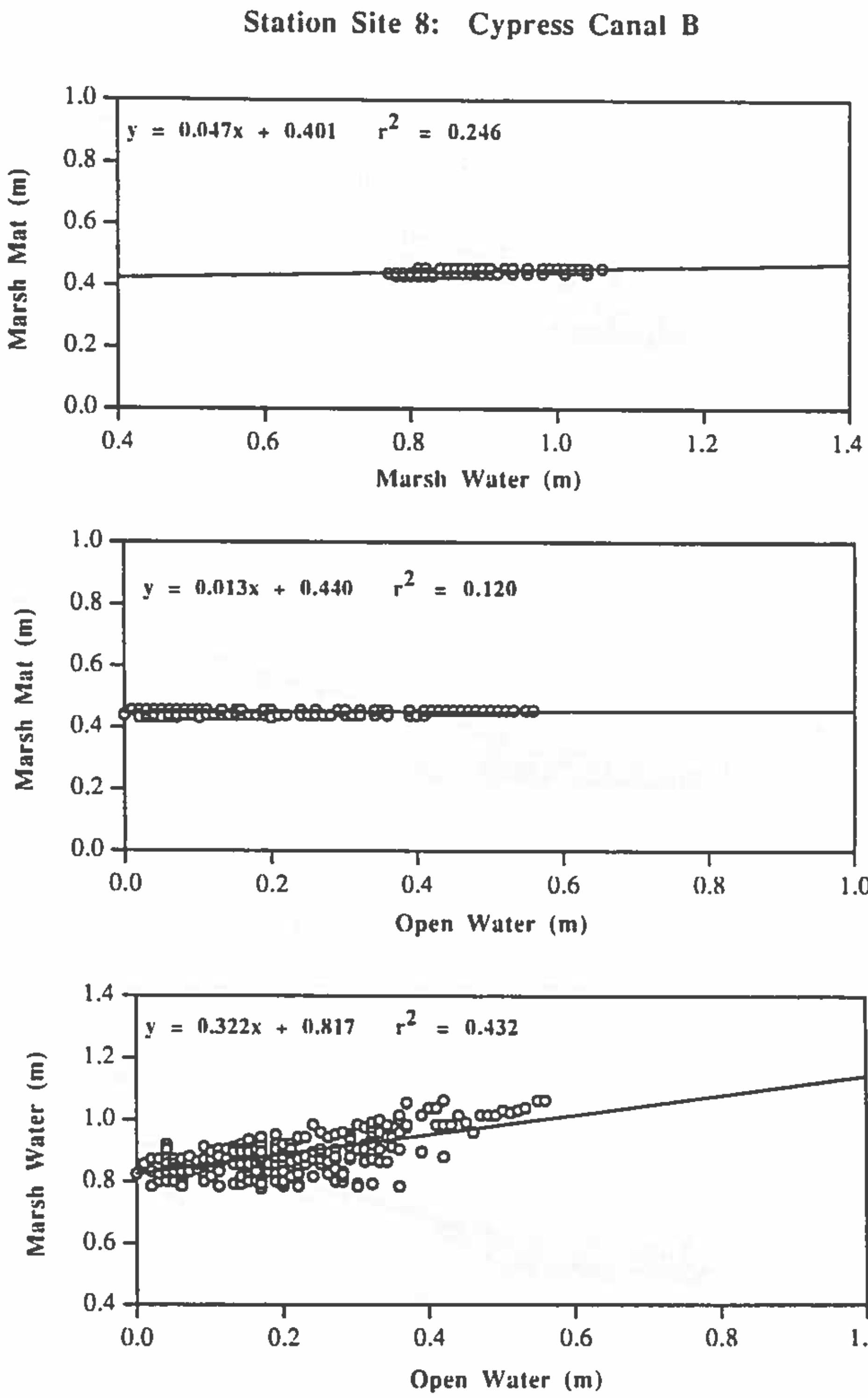


Figure 3.32. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the middle station (Cypress Canal B - Site 8) on the East Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

Station Site 10: Delta Farms

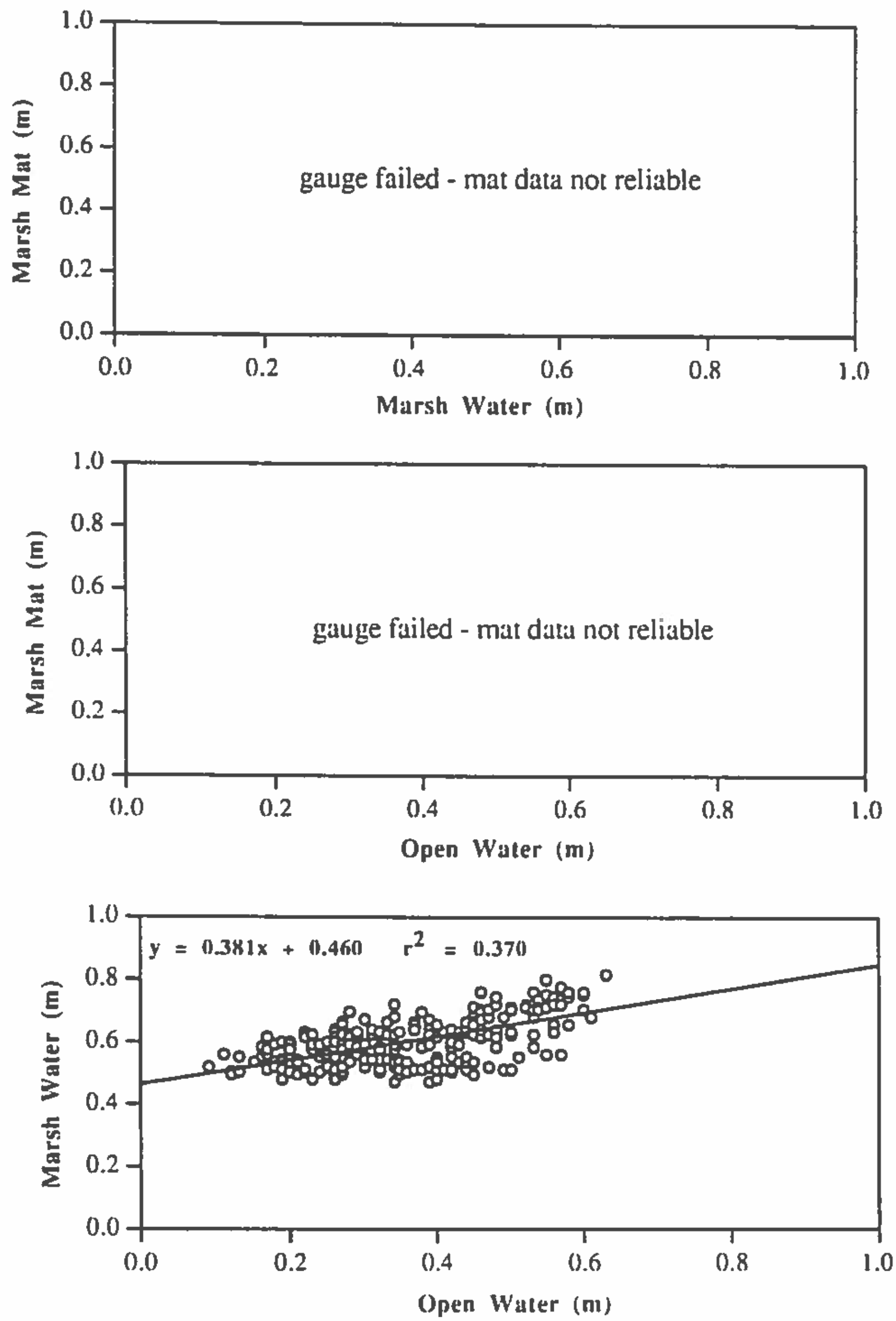


Figure 3.33. Plots of (top to bottom) marsh mat versus marsh water; marsh mat versus open water and marsh water versus open water for the south station (Delta Farms - Site 10) on the East Barataria longitudinal transect. The results of a regression analysis are indicated on the plot. The name of the station is indicated on each plot.

CHAPTER 4:
VEGETATION AND SUBSTRATE CHARACTERISTICS

INTRODUCTION

This section of the project describes the vegetation and substrates found at the 13 hydrology study sites (see Chapters 1 and 3, Figure 1.2). These stations were chosen to represent the major types of floating marsh vegetation that occur in the Louisiana deltaic plain (see Chapter 1, Sasser et al. in press). The objective of this chapter is to classify the 13 study sites based on their floristic composition and compare substrate characteristics among sites with different vegetation types.

Data collected at each study site to describe vegetation and substrate included:

1. Complete species list
2. Aboveground biomass by species
3. Belowground biomass
4. Substrate bulk density
5. Substrate percentage organic matter

A summary of the major vegetation, substrate, and hydrology parameters measured at each site and a brief description of each site is provided in Appendix B. This Chapter describes the grouping of study sites based on aboveground biomass of each species and compares belowground biomass and substrate characteristics among all study sites as well as among vegetation types.

METHODS

Aboveground Biomass and Species Composition

In early October 1993, five sampling stations were located at each gauge site randomly along a transect line which started 1m from the marsh water gauge. At each of these sampling stations, we harvested aboveground biomass of an area large enough to be representative for the vegetation type (Causton 1988). For most sites this area was 0.25 m^2, except for the sites dominated by *E. baldwinii* and site 12 (Bayou de la Gauche) where 0.10 m^2 plots were harvested. The aboveground biomass was harvested and transported to the lab were the plant material was sorted by species and then dried in a 65 °C oven to constant weight. Nomenclature follows Godfrey and Wooten (1981).

Belowground Biomass, Bulk Density and Percentage Organic Matter

After the aboveground biomass was removed, two 7.6 cm diameter cores were taken in the same plot to include the top 40 cm of the substrate, or (most of the time) the entire mat thickness, which ever was less. Both cores were divided into 5 cm increments and stored in plastic bags for transportation to the lab. Each replicate core was randomly assigned to be analyzed for belowground biomass or bulk density and percentage organic matter. Cores for belowground biomass were washed in a 0.5-mm mesh sieve to remove soil particles, and then live roots and rhizomes were separated (based on their whitish color) from the remaining matrix of dead roots and other organic material. Roots and rhizomes were then dried to constant weight in a 65 °C oven. The reported belowground biomass combines roots and rhizomes from the whole core, and represents all living tissue in the top 40 cm of the substrate.

Cores for substrate characteristics were first dried to constant weight to determine dry bulk density. After bulk density was determined, the sample was ground in a Wiley Mill, and subsequently, a sub-sample was burned at 450 °C for 4 hours to determine percentage organic matter.

Analyses

Vegetation was analyzed for species composition of individual samples with detrended correspondence analysis (DECORANA; Hill 1979a) and two-way indicator species analysis (TWINSPAN; Hill 1979b). Differences in biomass and substrate characteristics among vegetation types and sites were tested using analysis of variance (ANOVA) in combination with a comparison of the means using Duncan's multiple range test (SAS 1985). All differences are significant at the α=0.05 level unless stated otherwise.

RESULTS AND DISCUSSION

Comparisons Among Sites

Vegetation

DECORANA showed that the vegetation of the study sites can be divided into four groups: 1) sites dominated by *Eleocharis baldwinii*, 2) sites dominated by *Spartina patens*, 3) sites dominated by *Sagittaria lancifolia*, and 4) sites dominated by *P. hemitomon* (Figure 4.1). Sites

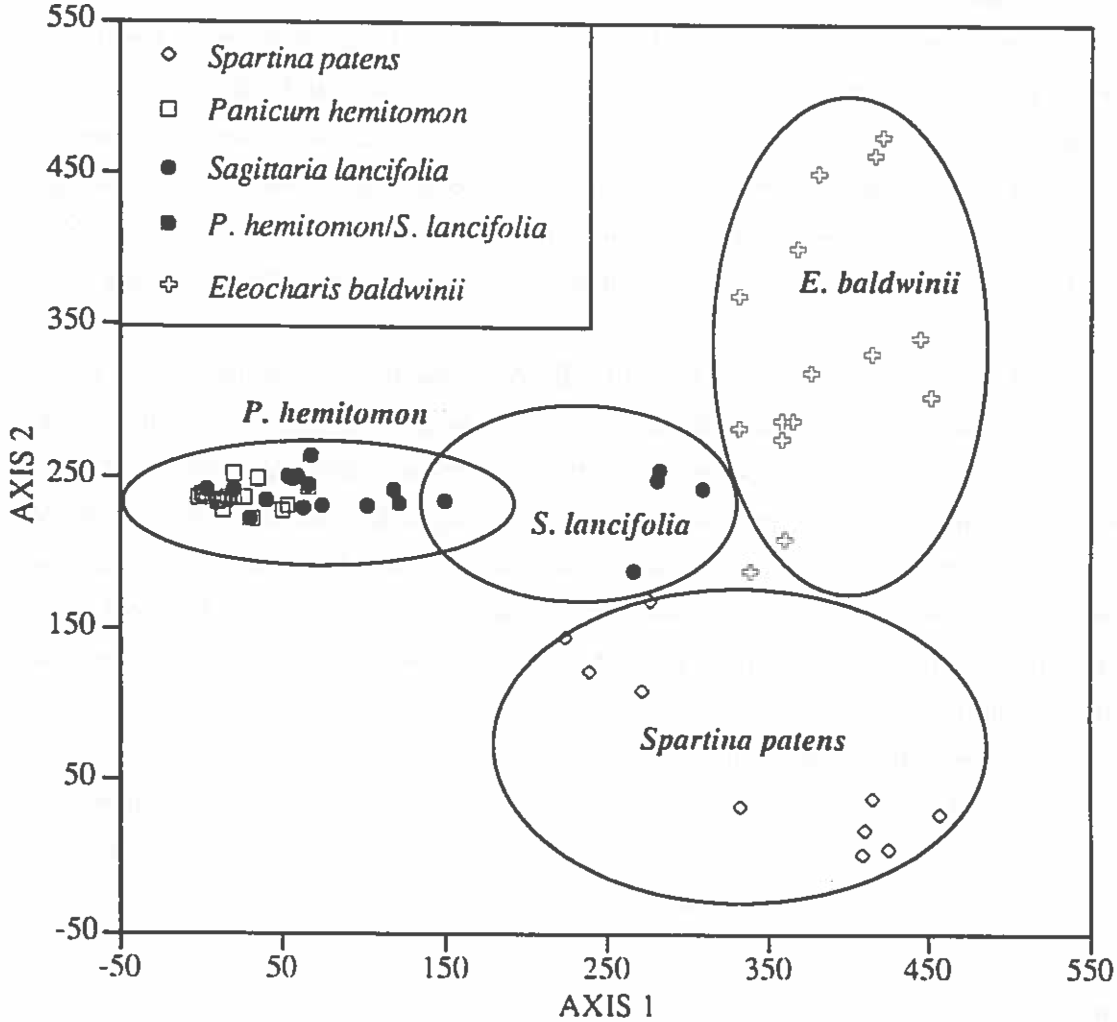


Figure 4.1. First two axes from DECORANA showing the separation of the sites into four vegetation types.

that changed from *S. lancifolia*-dominated in the spring to *P. hemitomon*-dominated in the fall were similar in vegetation composition to those that were dominated by *P. hemitomon* throughout the growing season.

TWINSPAN separated the vegetation into three groups (Table 4.1). The first separation between sites was based on the presence/absence of *P. hemitomon*. Sites without *P. hemitomon* were then separated based on the presence/absence of *E. baldwinii*. This results in the following three vegetation types: 1) sites dominated by *P. hemitomon*, 2) sites characterized by *Eleocharis baldwinii*, and 3) sites that contain *Eleocharis rostellata.*, *Spartina patens*, *Sagittaria lancifolia* and/or *Sacciolepis striata*. This last group combines the *Spartina patens*-dominated intermediate sites with the only *Sagittaria lancifolia*-dominated site, because all of them contain combinations of *Sagittaria lancifolia*, *Sacciolepis striata*, and *Polygonum punctatum*. In this case, TWINSPAN is less useful in separation of vegetation types due to the large overlap in species among samples and sites.

For further analysis, we used the DECORANA separation augmented by our knowledge of sites where vegetation dominance had changed during the growing season. We did this because vegetation surveys in the spring (when the study sites were selected) added useful information to distinguish actual vegetation types, which could not be included in the DECORANA analysis. The division, therefore, consists of the separation based on DECORANA with a further division between the *P. hemitomon*-dominated sites into (1) sites dominated by *P. hemitomon* throughout the growing season and (2) sites that changed from *S. lancifolia*-dominated in the spring to *P. hemitomon*-dominated in the fall (*P. hemitomon/S. lancifolia* sites). Table 4.2 shows our assignment of vegetation type to the study sites.

Species diversity (the mean number of species per plot) was extremely variable ranging from 3.6 at VD Canal to 12.4 at Lake Boeuf (Table 4.2). A complete listing of all the species observed at each site is provided in Appendix B.

Biomass

Aboveground biomass was lowest at the *E. baldwinii* sites (475 g dwt/m^2) and highest at the *S. patens* (959 g dwt/m^2) and *P. hemitomon* (921 g dwt/m^2) sites (Figure 4.2). However, there were no significant differences in aboveground biomass among vegetation types nor were there significant differences in aboveground biomass among sites (Figure 4.3).

Belowground biomass was significantly higher at the *P. hemitomon* -dominated sites than at the other sites (Figure 4.2). Whereas *E. baldwinii* sites had significantly lower belowground biomass than the other sites. The differences among sites reflected the differences among vegetation types (Figure 4.3).

Table 4.1. TWINSPAN division into vegetation types.

Species	Site		
	11 111 8	11111111118888	88888
	66666999225592277770024000445544579b	1111122222bbbb	11aaaaa33333111
Triadenum virginicum	111-1-11----------------------------	--------------	1-----------1-1
Solidago sempervirens	2--11-------------------------------	--------1-----	---------------
Eleocharis parvula	-1----------------------------------	--------------	---------------
Andropogon virginicus	1-----------------------------------	--------------	---------------
Decodon verticillatus	1-----------------------------------	--------------	---------------
Polygonum sagittata	11111-------------------------------	--------------	---------------
Juncus spp	-1----------------------------------	--------------	---------------
Aster spp	-2-12-------------------------------	--------------	---------------
Boehmeria cylindrica	------121-------------------------1-	--------------	---------------
Scirpus validus	--------------1---------------------	--------------	---------------
Conoclinium coelestinum	111--1-111---11---------------------	--------------	---------------
Cyperus spp	-111----1---------11---1------------	--------------	---------------
Thelypteris palustris	111111111---1---------11---21--52---	--------------	---------------
Panicum hemitomon	43444444444545422212222222434323425-	--------------	---------------
Dichromena colorata	--------------------2--1------------	--------------	---------------
Saururus cernuus	----------------------------------1-	--------------	---------------
Ipomoea sagittata	----------------------------------1-	--------------	---------------
Leersia oryzoides	111111111211111122222121121111123333	--------------	-------1-111---
Cyperus polystachyos	-111-1-111---------111-111--1-------	11-111-11----1	--1-111--------
Eleocharis rostellata	11111111111111-11111-1111111111111-1	31111522112111	---------------
Vigna luteola	11111---11---1-1--------------------	-----14111----	---------------
Sagittaria lancifolia	----1---11-----112111111111211-1111-	-----111112211	----1----------
Ludwigia peploides	------------------------------11----	--1-1---------	---------------
Galium tinctorium	---1-------------------------------1	---1-1--------	---------------
Kosteletzkia virginica	-----11-----------------------------	31------------	---------------
Scirpus olney	------------------------------------	12112-1-------	---------------
Carex alata	------------------------------------	-1-11---------	---------------
Rhynchospera compressa	------------------------------------	---1----------	---------------
Spartina patens	------------------------------------	521-111113----	---------------
Aster tenuifolius	------------------------------------	-----1111--1--	---------------
Distichlis spicata	------------------------------------	-----1-111----	---------------
Hydrocotyle spp	1111----1-----1------1111-----------	-1111--1111-11	1111111----1---
Polygonum punctatum	---1-----------------1--1-----1-----	---1-11-1-1111	-----1111-1----
Eleocharis spp	--------------------1---------------	------111-----	-------111-1--1
Sacciolepis striata	---11---1---1----------------------1	2---1--1112225	11-111111111111
Paspalum vaginatum	------------------------------------	---1----------	-1-------------
Phyla lanceolata	---------------------------------2-1	----1--11-1112	11111111111-1--
Ludwigia leptocarpa	------------------------------------	---11---------	------1--1--11-
Cyperus odoratus	----------------------------------1-	---1----------	-1-----1-------
Bacopa monnieri	------------------------------------	---11---------	--11111--------
Scirpus cubensis	------------------------------------	--------------	---------121---
Limnobium spongia	------------------------------------	--------------	------1-11-----
Fuirena pumila	------------------------------------	--------------	--1-1-11-11----
Aeschynomene indica	------------------------------------	--------------	--1---------211
Bidens laevis	------------------------------------	----------21--	1-111-111111---
Eleocharis baldwinii	--------------------1---11----------	-----------11-	111111111111111
Althernanthera philoxeroides	---------------1--1-----------------	--------------	--1111-11111---
Sagittaria latifolia	--------1----1----------------------	--------------	--11-1111111---

Table 4.2. Vegetation description of the gauge sites.

Site #	Site name	Vegetation Type	Species Richness[1]	Species Diversity[2]
1	Gallinule Canal	*Eleocharis baldwinii*	12	5.4
2	Victor Bayou	*Panicum hemitomon/ Sagittaria lancifolia*	22	7.6
3	North ICWW	*Eleocharis baldwinii*	16	9.8
4	Bayou Penchant	*Panicum hemitomon*	17	6.0
5	VD Canal	*Panicum hemitomon*	6	3.6
6	Lake Boeuf	*Panicum hemitomon*	24	12.4
7	Company Canal	*Panicum hemitomon/ Sagittaria lancifolia*	13	4.8
8a	Cypress Canal A	*Eleocharis baldwinii*	16	9.8
8b	Cypress Canal B	*Sagittaria lancifolia*	14	6.8
9	Huth Canal	*Panicum hemitomon*	20	6.6
10	Delta Farms	*Panicum hemitomon/ Sagittaria lancifolia*	15	7.0
11	Little Bayou Carencro	*Spartina patens*	21	8.4
12	Bayou de la Gauche	*Spartina patens*	20	9.6

[1]Total number of species observed near the gauge

[2]Average number of species observed per plot

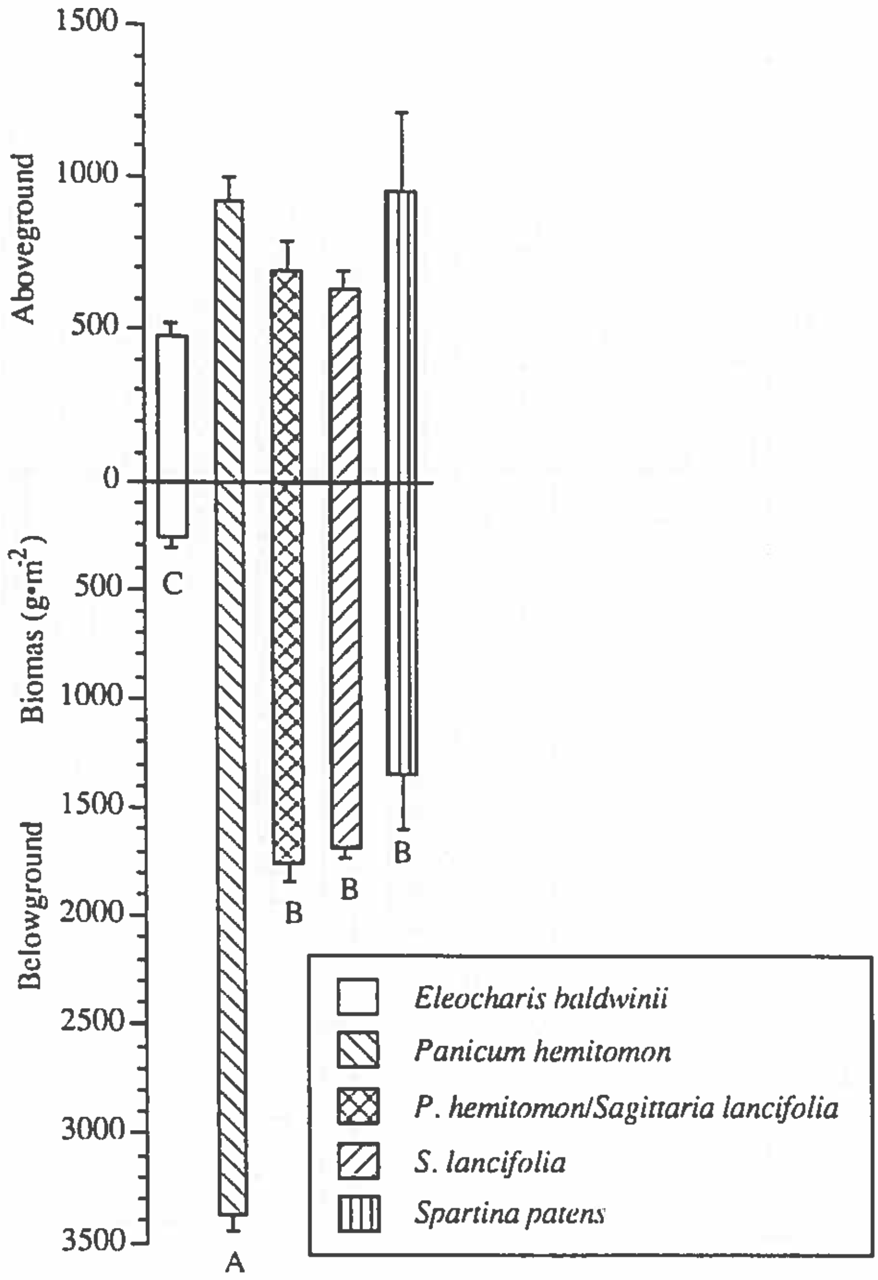


Figure 4.2. Aboveground and belowground biomass (up to 40 cm depth) for the different vegetation types. Error bars represent one standard error. Letters indicate significant differences in belowground biomass among vegetation types.

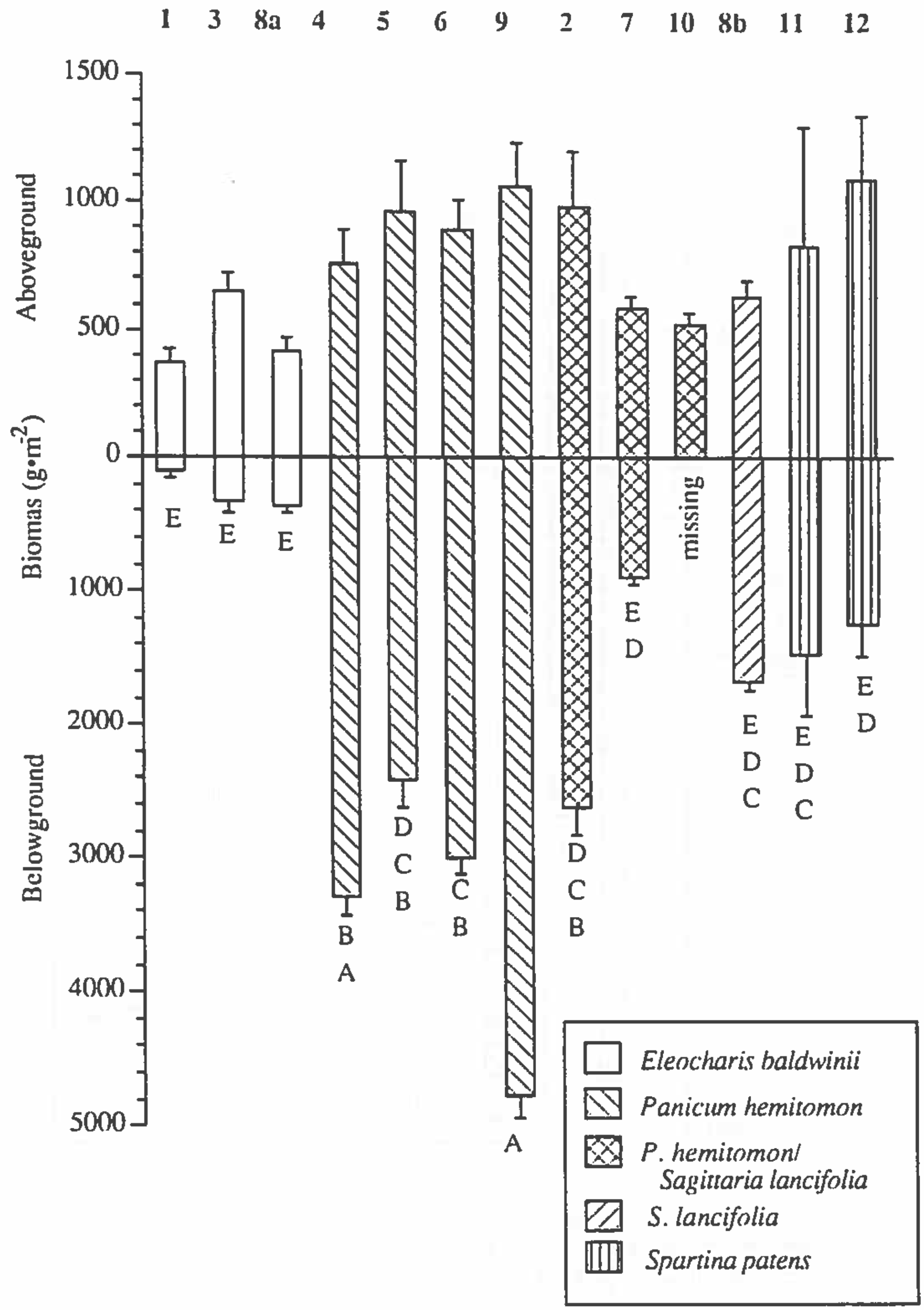


Figure 4.3. Aboveground and belowground biomass (up to 40 cm depth) for the different sites. Error bars represent one standard error. Letters indicate significant differences in belowground biomass among sites.

Substrate

The percentage organic matter of *S. patens* and *P. hemitomon/S. lancifolia* vegetation types was significantly lower than for the other vegetation types (Figure 4.4). The percent organic matter for individual sites followed mostly the distribution as expected from the vegetation type (Figure 4.5). However, the Delta Farms site (site 10) had a higher percent organic matter than expected from the vegetation.

Panicum hemitomon/S. lancifolia sites had a significantly higher bulk density than all other sites. The next highest bulk density was found at the *S. patens* sites, while the other sites had similar low bulk densities (Figure 4.6). Bulk density of individual sites followed mostly the distribution as expected from the vegetation type (Figure 4.7). Again, the Delta Farms site (site 10) had a lower bulk density than expected from the vegetation.

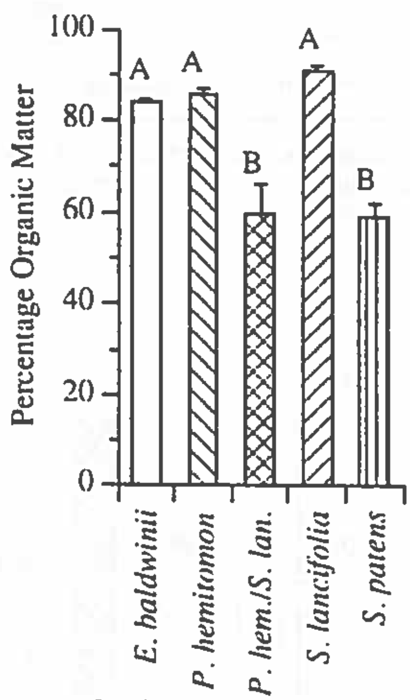


Figure 4.4. Percentage organic matter for the different vegetation types. Error bars represent one standard error. Letters indicate significant differences among vegetation types.

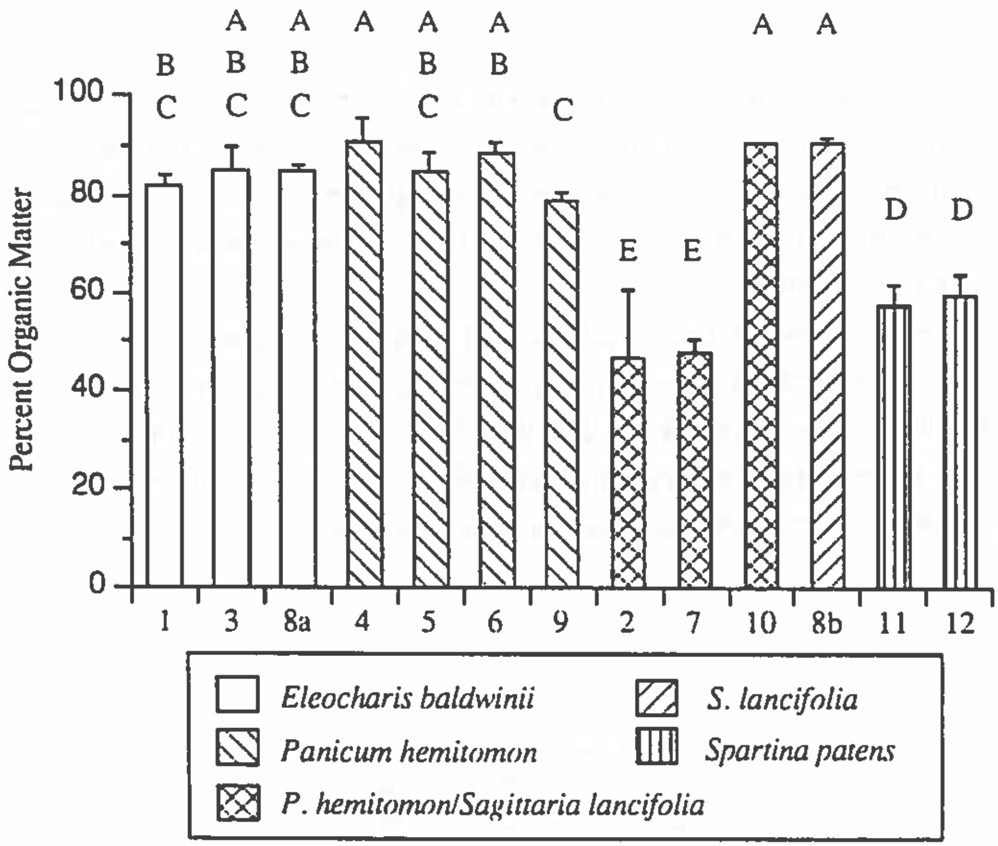


Figure 4.5. Percentage organic matter for the different sites. Error bars represent one standard error. Letters indicate significant differences among sites.

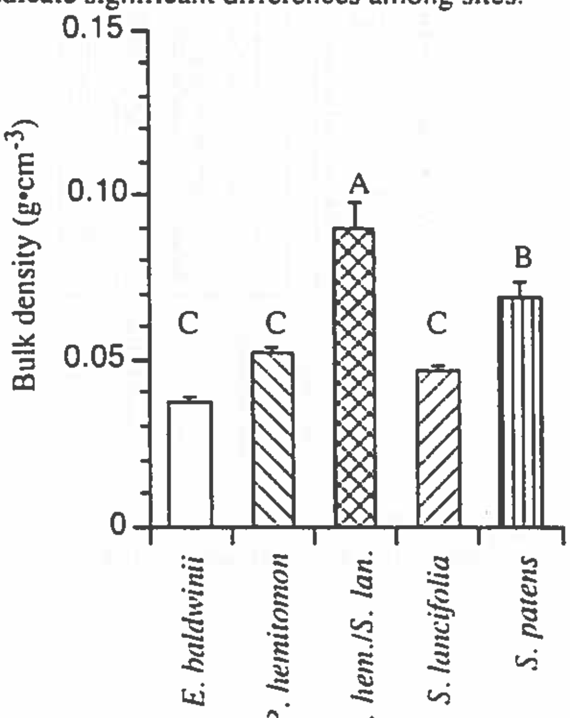


Figure 4.6. Bulk densities for the different vegetation types. Error bars represent one standard error. Letters indicate significant differences among vegetation types.

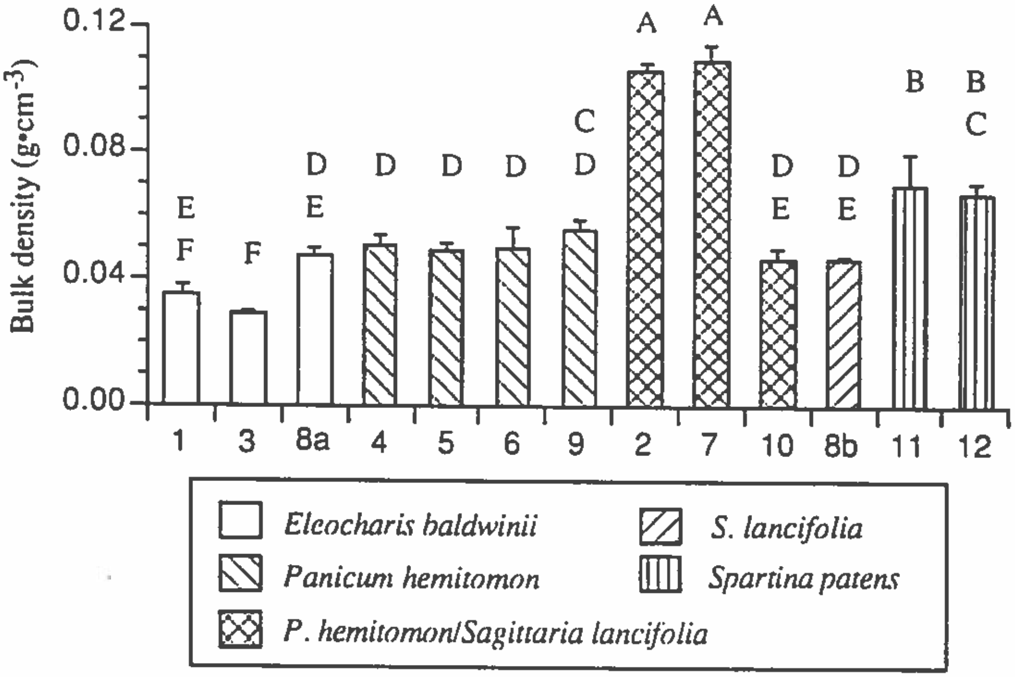


Figure 4.7. Bulk densities for the different sites. Letters indicate significant differences among sites.

CHAPTER 5: SUMMARY AND DISCUSSION

INTRODUCTION

Floating marshes are of interest for several reasons. From an ecological point of view continuously floating marshes represent an unusual "endpoint" of plant succession, in which the variability and stress related to hydrology are reduced to a minimum by the floating habit. How this comes about and what its ecological consequences are to the community in terms of diversity, productivity, stress, robustness, and longevity are questions of considerable scientific interest. At the same time the need for data to answer the immediate questions related to management issues such as described below is of utmost importance. The focus of this work is on an applied research project that should provide data immediately useful in developing a management plan for the Barataria and Terrebonne basins, in the Mississippi River Delta Plain of coastal Louisiana.

Management Issues

Until now management and regulation of floating marshes have been governed by the same rules as for attached marshes, yet it is likely that quite different strategies are appropriate. The following summary of the major issues related to floating marshes illustrates the potential importance of different management schemes for floating and non-floating marshes.

(1) An important management issue involves the stability of the floating marsh as hydrologic changes take place. The balance of primary production compared to losses from the organic system is integral to the stability of the marsh. Therefore, the magnitude of the fluxes of organic matter into and out of the marsh is an important factor in management decisions. A marsh management strategy offered to deal with this issue argues that in fresh and intermediate marsh areas most of the marshes are floating and impoundment is necessary to prevent the scour of fluid sediments from beneath the mat. Otherwise the loss of this material would weaken and ultimately destroy the marsh (Gagliano and Wicker 1989). The objective documentation to support or reject this hypothesis is minimal, but it is clearly an important question for marsh stability and maintenance. It is important to quantify the flux of materials, and to document carefully the possible positive results of impoundment in floating marshes, since impoundment is detrimental in other respects. It reduces estuarine nursery value (Herke et al. 1987, Chambers 1980) and decreases the mineral sediment input required to maintain most attached marshes in the intertidal zone (Cahoon and Groat 1990).

(2) Second, in response to the dramatic loss of wetlands in Louisiana over the last several decades, management plans to reduce or reverse this trend have proliferated. This is particularly true now with the current high level of activity driven by the Barataria/Terrebonne National Estuary Program (BTNEP) and the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The emphasis of much of the planning and the restoration projects initiated by CWPPRA is on freshwater diversion and sediment introduction. Although most coastal scientists would agree on the general beneficial effects of mineral sediment input into wetlands, its impact on floating marshes is not completely known. The impact may be particularly important in those areas supporting marsh mats that float seasonally. This work and other recent studies (Sasser et al. in press, Swarzenski et al. 1991) indicate that some marshes (examples are the Turtle Bayou area of Terrebonne Basin and around Lake Salvador in Barataria Basin) are flooded in winter and spring, and float only in the summer and fall. Recent work by Sasser et al. (in press) demonstrates that sediment input into these marshes during the winter and spring "resting" phase may ultimately increase density of the mat, thereby decreasing its ability to float. This could happen over a short period if the marsh is impacted from high sediment loads associated with floods or tropical storms. In marshes that float continuously all year, sedimentation would not occur over the marsh surface, but there are sigificant questions about the fate and utilization of sediments introduced into these areas. If diverted sediments move under the floating mat, drop out, and accrete underneath the marsh mat, could this eventually lead to a grounding of the floating mat? Does the suspended sediment moving under the mat providing essential nutrients for the mat-building vegetation to sustain its productivity?

(3) Dredging is a widespread activity within coastal wetlands in the Barataria/Terrebonne estuary. Conventional spoil placement along dredged canals sinks the floating marsh, cutting off its subsurface water and potential nutrient supply. We have demonstrated in this study that this kind of impounding reduces the flux of water under the floating marsh. What effect this has on the marsh is unknown, but it illustrates the importance of understanding ecological processes in these marshes.

(4) Other Issues

Impacts of Nutria. The impacts of nutria grazing on floating marshes may be an important factor influencing marsh stability. Observations during this study and by Louisiana Department of Wildlife and Fisheries personnel (Greg Linscombe, personal communication) indicate heavy grazing by nutria in some floating marshes. The overall impact of grazing by herbivores is unknown.

Nutrient status. The nutrient status of the floating marsh types was not determined, but it may be important in explaining variations in their condition. Delaune et al. (1986) showed nitrogen to be limiting the growth of *Panicum hemitomon* in a freshwater marsh west of Bayou Des Allemands in Barataria Basin.

Burning. Periodic burning of vegetation cover from floating marshes is a widespread practice in coastal Louisiana marshes. The short and longer term effects of burning on floating marsh habitats are unknown.

Value of floating marshes. There is little information concerning the functions and values of floating marshes. Observational data indicate high usage of these habitats by wading birds, alligators, deer, and nutria. There is no information on the nursery function of floating marshes for fish and shellfish.

SUMMARY OF RESULTS

Vegetation and Substrate

The vegetation and substrate characteristics of sites in this study (Figure 1.2) were discussed in Chapter 4. The dominant vegetation in most floating marshes includes *Panicum hemitomon, Sagittaria lancifolia*, or *Eleocharis baldwinii*. *Spartina patens* also vegetates floating marshes in the intermediate salinity zone, but its overall importance as a floating marsh species is not yet determined. All of the floating marshes in this study are highly organic, with low bulk densities (Table 5.1 and 5.2). Organic content ranges from 47% to 91% at the sampling sites we determined to be floating. Bulk density values ranged from 0.03 g/cm^3 to 0.11 g/cm^3. These values are comparable to those determined in earlier studies of floating marshes (Sasser et al. in press, Sasser et al. submitted, Swarzenski et al., 1991).

Table 5.1. Summary for all of the gauge sites.

Location	Station	MM:MW*	Belowground Biomass ($g\ m^{-2}$)	Bulk Density ($g\ cm^{-3}$)	Organic Content of Mat (% dry mass)	Dominant Vegetation	Summary
WTN†	1 Gallinule	1.00	93	0.04	82	*Eleocharis baldwinii*	Thin mat, floating
WTS	2 Victor Bayou	0.30	2614	0.11	47	*Panicum hemitomon /Sagittaria lancifolia*	Thick mat, damped floating
ETN	3 North ICWW	1.00	339	0.03	85	*Eleocharis baldwinii*	Thin mat, floating
WTM	4 Bayou Penchant	0.42	3295	0.05	91	*Panicum hemitomon*	Thick mat, floating
EBN	5 VD Canal	0.12	2417	0.05	85	*Panicum hemitomon*	Thick mat, micro-floating
WBN	6 Lake Boeuf	1.00	2992	0.05	89	*Panicum hemitomon*	Thick mat, floating
WBM	7 Company Canal	0.11	893	0.11	48	*Panicum hemitomon /Sagittaria lancifolia*	Thick mat, micro-floating
EBM	8a Cypress Canal A	0.57	357	0.05	85	*Eleocharis baldwinii*	Thin mat, seasonally floating
EBM	8b Cypress Canal B	<0.07	1678	0.05	91	*S. lancifolia*	Thick mat, micro-floating
ETM	9 Huth Canal	0.80	4770	0.06	79	*Panicum hemitomon*	Thick mat, floating
EBS	10 Delta Farms	nd	nd	0.05	91	*Panicum hemitomon /Sagittaria lancifolia*	Thick mat, floating
ETS	11 Little Bayou Carnecro	nd	1456	0.07	58	*Spartina patens*	Thick mat, floating
WBS	12 Bayou de la Gauche	0.25	1231	0.07	60	*Spartina patens*	Thick mat, floating

* ratio of maximum marsh mat movement to maximum marsh water movement
† W=West E=East
T=Terrebonne Basin B=Barataria Basin
N=North M=Middle S=South

Table 5.2. Summary of gauge sites by vegetation type.

Vegetation Type	Gauge site	Map category	Buoyancy	Bulk Density (g/cm^3)	Organic Matter (percent)	Mat Character
Panicum hemitomon	Bayou Penchant	1	Floating	0.05 ± 0.003	91 ± 1	Thick mat
	VD Canal	1	Micro-floating	0.05 ± 0.003	85 ± 1	Thick mat
	Lake Boeuf	1	Floating	0.05 ± 0.007	89 ± 2	Thick mat
	Huth Canal	1	Floating	0.06 ± 0.003	79 ± 2	Thick mat
Panicum hemitomon /Sagittaria lancifolia	Victor Canal	2	Damped floating	0.11 ± 0.003	47 ± 5	Thick mat
	Company Canal	2	Micro-floating	0.11 ± 0.005	48 ± 3	Thick mat
	Delta Farms	2	Micro-floating	0.05 ± 0.003	91 ± 1	Thick mat
Sagittaria lancifolia	Cypress Canal B	3	Micro-floating	0.05 ± 0.001	91 ± 1	Thick mat
Eleocharis baldwinii	Gallinule Canal	4	Floating	0.04 ± 0.003	82 ± 2	Thin mat
	North ICWW	4	Floating	0.03 ± 0.001	85 ± 1	Thin mat
	Cypress Canal A	4	Seasonally floating	0.05 ± 0.002	85 ± 1	Thin mat
Spartina patens	Little Carencro Bayou	8.3	Floating	0.07 ± 0.010	58 ± 4	Thick mat
	Bayou de la Gauche	8.2	Floating	0.07 ± 0.003	60 ± 4	Thick mat

Indices of Buoyancy

In this project we investigated the relationship of vegetation associations to mat buoyancy. Vegetation does not appear to be a reliable index of marsh mat buoyancy. For example, *Panicum hemitomon* occurs on mats that float, but not in all cases. O'Neil recognized this in his work and pointed out that the growth of this species in non-floating conditions in the Chenier Plain adds credibility to the theory that flotant forms on a broad scale from the subsidence of substrate in areas of *Panicum hemitomon* dominance. On the other hand our data suggest that *Panicum hemitomon* in association with other species, such as *Thelypteris palustris* and orchids, indicate a buoyant marsh mat.

From earlier work (Sasser et al. in press) we have suggested that floating marshes typically have bulk densities that are less than 0.1 g/cm^3. The two sites in this study with bulk density greater than 0.1 g/m^3 (Company Canal and Victor Bayou) have modified floating characteristics. The Company Canal marsh is described as micro-floating (less than 5 cm vertical floating range). The marsh at the Victor Bayou site floats damped, and often submerged. The high bulk density at these two sites, however, does not entirely explain the lower mat buoyancy, as the three other sites described as micro-floating (VD Canal, Delta Farms, and Cypress Canal B *(Sagittaria lancifolia)* have lower bulk densities of 0.05 g/m^3.

Hydrology

The hydrology of the floating marsh sites in this study is discussed in Chapter 3. A summary of the different hydrologic charcteristics determined from data in this study includes:

1. Free Floating: These sites have a free connection between open water and marsh water, and close correspondence between open water level and marsh level ($r^2 > 0.8$; slope > 0.8).

2. Damped Floating: These sites behave similar to free floating marsh but the mat sometimes floats while submerged.

3. Impounded Floating: These sites exhibit a poor relationship between the marsh water level and open water level ($r^2 < 0.5$), and a strong positive relationship between marsh mat level and marsh water level ($r^2 > 0.8$). This could be caused by impoundment of the marsh water due to the presence of canal spoil banks and/or high natural levees and/or limited exchange due to low porosity.

4. Micro-floating: These are sites in which there is a strong relationship between the marsh water and the marsh mat but the mat movement is only on the order of 5 cm; that is, the slope of mat movement to water movement is < 0.5. These may be sites at which (a) the mat sensor is measuring expansion and contraction of the mat as opposed to actual floating, or (b) the mat is able to float but is restrained, possibly by plant roots growing into a firm substrate. We do not consider this mat type floating; however, it is one that could potentially break free and become fully floating under high water level conditions for an expended period of time.

5. Non-floating: The mat data show no evidence of mat movement.

Mapping

In the last decade there has been considerable uncertainty concerning the status and condition of the freshwater floating marshes described as extensive in the Barataria and Terrebonne Basins of the Mississippi River Delta Plain by O'Neil (1949). In this study we conclude that large areas of floating marshes still occur in the fresh and intermediate areas of the upper regions of these basins. Tentative estimates derived from subsampling the mapping data base (because actual areas of marsh habitats are not yet digitized, the areas given here are estimated from measured subsamples of the study area) indicate at least 65% (~108,000 ha) of the total fresh and intermediate marsh area of both basins is flotant (the terms flotant and floating marshes are used interchangeably). Additional marshes may be floating; however, the variable results regarding their mat buoyancy leave their status undetermined.

Floating Marsh Types

Five general types of floating marshes were identified in this study of the Barataria and Terrebonne basins, based on vegetation, hydrology, and soil characteristics. These results confirm the previous classification of flotant types reported by Sasser et al. (submitted), determined from data gathered on small-scale studies at sites in these basins (Table 5.3). In this report we follow this classification scheme. A brief description of the floating marsh types in this study are given below.

Type I We group our mapping categories 1, 1.1, and 1.2 into Type I, a flotant type dominated by *Panicum hemitomon* (maidencane, paille fine). This is the type of flotant that O'Neil described as extensive in the 1940's, covering most of the freshwater marshes in the upper basins of the Mississippi River Delta Plain. Other species common to this type are *Thelypteris*

Table 5.3. Classification of floating marshes in the Louisiana coastal wetlands (including a non-floating example for comparison); and vegetation, buoyancy, and substrate characteristics of the primary sites sampled. Buoyancy is based on hydrology measurements at each of these sites for 1 to 4 years by either continuous recording water level gauges, or monthly observation on staff gauges (modified from Sasser et al., submitted to Vegetatio).

Class	Typical Site	Buoyancy / Slope*	Range of mat movement (cm)	Characteristic Vegetation	Substrate Description	Bulk Density (g cm^{-3})	Organic Content of Mat (% dry mass)
I	Lake Boeuf—*Panicum*	Floats continuously over water / slope=1.00; mat is seldom inundated.	110	*Panicum hemitomon* *Thelypteris palustris* Orchids *Sphagnum* sp.	Thick firm mat, highly organic fibric, dense mass of interwined roots and rhizomes.	0.049 ± 0.01	88 ± 4
II	Victor Bayou	Floats damped / slope=0.78; sometimes floats submerged.	40	*Panicum hemitomon* *Sagittaria lancifolia* *Leersia oryzoides* *Thelypteris palustris* *Typha latifolia*	Thick firm mat, highly organic moderately dense root structure.	0.062 ± 0.003	82 ± 6
III	Lake Salvador #1	Floats seasonally / slope=0.83; mat floats in summer, not in winter.	35	*Sagittaria lancifolia* *Eleocharis* spp. *Spartina patens* *Typha latifolia*	Thick firm mat, highly organic, less fibric, roots not as dense and die back in winter.	0.066 ± 0.011**	83 ± 7**
IV	Turtle Bayou	Floats in summer / slope=1.00; mat not always buoyant during winter.	35	*Eleocharis baldwinii* *Eleocharis parvula* *Ludwigia leptocarpa* *Phyla nodiflora*	Thin mat, highly organic, held together with fine, shallow roots, highly decomposed.	0.029 ± 0.002	78 ± 1
V	Lake Boeuf—shrub	Floats	40	*Myrica cerifera* *Panicum hemitomon*	Thick, organic mat.	0.051 ± 0.006	90 ± 1
	Bayou Rigolettes	Non-floating	3	*Spartina patens*	Organic root mat overlying clayey muck	0.160 ± 0.040**	47 ± 9**

* Slope=ratio of mat movement to water movement
** Swarzenski *et al.* 1991

palustris, *Conoclinium coelestinum*, and *Leersia oryzoides*. The presence of orchids, including *Calopogon tuberosus* and *Habenaria nivea* may prove to be an indicator of a buoyant mat for this marsh type. The marsh mat floats continuously throughout the year. The vigorous growth of maidencane builds a thick mat (>40 cm) of densely intertangled live and decomposing roots. An extensive root system develops due to the high productivity of this species and remains intact over the winter, providing an excellent, persistent structural framework to the mat. *Panicum hemitomon* is perhaps the ideal plant species for a floating marsh. It is highly productive, providing buoyant plant material containing large aerenchyma that enhance the ability of the mat to float.

Sites 4 (Bayou Penchant), 6 (Lake Boeuf), and 9 (Huth Canal) are examples of the *Panicum hemitomon*-dominated thick-mat flotant. All hydrologic records from these sites indicate floating mats. Our site 5 (VD Canal) is located in a *Panicum hemitomon*-dominated marsh, but apparently the mat at this site does not float. However, additional field investigations by helicopter of the surrounding area clearly indicate the marsh in the general area is floating. The VD site is located in the marsh behind a low spoil bank, and may be influenced by the dredged material. Coring at the VD site showed live roots growing into a clay and peat substrate.

Based on our analysis of the mapping data using sub-sampling, we estimate approximately 16% (~27,000 ha) of the study area (both basins) is covered by this type. In the Barataria Basin Type I covers approximately 18%, compared to approximately 14% in the Terrebonne Basin. This flotant type is found throughout the freshwater areas of both basins. It is extensive in many areas, covering large expanses in regions such as the natural levee flanks of Bayou Penchant in Terrebonne Basin and the Bayou des Allemands region in Barataria Basin.

The marsh surrounding Lake Boeuf in Barataria Basin is our best-studied example of this type, as it is a long-term study site with annual sampling since 1978. This flotant has changed little over the period of the long-term study, although the most recent mapping indicates the flotant in outlying areas separated from the larger marsh around the lake may be undergoing changes.

Large areas of marsh that were classified as *Panicum hemitomon* flotant by O'Neil in 1949 have now changed to a predominantly *Sagittaria lancifolia* marsh (our mapping category 3.1). This type occurs extensively in the Barataria Basin where it covers approximatley 25% (~20,000 ha) of the study area in that basin. Much of this area is north of Lake Salvador between the intermediate marsh zone and the swamp forest. This may be an area of increasing salinity, which would lead to development of an intermediate marsh.

Type II A second type of flotant noted by Sasser et al. (in press) is dominated by *Panicum hemitomon* and *Sagittaria lancifolia*. This type falls under our mapping category 2. This marsh also has a thick-mat, but the hydrologic record indicates damped floating and often submerged floating. Site 2 (Victor Bayou) is an example of this habitat.

Sites 7 (Company Canal) and 10 (Delta Farm) are examples of the vegetation associations of the Type II habitat; however, the hydrologic pattern at these sites differ from the Victor Bayou site. The mat at site 7 exhibits a micro-floating hydrology. This highly reduced-floating/non-floating condition in the *Panicum/Sagittaria* habitat may be related to its location at an interface with a different habitat dominated by *Sagittaria lancifolia* (category 3.1), which field investigations by helicopter in this area indicate is probably non-floating. The mat movement at site 10 was not determined over most of the study period due to gauge failure; however, short periods of record indicate the mat to be micro-floating. Additional work will be required to determine the trends in hydrology influencing this type of marsh, and to investigate the possible basin differences (site 2 is in Terrebonne Basin; sites 7 and 10 are in Barataria Basin) indicated by these results.

The *Panicum hemitomon/Sagittaria lancifolia*-dominated marsh type covers about 7% (~12,000 ha) of the study area. It is more widespread in the Barataria Basin, where it covers approximately 14% , compared to only about 1% in the Terrebonne Basin. In the Terrebonne Basin this flotant type is found in only a few areas in the southern freshwater zone within the sediment shadow of the Atchafalaya River (i.e. Victor Bayou site). In Barataria Basin these marshes are generally widely distributed, with the largest concentration occurring in the north central portion of the basin, northwest of Lake Salvador.

Type III The third type is an intermediate marsh dominated by *Sagittaria lancifolia*. This type corresponds to our mapping category 3. The marsh mat floats only during the summer, and is submerged during high water periods in the winter and early spring (see also Swarzenski et al. 1991). This type of flotant is found in the fresher (inland) portion of the intermediate zone, occupying in general the interface of the intermediate and freshwater marsh zones. Site 8B (Cypress Canal-*Sagittaria*) is similar vegetatively to the Type III marsh, although it is located in a fresher region of the upper basin. We have determined through field visits to this marsh by helicopter that much of the surrounding marsh floats, although the gauge data shows a micro-floating record. The location of the gauge site near the spoil bank may explain floating differences observed from the edge into the marsh interior.

The *Sagittaria lancifolia*-dominated thick mat marsh covers approximately 6% (~10,000 ha) of the total study area including both basins. It occurs primarily in the Barataria Basin where it covers approximately 12% of the study area, compared to less than 1% in the Terrebonne Basin.

Type IV The fourth type is dominated by *Eleocharis* spp. This type includes our mapping categories 4, 4.1, and 4.2. The marsh mat is thin (<25 cm), such that walking on this mat by an adult is only possible late in the growing season after vegetative growth makes the mat firmer. The hydrologic record for this type indicates irregular (sometimes grounded or submerged floating when water levels were high) floating over the year. This habitat has formed only in the past 30 years or so, in habitats formerly dominated by *Panicum hemitomon*, and was described in the scientific literature for the first time recently by Sasser et al. (in press). Sites 1 (Gallinule Canal), 3 (North ICWW), and 8a (Cypress Canal A) are examples of this type. Sites 1 and 8a floated throughout much of the year, while site 3 floated damped.

The thin-mat flotant covers about 20% (~32,000 ha) of the combined study areas in both basins. It is significantly more widespread in Terrebonne Basin where it covers approximately 26% of the study area, compared to approximately 11% in Barataria Basin. This type of flotant is found primarily in the upper reaches of both basins. In Terrebonne Basin it is concentrated in the Turtle Bayou region. In Barataria Basin large areas of thin-mat marsh are in the region around Lake Cataouatche and east of Lac des Allemands. The Turtle Bayou area is somewhat isolated hydrologically from the Bayou Penchant drainage to the south, with low suspended sediment concentration (Sasser et al., in press) The thin-mat marshes seem to be found in general in similar, low flow hydrologic conditons.

Type V The fifth type of flotant is a shrub community dominated by *Myrica cerifera* (wax myrtle). In this study we did not occupy sites in examples of this habitat with mat level and water level monitoring equipment. Our assumption that this mat is buoyant is based on measurements in previous work by Williamson et al. (1984) and Sasser et al. (submitted) at sites in the Barataria Basin at Lake Salvador and Lake Boeuf.

The wax myrtle flotant accounts for approximately 10% (~18,000 ha) of the overall study area, with an estimated 14% and 7% in Terrebonne and Barataria Basins, respectively. This flotant type is located throughout the fresh and intermediate zones of both basins. In most cases, this habitat occurs as a succession due to the colonization of *Myrica cerifera* on the *Panicum hemitomon*-dominated flotant, and its successful growth to maturity. Marsh burning while the shrubs are small typically prevents *Myrica cerifera* from reaching maturity.

Other Floating (or Probably Floating) Marsh Types

Type: Intermediate-<u>Spartina patens</u> and associated species. Several vegetation associations of *Spartina patens* with other species including *Eleocharis* spp., *Sacciolepis striata*, and *Scirpus olneyi* are found in the more saline portions of the intermediate marsh zone (seaward portions), along the interface with the brackish marsh. Our mapping categories 3.2, 8.2, and 8.3 are included in this group. We investigated the marsh mat and water level movement dynamics of two of these associations by establishing gauge sites at Bayou de la Gauche (site 12) and Little Bayou Carencro (site 11). Results indicate the mats at both of these sites were floating. We did not have enough gauges to site other associations in this group, or to provide replication at the gauged sites. Although at this point we tentatively conclude that the intermediate marsh associations are buoyant to some extent, verification of their hydrology with additonal sampling should be carried out.

Type: Brackish <u>Spartina patens</u>-floating marsh A homogeneous stand of floating *Spartina patens*-dominated marsh was identified in the Bayou Perot area of Barataria Basin during field verification for the mapping. Other types of this marsh have been observed in Barataria Basin (Andy Nyman, personal communication); however, the only data reported for this marsh type is from an earlier study and indicates a non-floating mat (Swarzenski et al. 1991). The marsh identified in this study as floating was very close to the intermediate/brackish marsh interface, and may represent an area undergoing succession from mixed intermediate species to homogeneous *Spartina patens*.

FLOATING MARSH STABILITY

Earlier work by O'Neil (1949) mapped most of the freshwater wetlands of the Mississippi River Delta Plain as floating in the 1940's. We now know from this study that large portions of the freshwater and intermediate marshes in the Barataria and Terrebonne basins remain floating marsh. How stable are these floating marshes? Based on mapping of habitats in this study and the results of other recent work (Sasser 1994) we know that some floating marsh habitats have changed from the *Panicum* flotant to another type, or to open water over the last several decades. In the northern Terrebonne basin, for instance, large areas of formerly Type I (*Panicum hemitomon*) flotant are now Type IV (thin-mat *Eleocharis* spp.) floating marshes.

What processes caused the floating marsh habitat changes? Why did the thick-mat *Panicum hemitomon* flotant (Type I) change to open water in some areas, to thin-mat flotant in others, and to a mixed-species dominance with *Sagittaria lancifolia* in others? Answers to these questions may lead to management strategies that would provide a greater degree of habitat stability.

Processes Affecting Flotant Stability

Lake Boeuf and Turtle Bayou Examples

Two examples are illustrative of the extremes of stability in the *Panicum* flotant. At Lake Boeuf in the Barataria Basin, the results of 16 years of data collection in the *Panicum*-dominated flotant around the lake indicate a very stable habitat (Sasser et al. accepted). Species composition of vegetation has remained the same, and high levels of productivity have been maintained over the period of the reported work (1979-1990). Conversations with local residents indicate that the marsh has remained in its present condition for generations. On the other extreme large areas of similar *Panicum hemitomon*-dominated flotant in the Turtle Bayou area in the upper Bayou Penchant region of Terrebonne Basin have undergone drastic changes over the last 30 years. The thick-mat *Panicum* flotant has changed over broad areas to open water, or to thin-mat floating marsh. What processes have operated on these areas that produced such dramatically different results? Although there are several theories as to the demise of the Bayou Penchant basin Type I flotant marshes, it is safe to say that the exact causes are not clearly known. Possible contributors to the changes include: altered hydrology due to canal construction and dredging; flux of organic material from the marsh due to hydrologic changes; nutria herbivory; nutrient dynamics due to altered hydrology; burning; and floods/storms. Current work is underway to relate a time series of aerial imagery showing habitat changes in this region to possible causal parameters.

Species Shift to Increasing Sagittaria lancifolia

Results of this study indicate *Sagittaria lancifolia* is frequently a co-dominant species with *Panicum hemitomon* in the extensive fresh marshes of both Barataria and Terrebonne basins that have historically been dominated by *Panicum hemitomon*. Similar observations were made by Greg Linscombe and Noel Kinler of the Louisiana Department of Wildlife and Fisheries over the last several years during various helicopter surveys in portions of the study area (personal communication). The occurrence of *Sagittaria* sp. is often associated with a disturbance or stress to a mature habitat, such as induced by saline water, over-grazing by herbivores, etc. Whether or not this increase in *Sagittaria lancifolia* marks a trend toward an intermediate marsh association cannot be determined in this study. Additional work in areas where this transition occurred will be required to determine (1) whether the change in species is a short term event or a trend; (2) changes in soil and water salinity conditions; (3) soil characteristics as related to possible increased salinities; (4) buoyancy characteristics of the mat (i.e. whether the mat floats or not, and if so, its floating characteristics); and (5) possible alterations in buoyancy associated with the vegetation changes.

Salinization

One pathway of change is likely due to the effect of saline water on the freshwater habitat. The intermediate marsh habitat is the zone in which low salinity water interacts with freshwater vegetation. The freshwater marshes adjacent to the intermediate zone are highly organic, and in most areas have a buoyant mat. *Panicum hemitomon* and associated species usually dominate these freshwater marshes. A variety of factors cause salinity levels in the intermediate marshes to vary temporally and spatially from fresh to as much as 9 ppt (Chabreck 1972). These factors include geological factors (subsidence and compaction) that operate over the long term, and those such as weather conditions (wind and precipitation) that vary over the short term. The vegetation species adapted to conditions in the intermediate zone are those that handle the stresses involved in varying salinity, as well as the occasional surge of high salinity water due to high tides associated with strong storms.

A preliminary review of the major vegetation community mapping results in the Mississippi River Delta Plain (O'Neil 1949; Chabreck 1988, this study) indicates shifts in some areas from freshwater marsh to intermediate marsh. The general inland movement of higher salinity water is due to the combination of natural processes of soil subsidence, compaction, etc., and as a result of man-induced hydrologic alterations that contribute to net marsh submergence.

Although laboratory studies by Mendelssohn and Mckee (1989) indicate *Panicum hemitomon* can withstand salinities up to about 9 ppt, which is within the range of salinities reported in the intermediate marshes, our field observations indicate that *Panicum hemitomon* only rarely (almost never) occurs in intermediate marshes of that salinity range. Generally, in areas where a species shift is successful (i.e. does not lead to conversion to open water) the response of vegetation communities to salinization is a shift from *Panicum hemitomon*-dominated freshwater marshes to *Sagittaria lancifolia*, and eventually to *Spartina patens*. We have evidence for this sequence of change from several sources:

1) The vegetation on the north shore marshes of Lake Salvador was mapped as *Panicum hemitomon*-dominated in the 1940's by O'Neil (1949). Chabreck classified this area as an intermediate marsh association in 1978. Results from this study indicate the marshes are intermediate, dominated by a mixed marsh of *Sagittaria lancifolia*, *Eleocharis* spp., *Spartina patens*, and other species.

2) Data from long-term sample sites in the intermediate marsh in the Clovelly region of Barataria Basin indicate a replacement of *Sagittaria lancifolia* as the dominant species by *Spartina patens*. This species change took place over the period 1978-1990 (Visser et al. 1994).

The impact of salinization on the geochemistry of the floating organic peat mats is not known. However, the loss or decline of the contribution of *Panicum hemitomon* as species shift is a major blow to the mat structure through diminished root production and aboveground biomass. The loss of the dense network of intertangled roots characteristic of *Panicum hemitomon* mats is not compensated for by the increase in dominance of intermediate marsh species such as *Sagittaria lancifolia*. This species produces thick underground roots and rhizomes that add buoyancy to the mat; however, rapid decomposition of this material takes place after senescence of the plants at the end of the growing season. *Panicum hemitomon*, on the other hand, produces roots which persist over the winter.

Relationships Among Floating Marsh Types

Some possible relationships among floating marsh habitats were discussed by Sasser (1994) and is illustrated in Figure 5.1. As indicated in the discussion above, in areas where salt water encroachment is occurring a shift from Type I to Type III is likely, shifting further to a brackish *Spartina patens*-dominated marsh as salinization continues. The net result of this transition will probably be a reduction in mat buoyancy.

In some areas, we have documented a transition from Type I to Type IV marshes within the last 20-30 years and likewise the change from Type I to open water. It is not at all clear whether Type I changes directly to Type IV, or through an intermediate stage of open water. At Turtle Bayou the conversion from thick-mat *Panicum hemitomon* marsh to thin-mat and open water occurred during the 1960's and 1970's (Evers and Sasser, unpublished). The exact reasons for the conversion are not clear; however, possible reasons offered include changes in hydrology, inundation by flood waters, smothering by *Eichornia crassipes* during high water (but it is difficult to see how the plants could raft upon a Type I flotant), hurricane effects, nutrient limitations related to hydrologic changes, and nutria herbivory.

In the absence of burning, *Myrica cerifera* is apparently an important agent of change. This shrub species becomes established on Type I flotant, eventually dominating the plant cover (Type V) without burning. The ultimate fate of the *Myrica cerifera* flotant is not clear, although evidence from Williamson et al. (1984) indicates that as the trees mature and become heavier, the mats become submerged, with subsequent die-off of the cover. Their submergence could lead to significant changes from Type V to open water. Whether the submerged mat redevelops as a floating mat (either Type IV thin-mat or Type I thick-mat) and continues the cycle, or is degraded and lost is unknown.

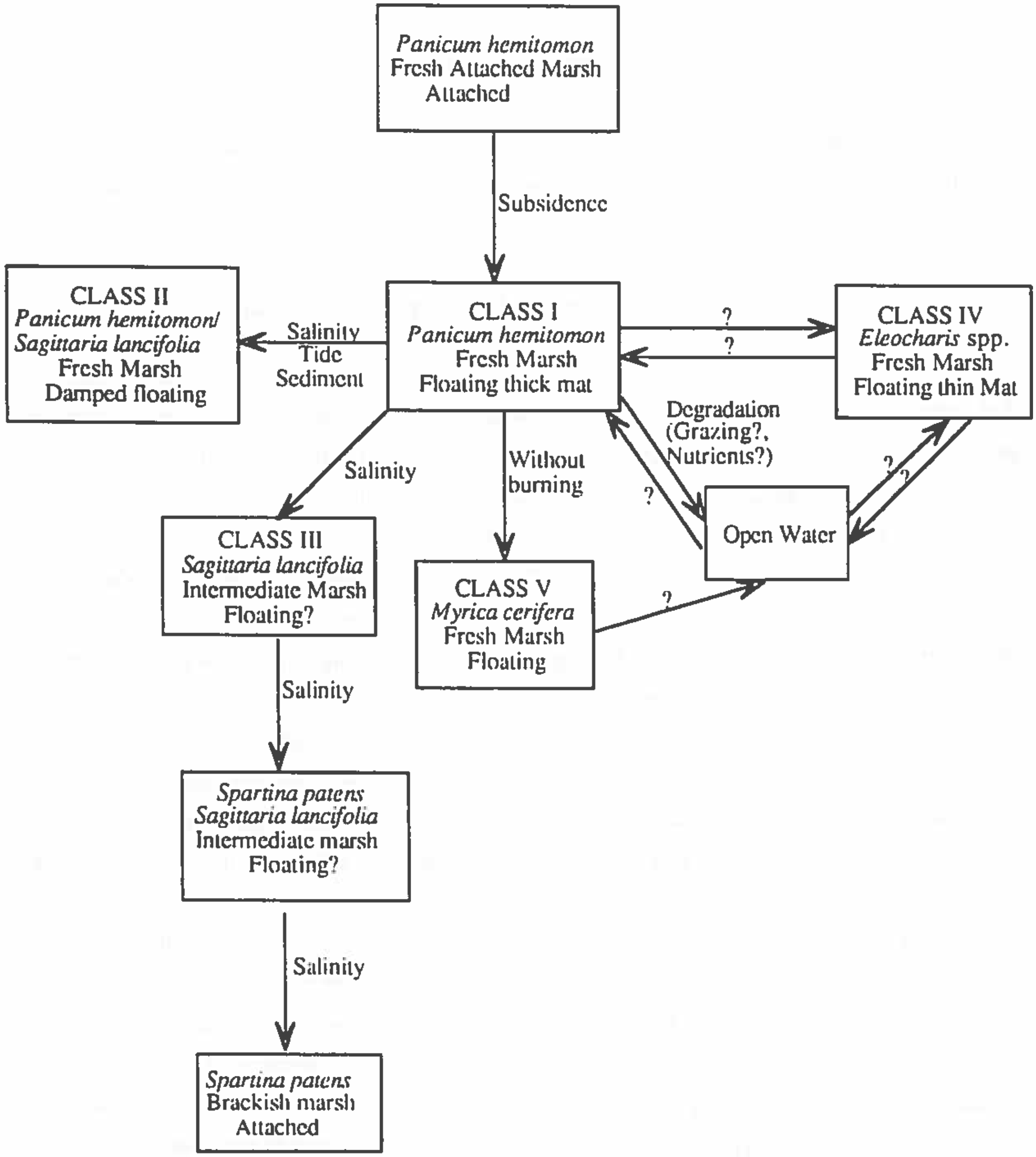


Figure 5.1. A diagram of possible relationships among floating marsh types that occur in the Mississippi River Delta Plain marshes (Sasser 1994).

MANAGEMENT STRATEGIES IDENTIFIED IN THIS STUDY

1. Mapping

We have found in this study that vegetation associations do not always provide a reliable index of buoyancy. The determination of buoyancy status is confounded by seasonal floating patterns in some cases, and by low water levels grounding the mat at the time of a field survey. Some vegetation associations (for example, *Panicum hemitomon*) occur similarly on both floating and non-floating marsh mats. This means that mapping floating marshes based on aerial imagery and vegetation cover must be interpreted with care. Classification of imagery with regard to floating marshes without adequate field verification is not likely to provide reliable results.

2. Thick-Mat, Continuously Floating *Panicum hemitomon* Flotant.

• We find that most *Panicum hemitomon*-dominated marshes in the Barataria and Terrebonne basins are floating. Even though some *Panicum hemitomon* marshes do not float, it is probably best to start with the assumption that they do.

• These marshes appear to be generally stable in the absence of salt water intrusion, except for the conversion to thin-mat marsh in the upper reaches of both basins. Although it is unlikely that salt water influenced the demise of *Panicum* flotant in these upper areas of the basin, it is likely an important factor in other areas.

• Sedimentation effects will probably be minimal on this marsh type, since it generally floats continuously.

• Determining the reasons for the drastic conversion of the thick-mat *Panicum hemitomon* marshes to other types in areas such as the Turtle Bayou sub-basin is crucial to establishing good management for this resource. With this in mind, critical issues for research are: quantification of the flux of materials from the flotant, sediment effects beneath the marsh mat, possible salt water intrusion and its influence on floating mats, nutria impacts, and nutrient status.

3. Thin-Mat Flotant

• The *Eleocharis* sp.-dominated thin-mat marshes are floating but are probably less stable than the thick-mat flotant. Our work indicates that the mat is easily disturbed during sampling. Our assumption is that the thin mat, which lacks the strong framework of thick roots, is more fragile than the thick-mat flotant. The thin-mat marshes are probably easily disrupted by storm winds and tides.

• Sediment introduction during the period when the mats are submerged would cause diminished mat buoyancy over time.

• The impacts of nutria herbivory on the thin-mat flotant are probably severe (Greg Linscombe, LDWF, personal communication), and may be a causal agent for their condition. Nutria control may be an effective strategy to promote mat stability and succession to thicker mats.

• Fencing (to reduce lateral erosion of the marsh mat) of thin-mat marshes may provide some stability.

• Fertilization should be tried on a small scale as a strategy to promote thin mat development (to a thicker mat).

• Research needs for the management of thin-mat floating marshes include an understanding of successional development leading to establishment of this habitat, effects of sediment input on top of and beneath the mat, nutria-grazing impacts, quantification of the flux of materials, and fertilization effects.

4. Intermediate Marsh

• Intermediate salinity marshes are probably in a transition from *Panicum hemitomon*-dominated fresh marsh, to dominance by *Sagittaria lancifolia*, and eventually *Spartina patens*.

• Drawing management implications for intermediate marsh vegetation associations requires additional information. Future research should focus on strategies to promote transition from fresh to intermediate marsh habitats without losing marsh. If this is not practical, strategies for maintaining fresh conditions should be considered.

(a) ***Sagittaria lancifolia***-dominated marshes associated with the fresher portion of the intermediate zone are floating. Some of these marshes float seasonally.

• This marsh type is sensitive to disruption because of the fine, low biomass root system and unconsolidated sediments.

• Sediment introduction into this habitat would probably decrease mat buoyancy.

(b) ***Spartina patens*-dominated** marshes associated with the more saline portion of the intermediate zone (seaward interface) are floating in some areas; however, their status is not fully determined.

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APPENDIX A: TIME SERIES PLOTS OF THREE-HOURLY MEANS HYDROLOGY DATA

This Appendix presents the time series measurements of the fluctuations of:

1. The open water
2. The water on the marsh surface (Marsh Water)
3. The marsh mat.

The data plotted are the three hour means (computed from the hourly data) and cover the time period from March 3, 1993 through May 5, 1994. The format is the same for all plots with the horizontal axis representing elapsed time (hours since March 3, 1993 01:00 Hours, CST) and the vertical axis representing level (water or mat) in meters. The range of the vertical axis is one meter for all plots to allow for ease of comparison. The plots are arranged by station in the following order for each station: (1) Open water, (2) Marsh water and (3) Marsh mat. Data is available for all three sensors at all stations except Gallinule Canal which is missing the open water data due to failure of the pressure sensor. The open water data for Cypress Canal B is the same as the open water data for Cypress Canal A since the sites are on the same water body. The first page presents a conversion table which lists the date as a function of the number of elapsed hours.

Elapsed time to date conversion table

Elapsed Time in Hours	Date	Elapsed Time in Hours	Date	Elapsed Time in Hours	Date
0	3-Mar-93	3500	29-Jul-93	7000	24-Dec-93
100	7-Mar-93	3600	2-Aug-93	7100	29-Dec-93
200	11-Mar-93	3700	6-Aug-93	7200	2-Jan-94
300	15-Mar-93	3800	11-Aug-93	7300	6-Jan-94
400	20-Mar-93	3900	15-Aug-93	7400	10-Jan-94
500	24-Mar-93	4000	19-Aug-93	7500	15-Jan-94
600	28-Mar-93	4100	23-Aug-93	7600	19-Jan-94
700	1-Apr-93	4200	28-Aug-93	7700	23-Jan-94
800	5-Apr-93	4300	1-Sep-93	7800	27-Jan-94
900	10-Apr-93	4400	5-Sep-93	7900	1-Feb-94
1000	14-Apr-93	4500	9-Sep-93	8000	5-Feb-94
1100	18-Apr-93	4600	14-Sep-93	8100	9-Feb-94
1200	22-Apr-93	4700	18-Sep-93	8200	13-Feb-94
1300	27-Apr-93	4800	22-Sep-93	8300	18-Feb-94
1400	1-May-93	4900	26-Sep-93	8400	22-Feb-94
1500	5-May-93	5000	1-Oct-93	8500	26-Feb-94
1600	9-May-93	5100	5-Oct-93	8600	2-Mar-94
1700	14-May-93	5200	9-Oct-93	8700	7-Mar-94
1800	18-May-93	5300	13-Oct-93	8800	11-Mar-94
1900	22-May-93	5400	18-Oct-93	8900	15-Mar-94
2000	26-May-93	5500	22-Oct-93	9000	19-Mar-94
2100	31-May-93	5600	26-Oct-93	9100	24-Mar-94
2200	4-Jun-93	5700	30-Oct-93	9200	28-Mar-94
2300	8-Jun-93	5800	4-Nov-93	9300	1-Apr-94
2400	12-Jun-93	5900	8-Nov-93	9400	5-Apr-94
2500	17-Jun-93	6000	12-Nov-93	9500	10-Apr-94
2600	21-Jun-93	6100	16-Nov-93	9600	14-Apr-94
2700	25-Jun-93	6200	21-Nov-93	9700	18-Apr-94
2800	29-Jun-93	6300	25-Nov-93	9800	22-Apr-94
2900	4-Jul-93	6400	29-Nov-93	9900	26-Apr-94
3000	8-Jul-93	6500	3-Dec-93	10000	1-May-94
3100	12-Jul-93	6600	7-Dec-93	10100	5-May-94
3200	16-Jul-93	6700	12-Dec-93	10200	9-May-94
3300	21-Jul-93	6800	16-Dec-93	10300	13-May-94
3400	25-Jul-93	6900	20-Dec-93	10400	18-May-94

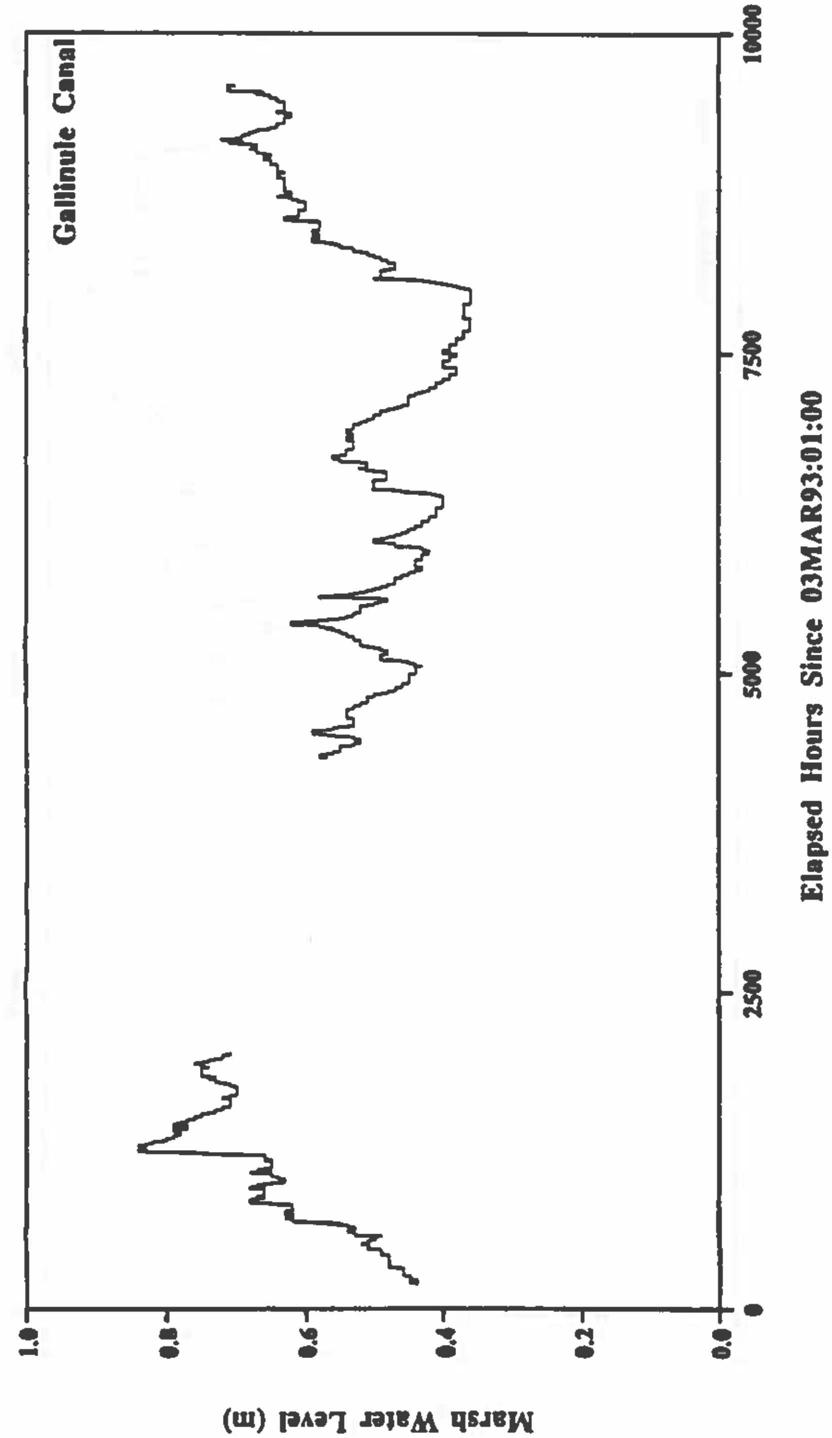

Figure A.1. Three hour means of marsh water from Site 1 (Gallinule Canal).

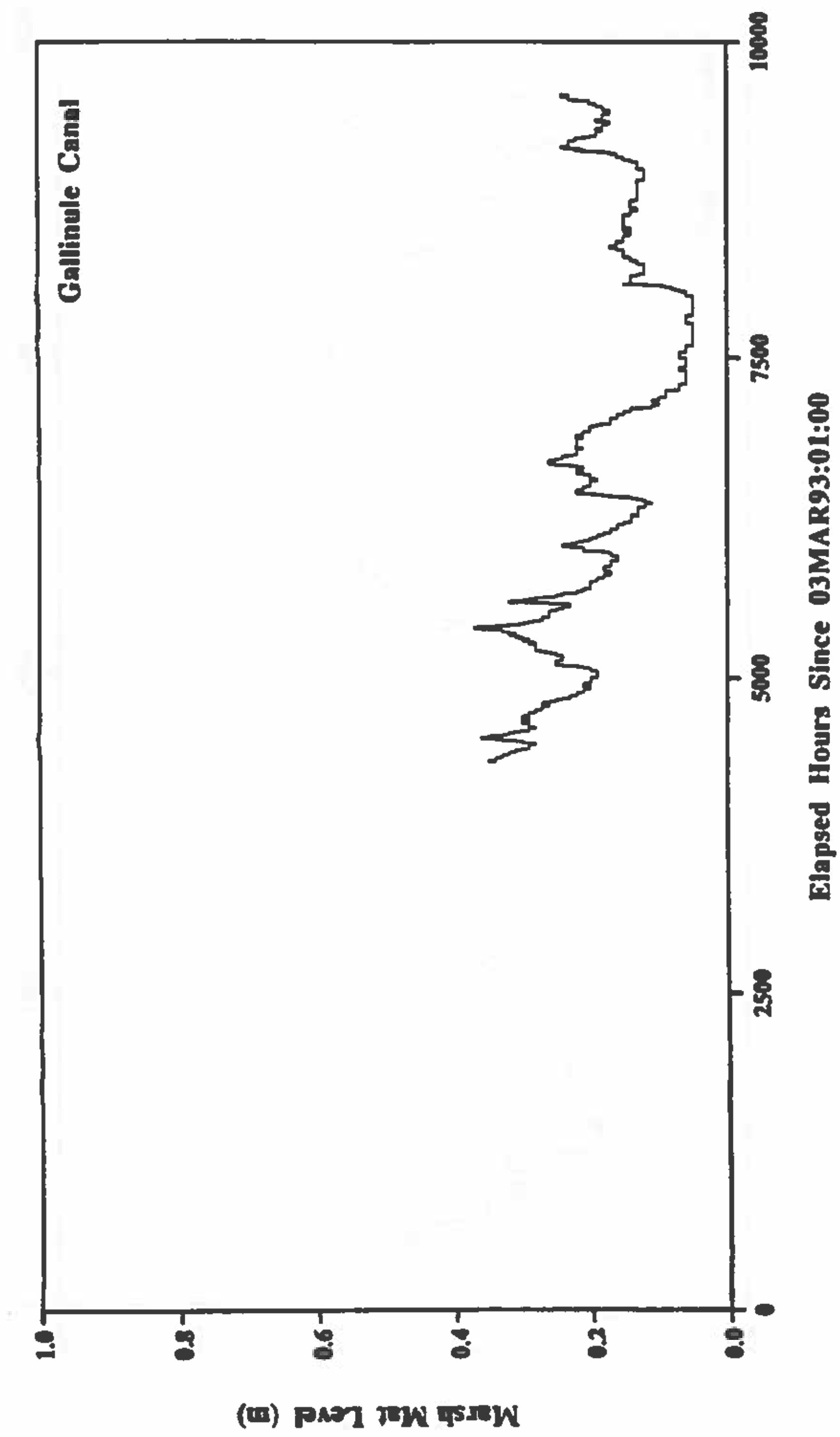

Figure A.2. Three hour means of marsh mat from Site 1 (Gallinule Canal).

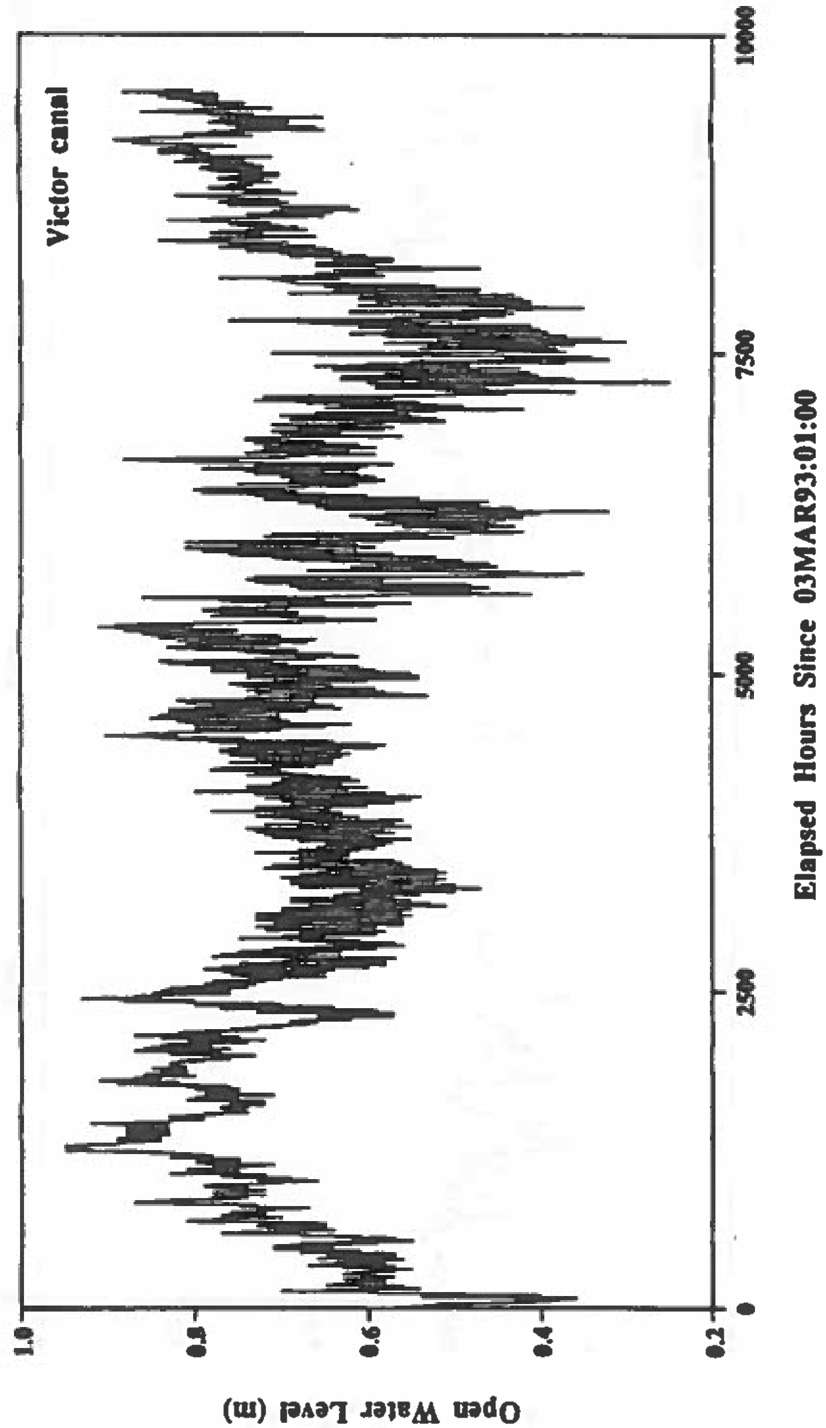

Figure A.3. Three hour means of open water from Site 2 (Victor Bayou).

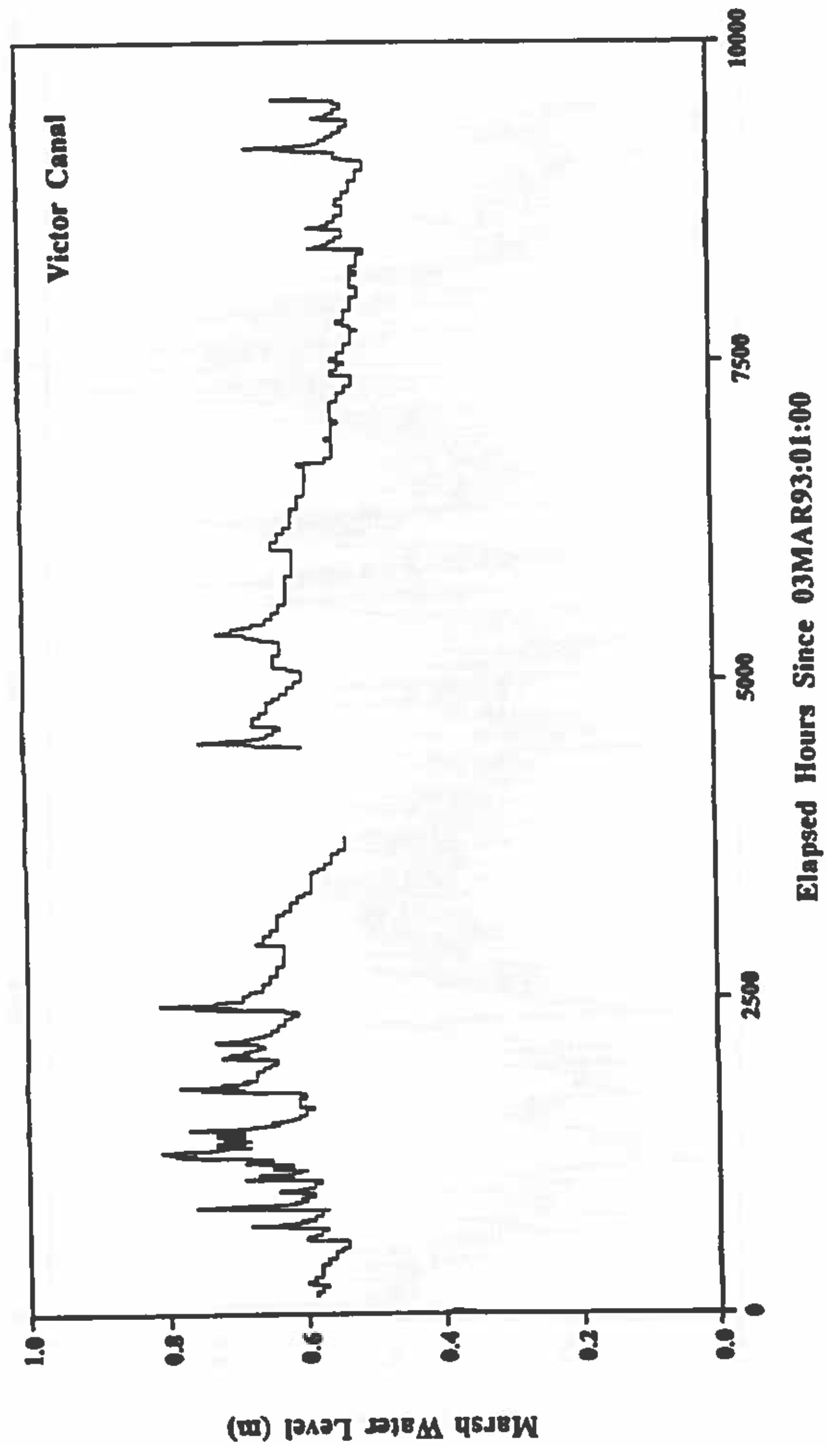

Figure A.4. Three hour means of marsh water from Site 2 (Victor Bayou).

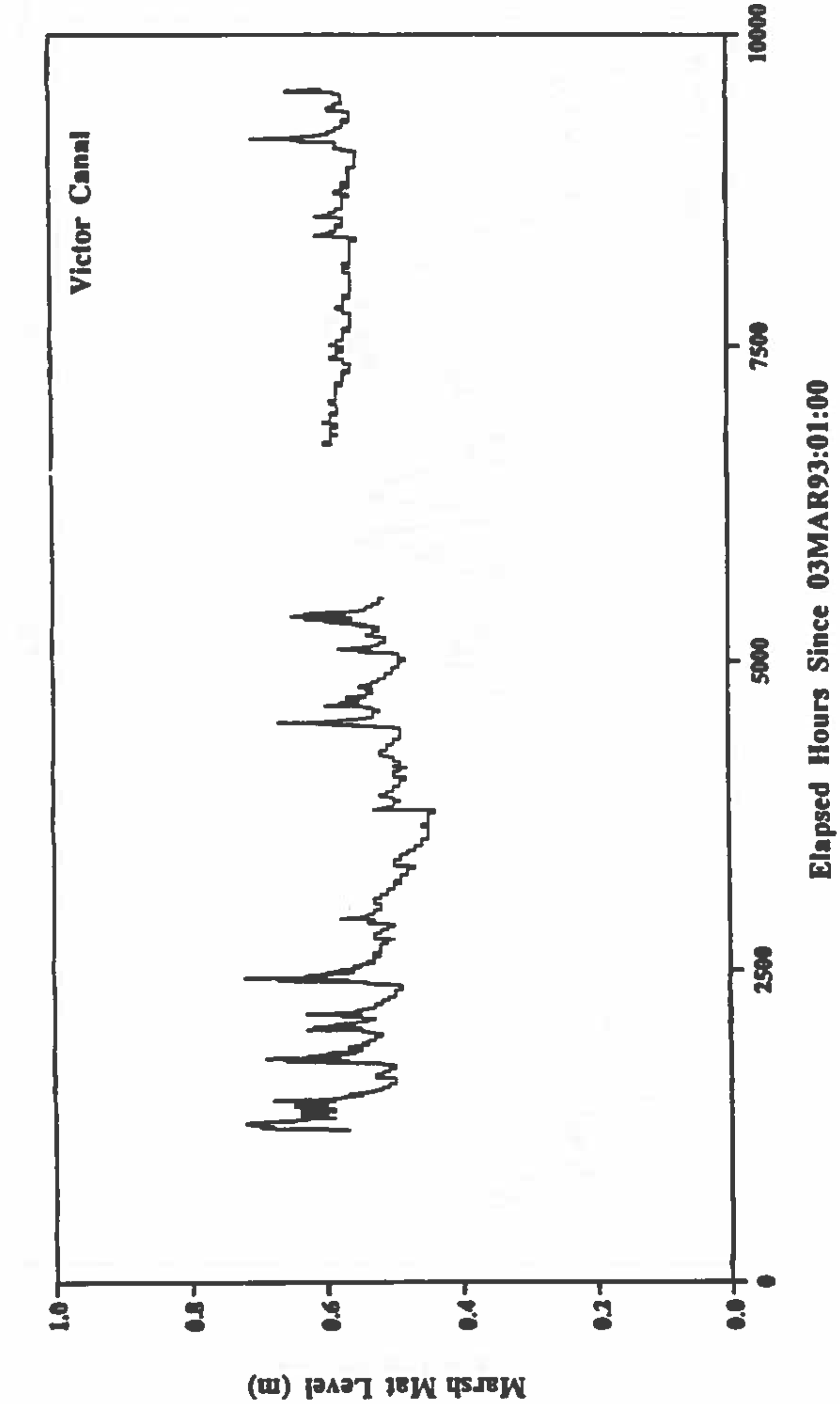

Figure A.5. Three hour means of marsh mat from Site 2 (Victor Bayou).

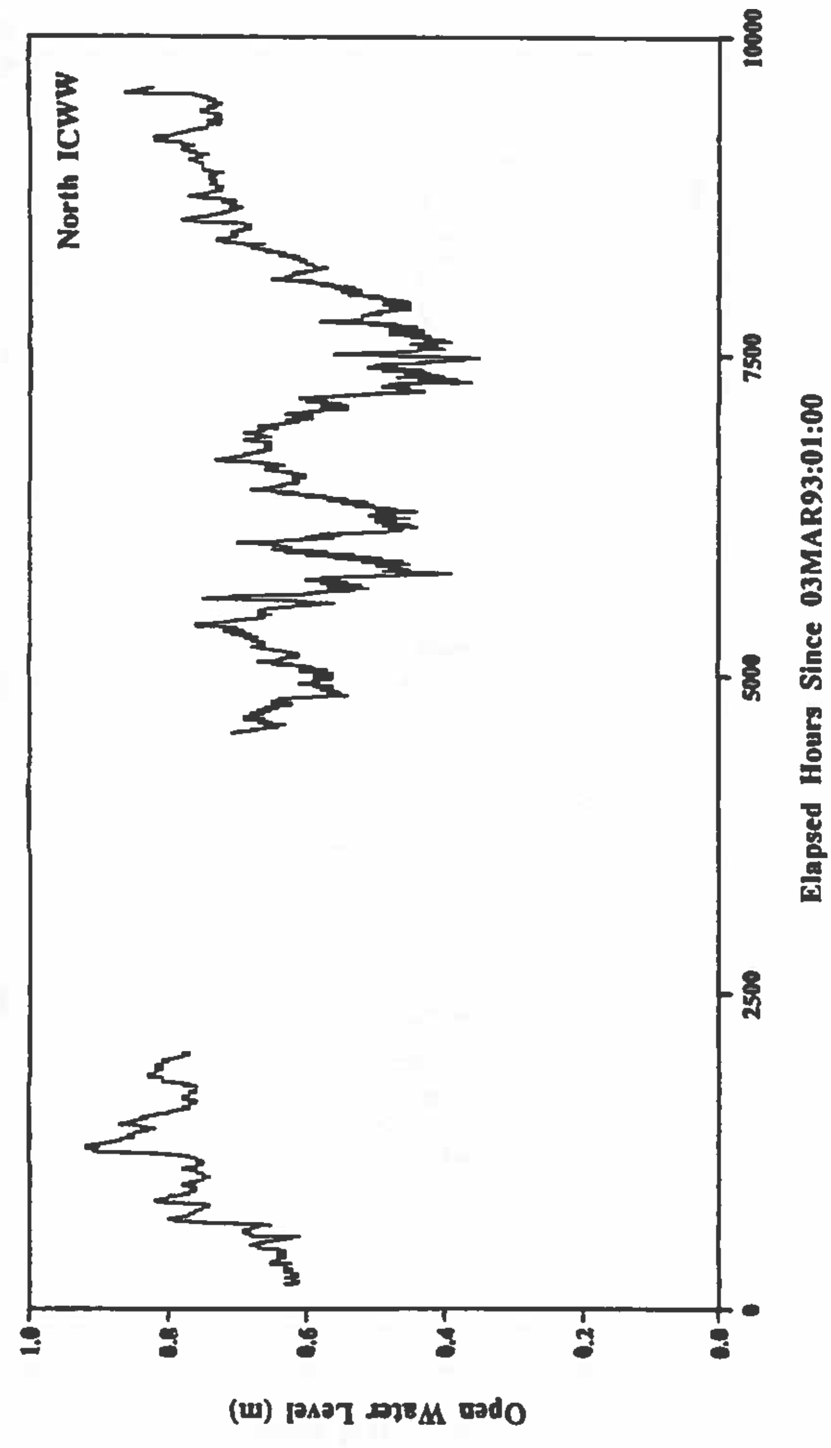

Figure A.6. Three hour means of open water from Site 3 (North ICWW).

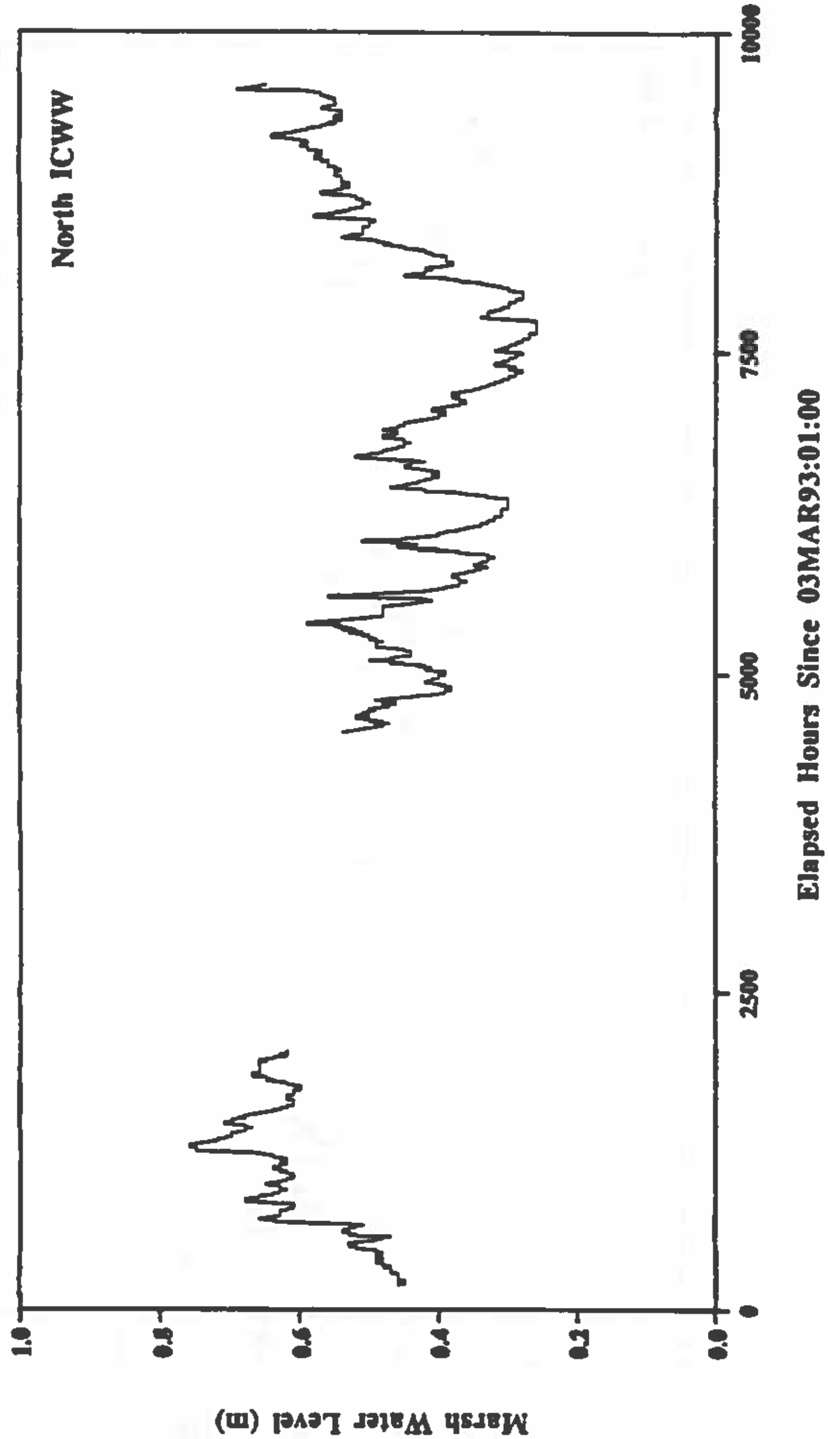

Figure A.7. Three hour means of marsh water from Site 3 (North ICWW).

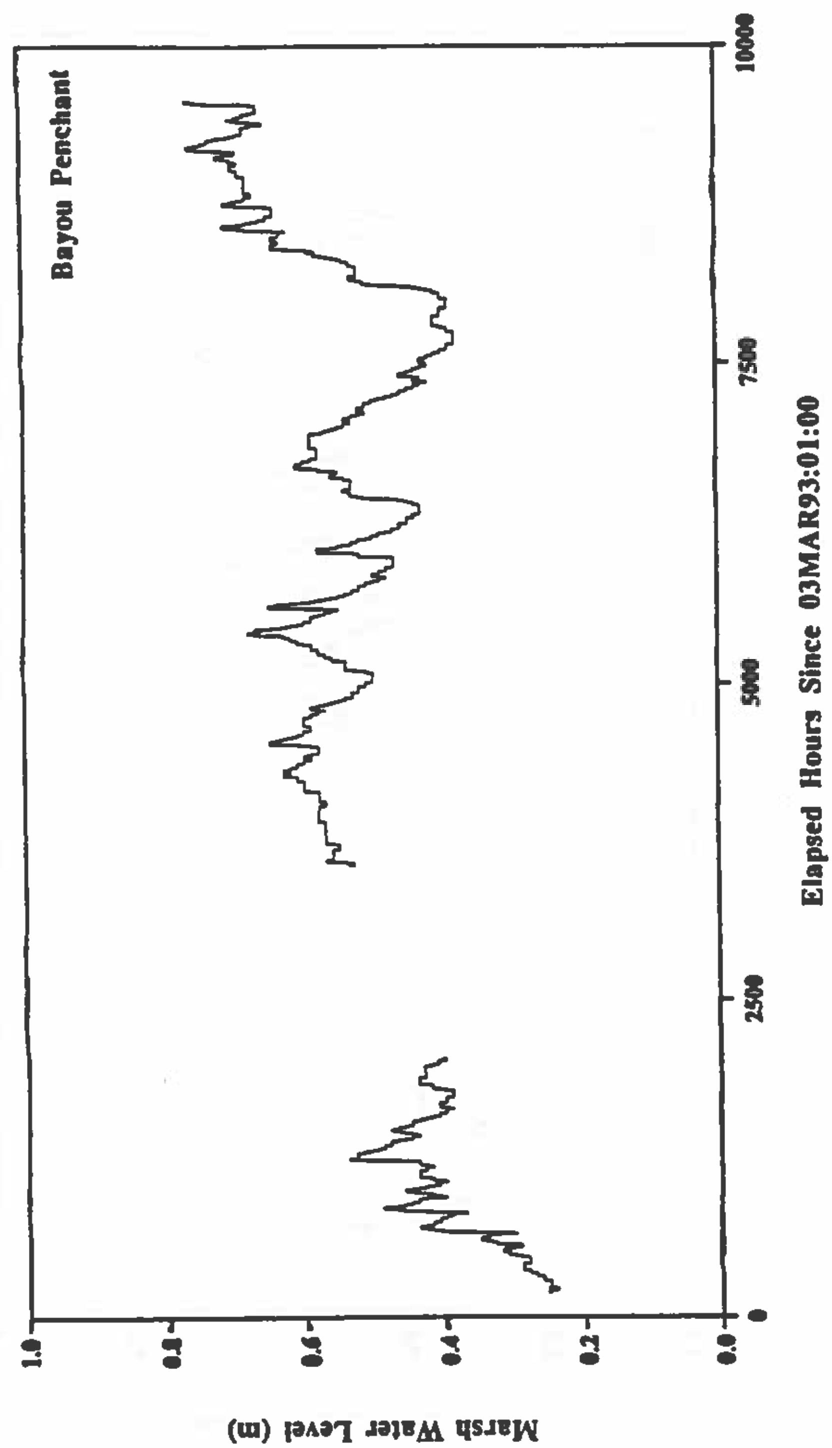

Figure A.10. Three hour means of marsh water from Site 4 (Bayou Penchant).

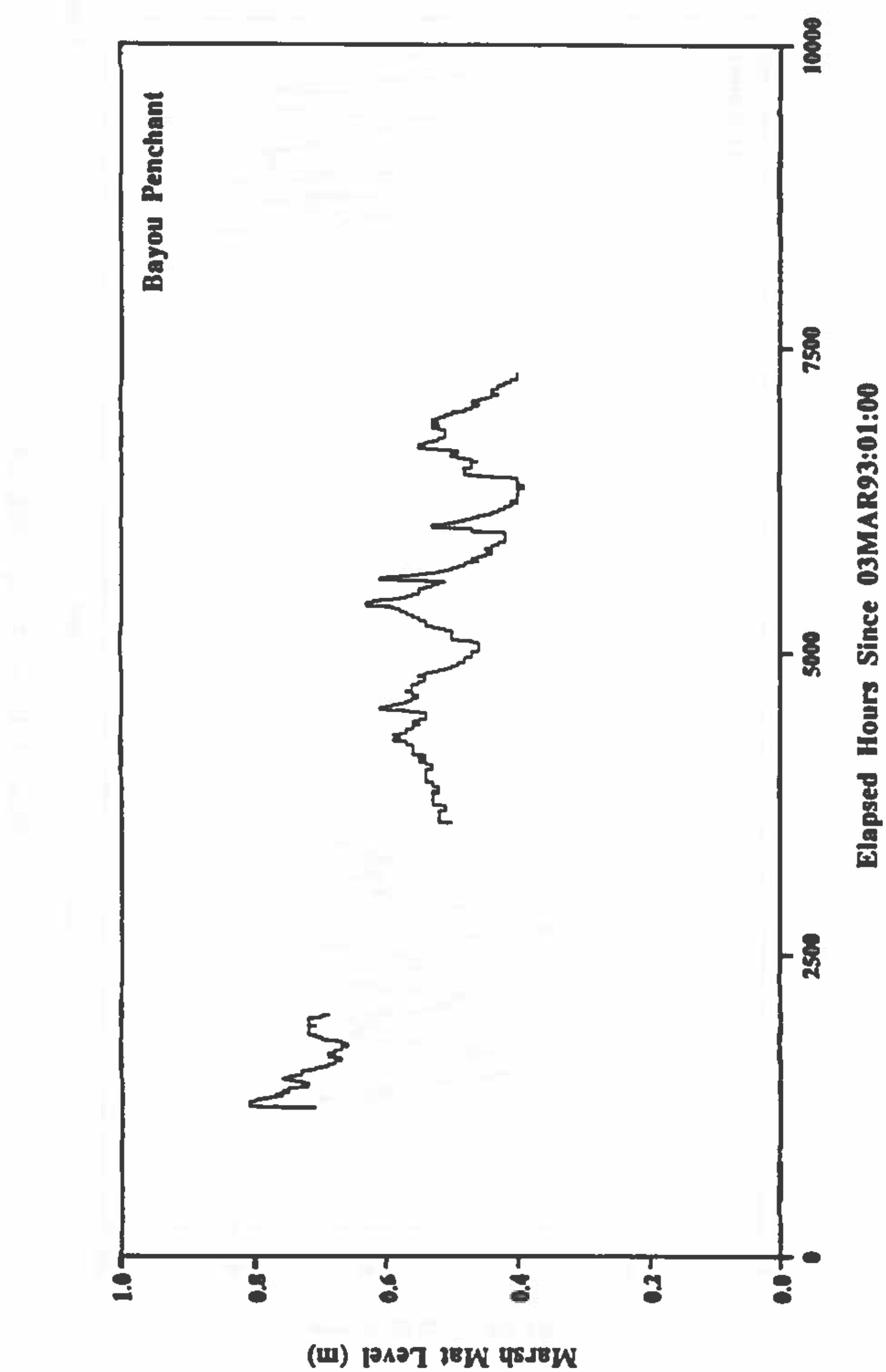

Figure A.11. Three hour means of marsh mat from Site 4 (Bayou Penchant).

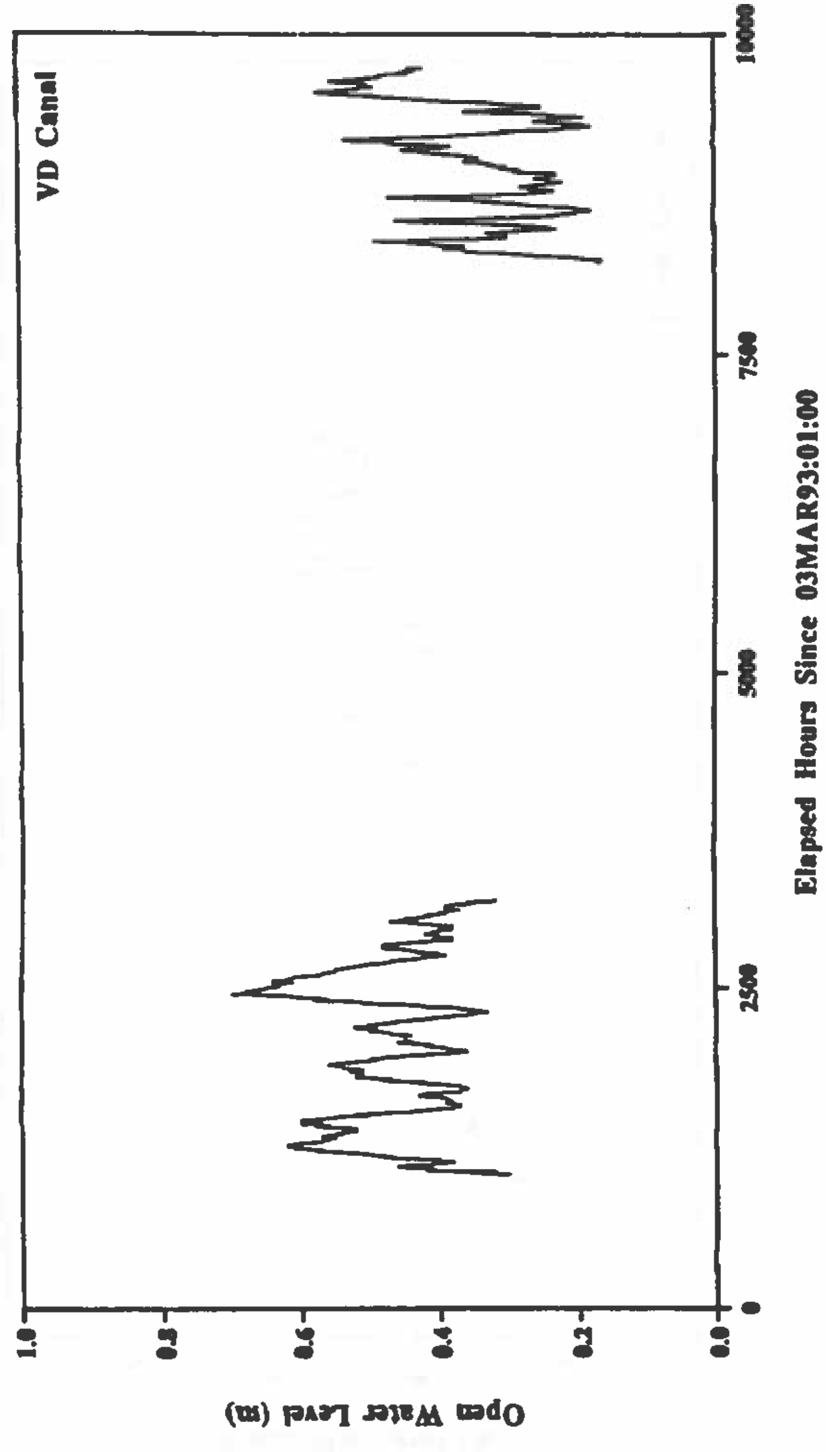

Figure A.12. Three hour means of open water from Site 5 (VD Canal).

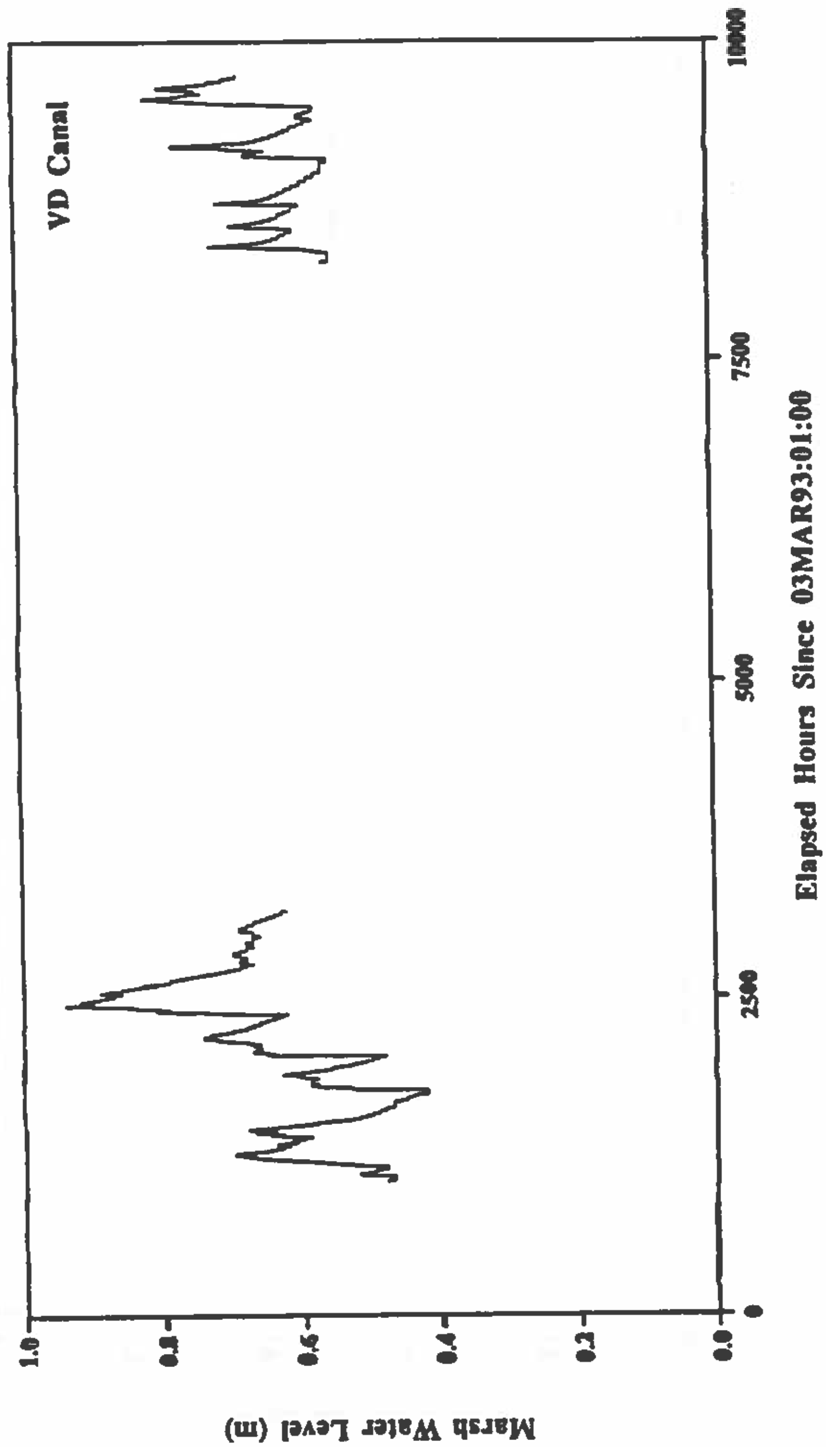

Figure A.13. Three hour means of marsh water from Site 5 (VD Canal).

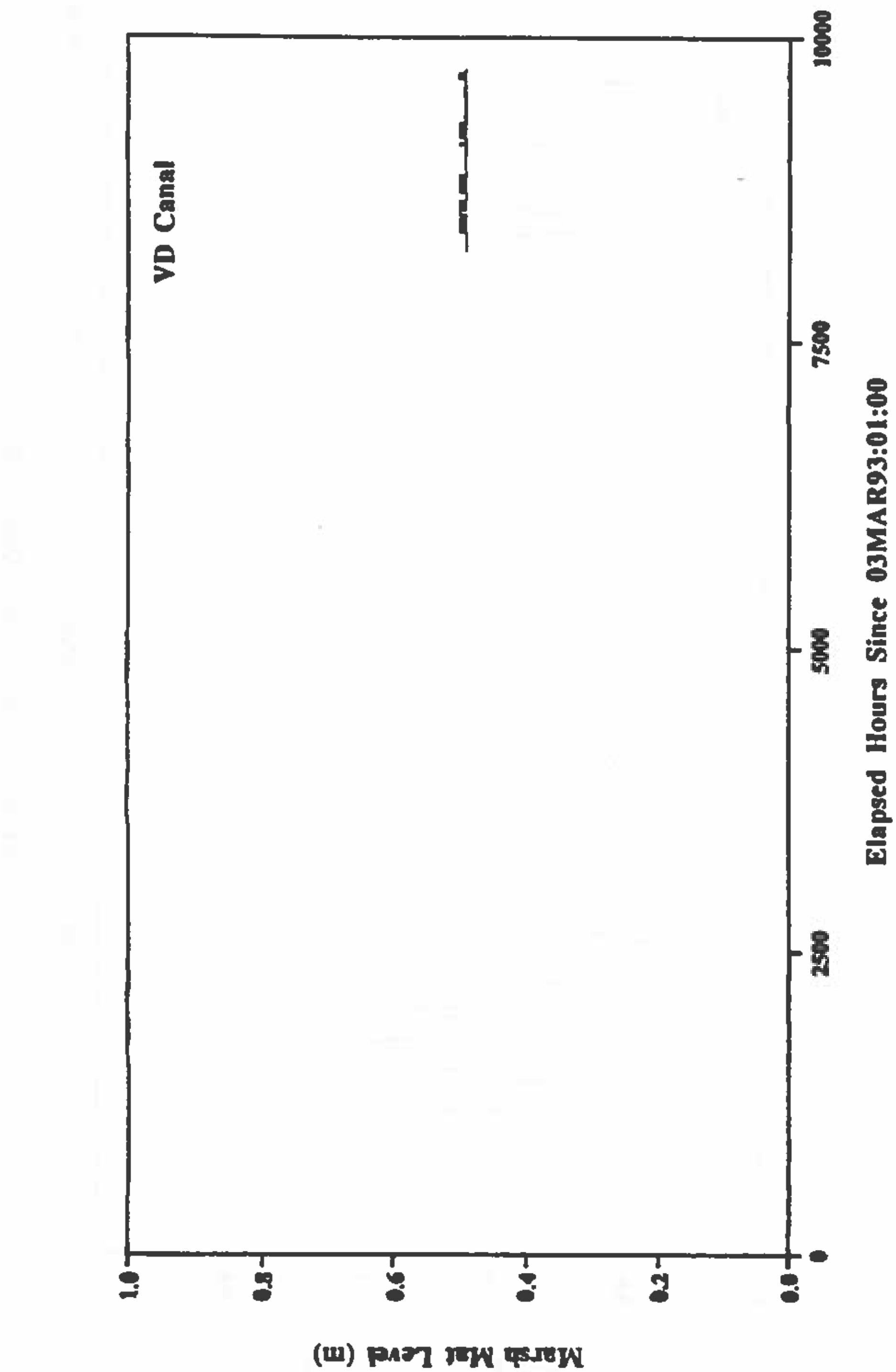

Figure A.14. Three hour means of marsh mat from Site 5 (VD Canal).

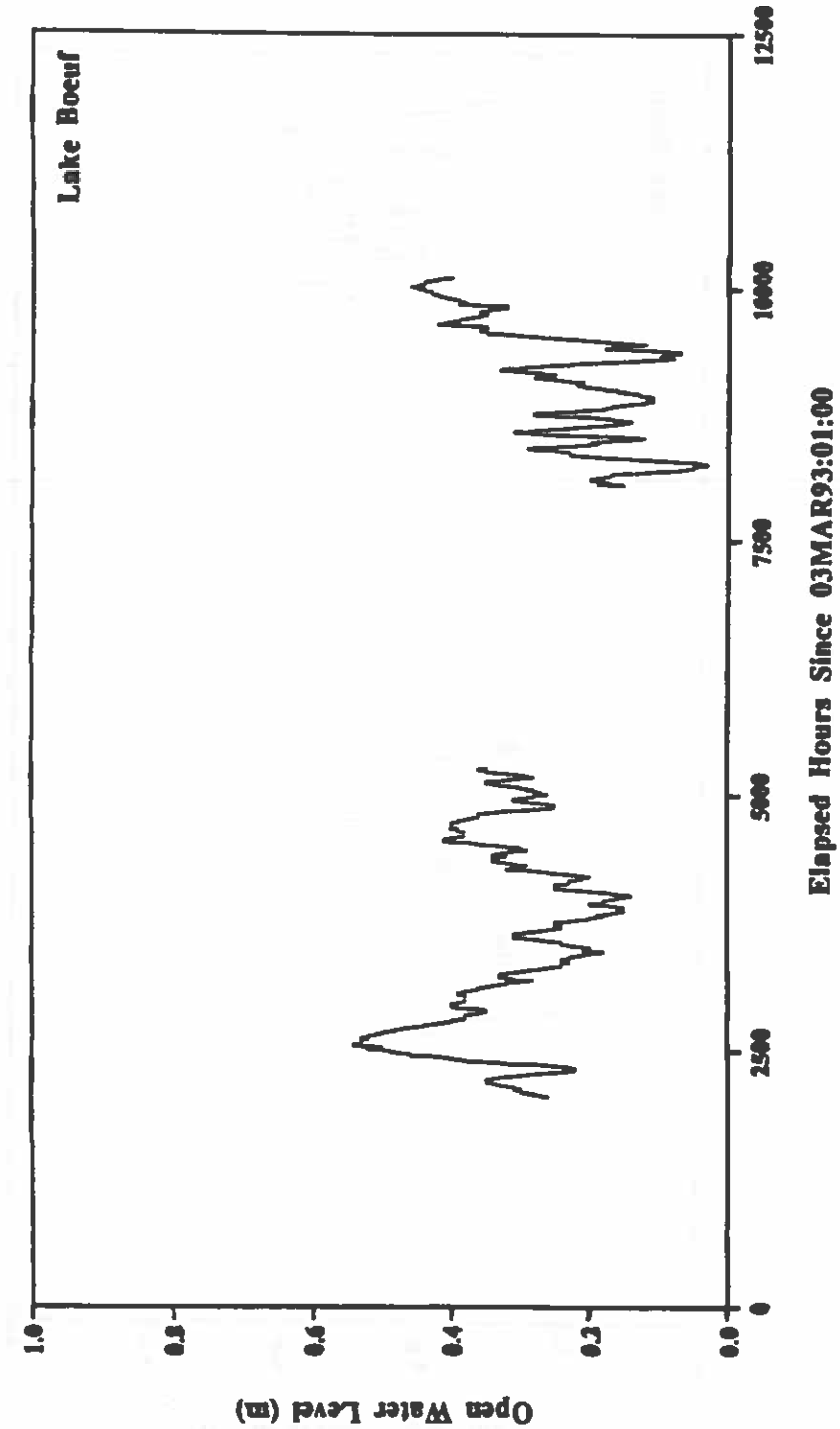

Figure A.15. Three hour means of open water from Site 6 (Lake Boeuf).

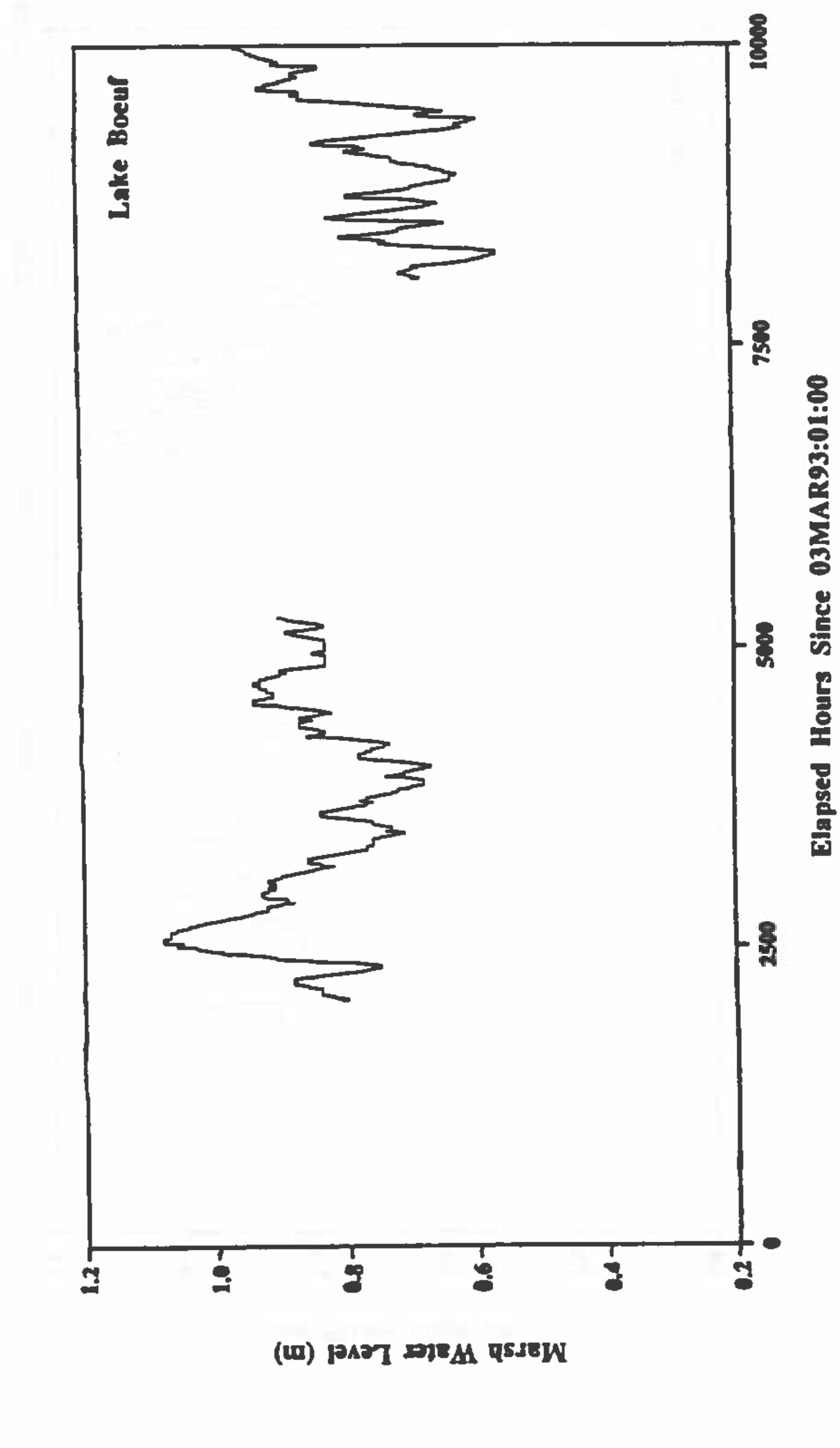

Figure A.16. Three hour means of marsh water from Site 6 (Lake Boeuf).

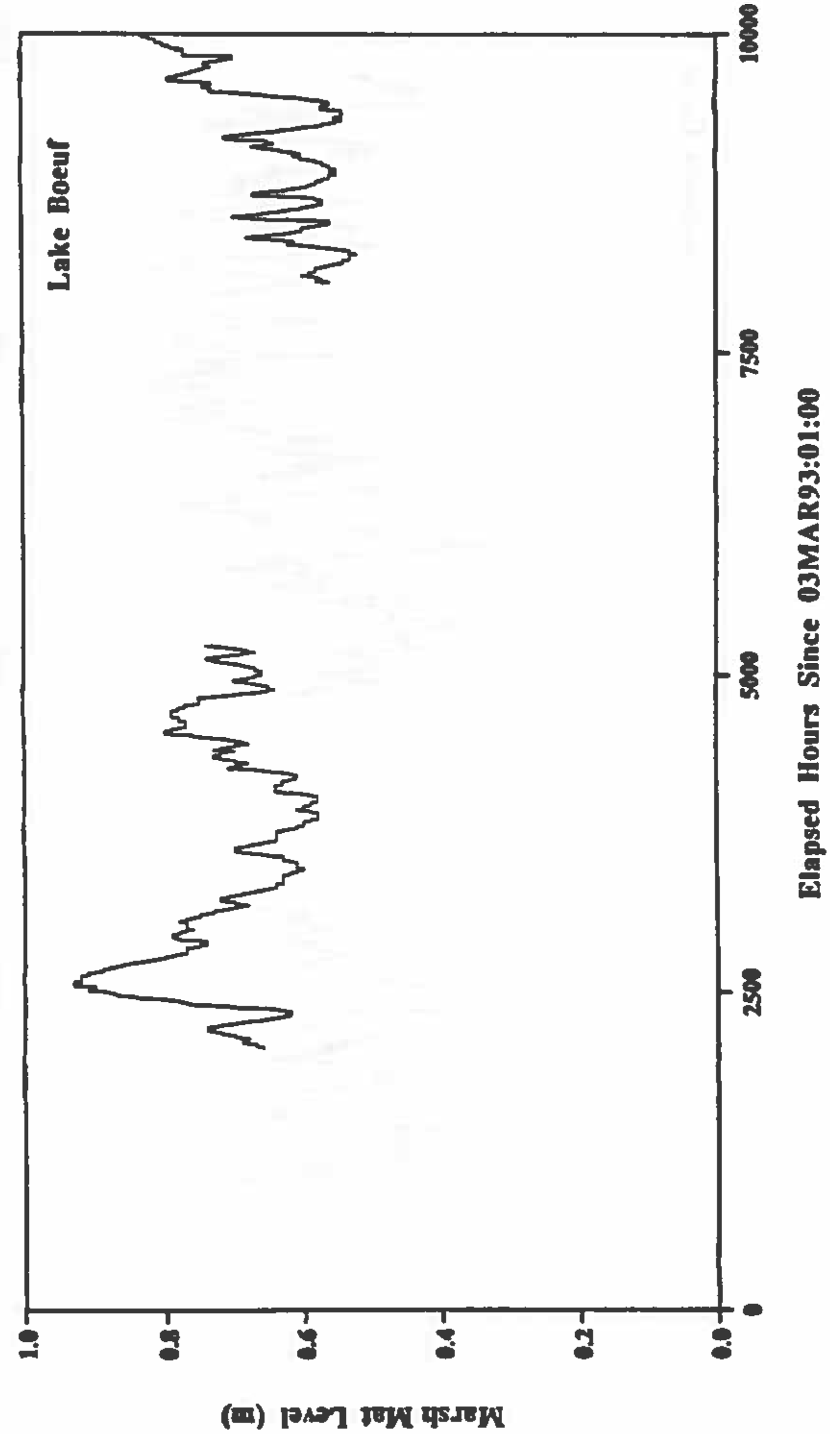

Figure A.17. Three hour means of marsh mat from Site 6 (Lake Boeuf).

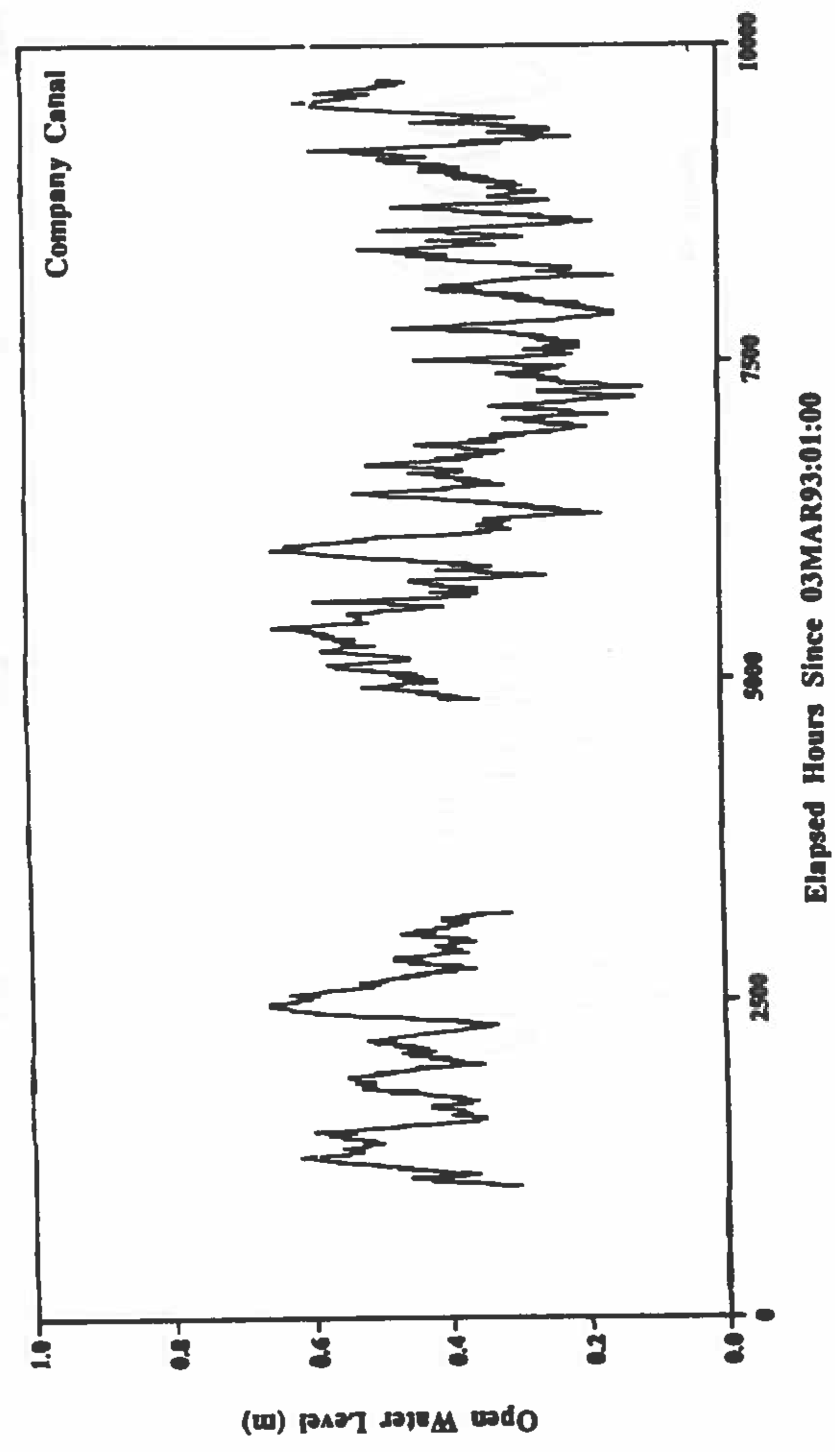

Figure A.18. Three hour means of open water from Site 7 (Company Canal).

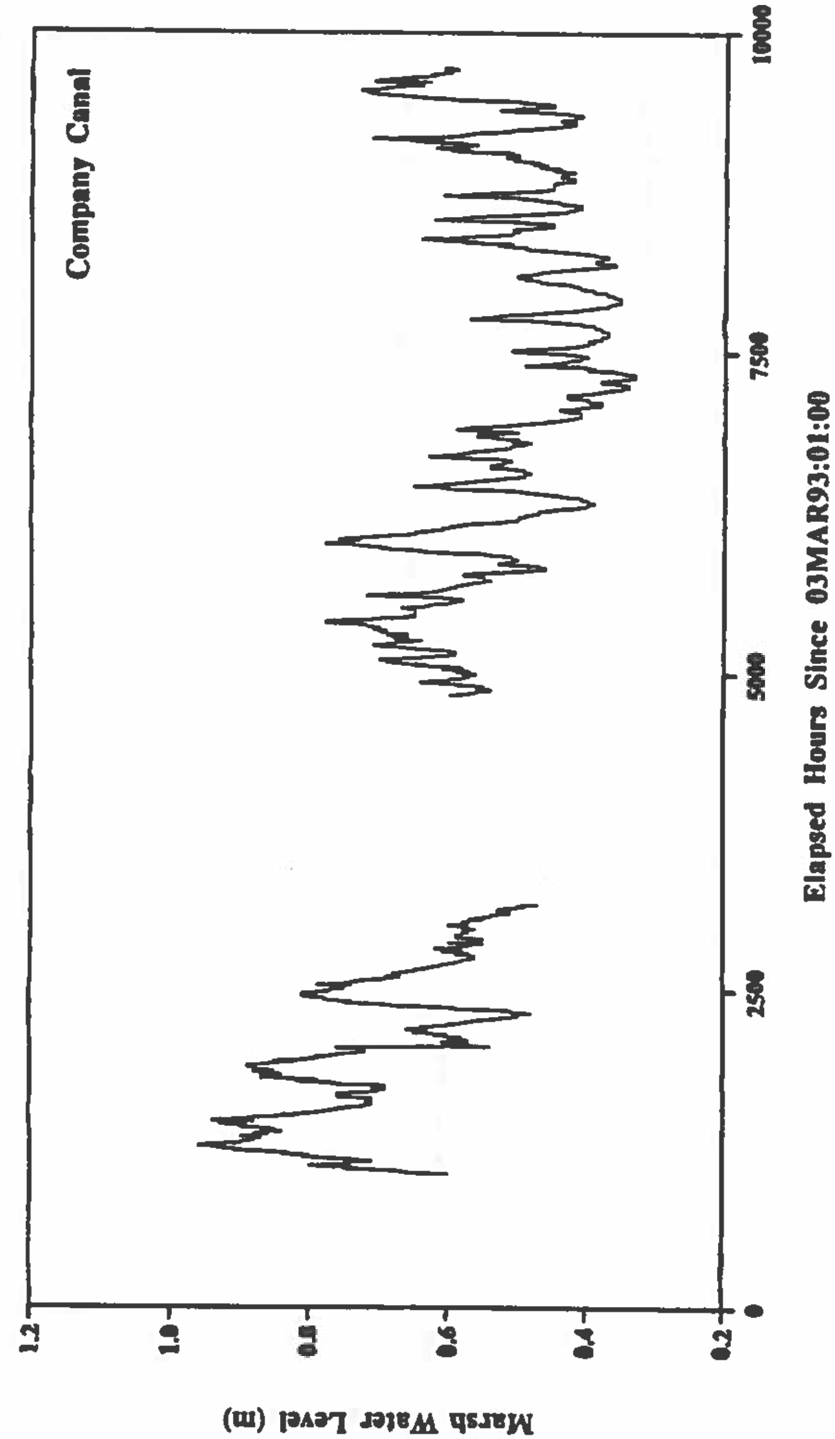

Figure A.19. Three hour means of marsh water from Site 7 (Company Canal).

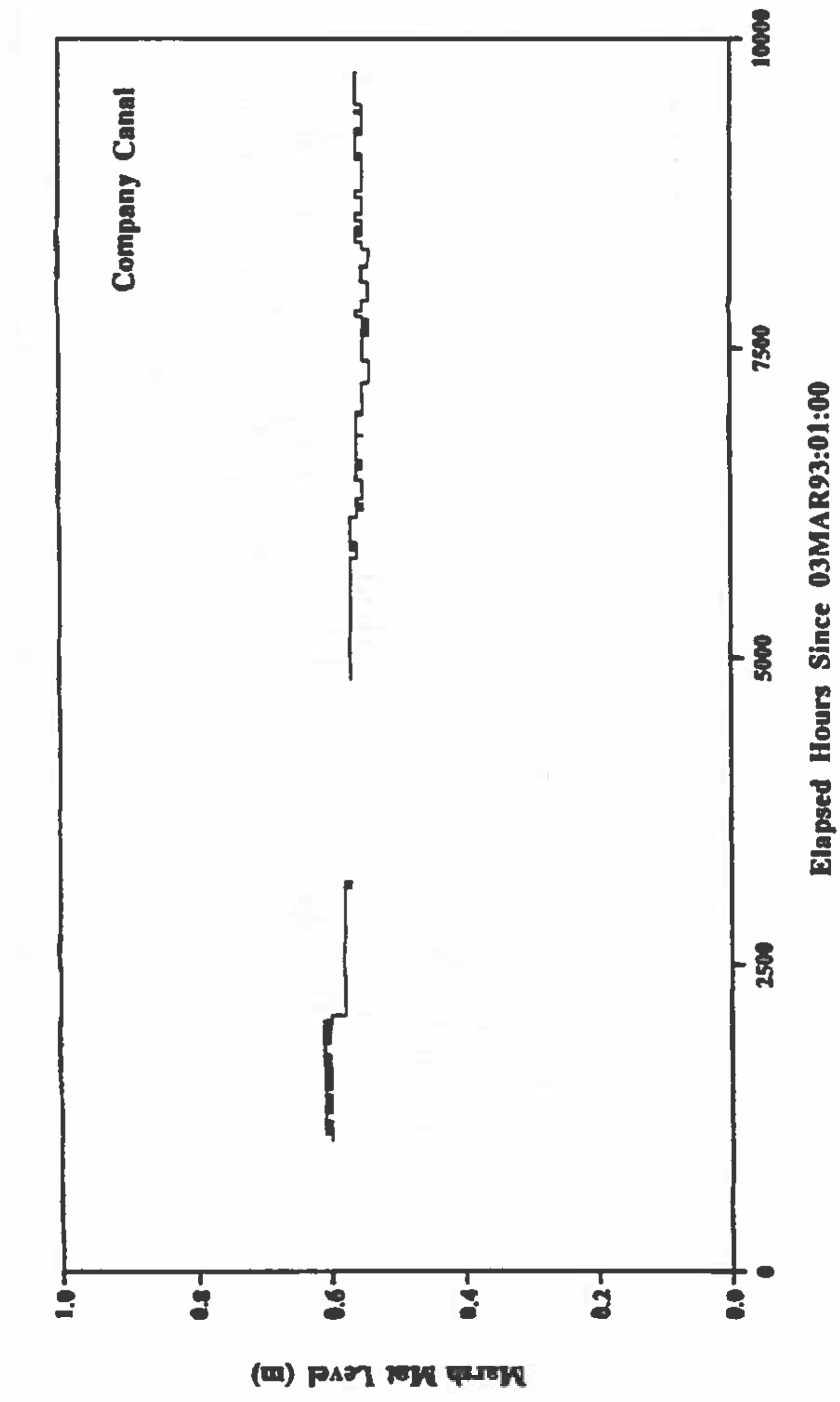

Figure A.20. Three hour means of marsh mat from Site 7 (Company Canal).

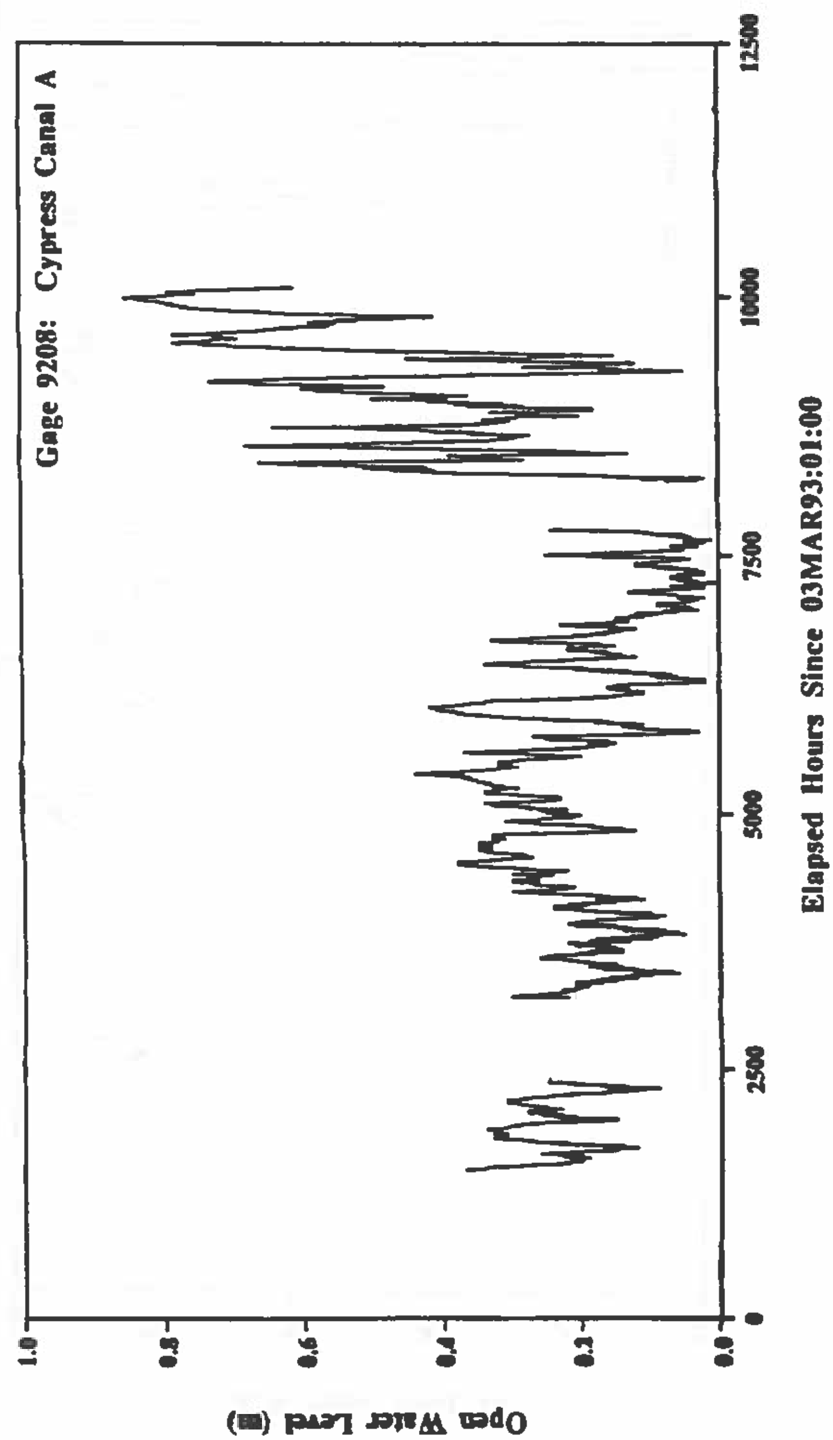

Figure A.21. Three hour means of open water from Site 8 (Cypress Canal A).

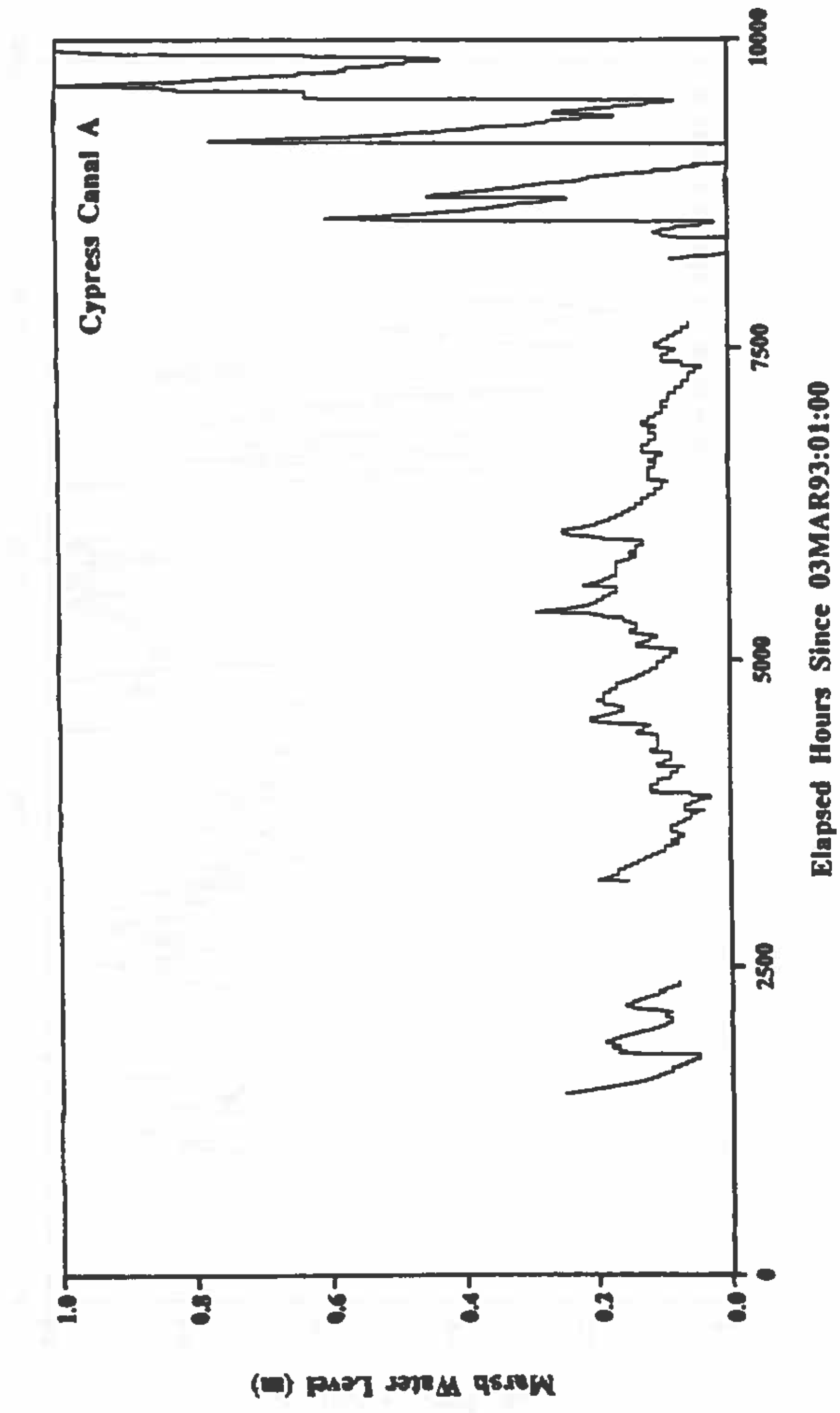

Figure A.22. Three hour means of marsh water from Site 8 (Cypress Canal A).

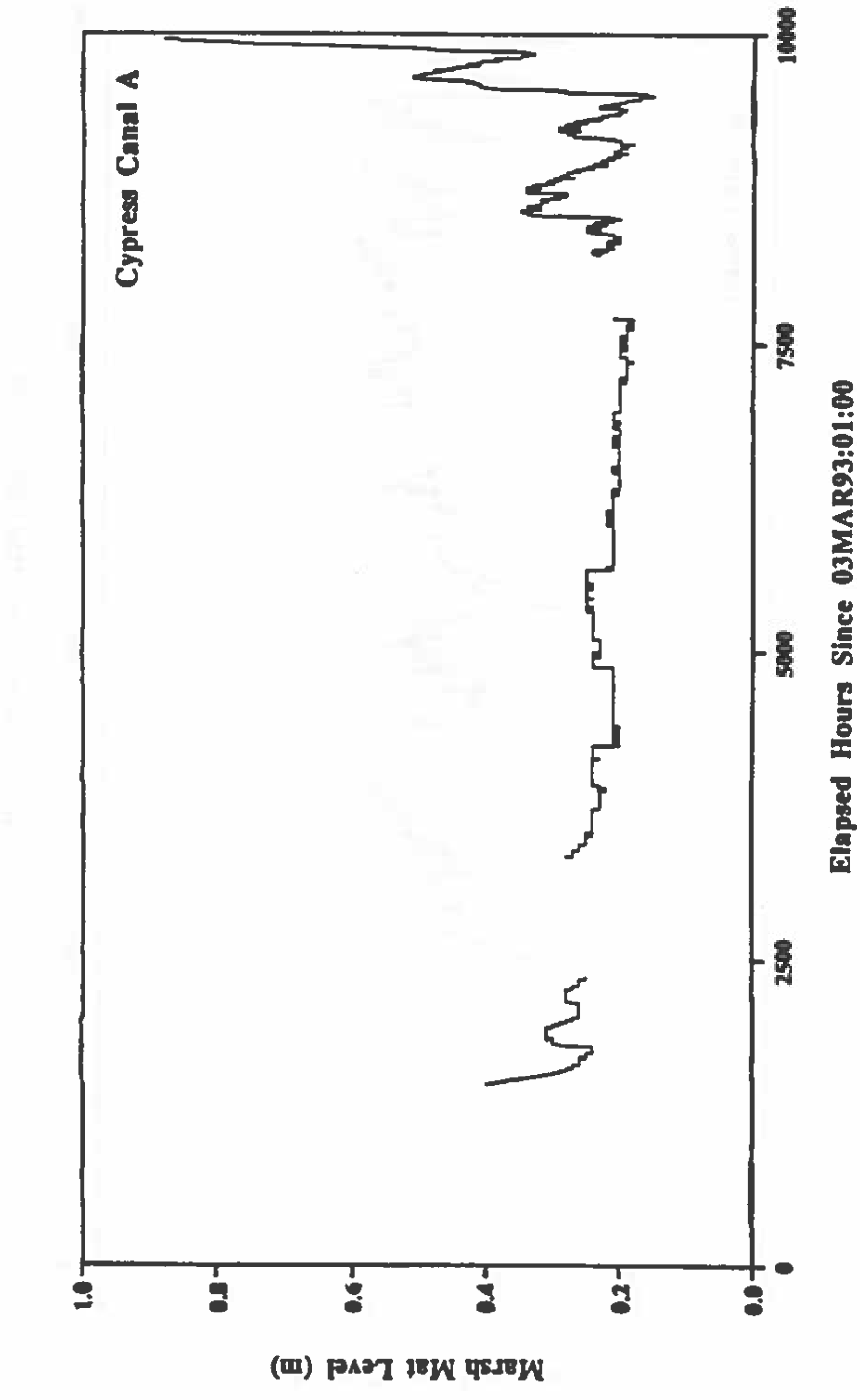

Figure A.23. Three hour means of marsh mat from Site 8 (Cypress Canal A).

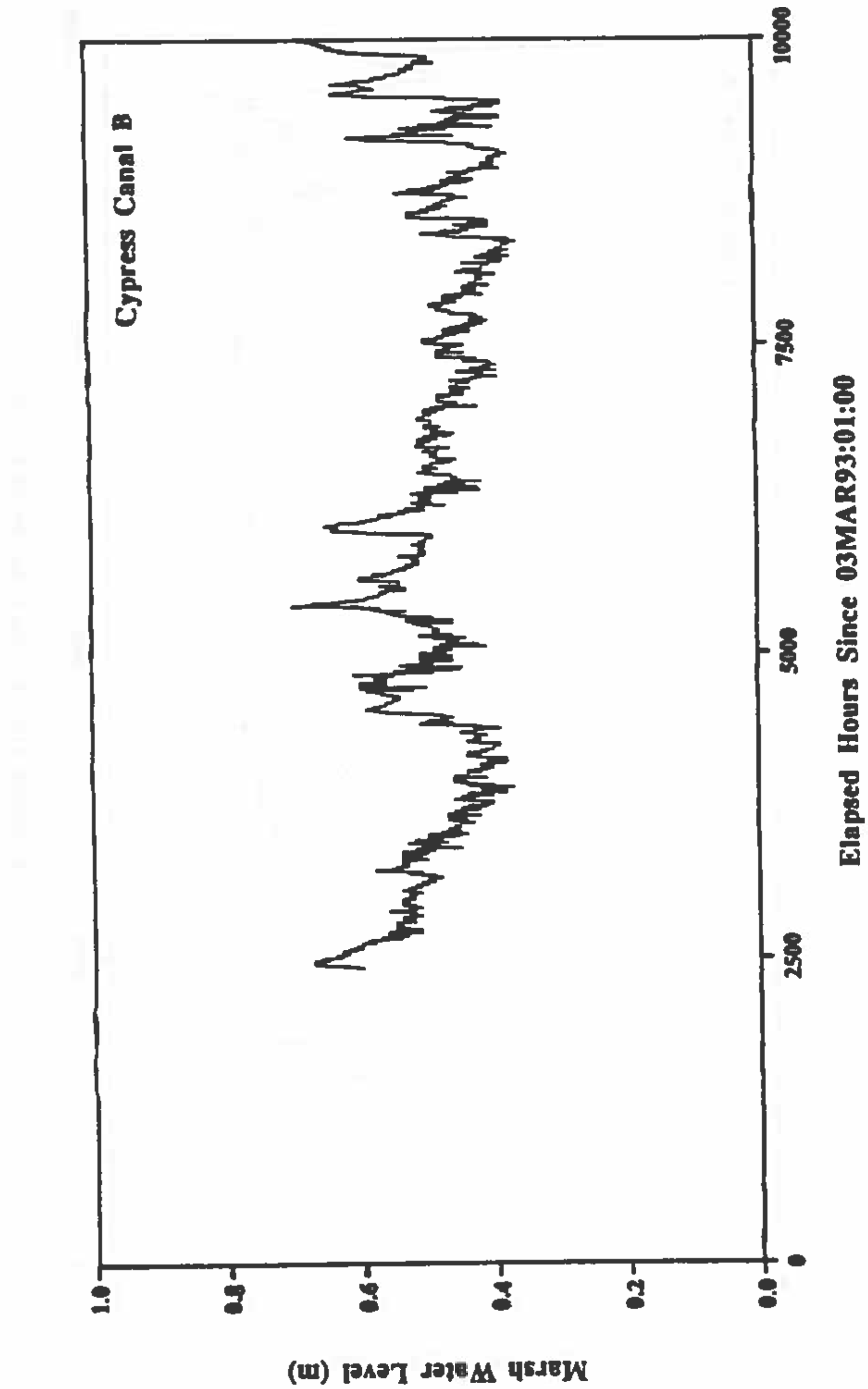

Figure A.24. Three hour means of marsh water from Site 8 (Cypress Canal B).

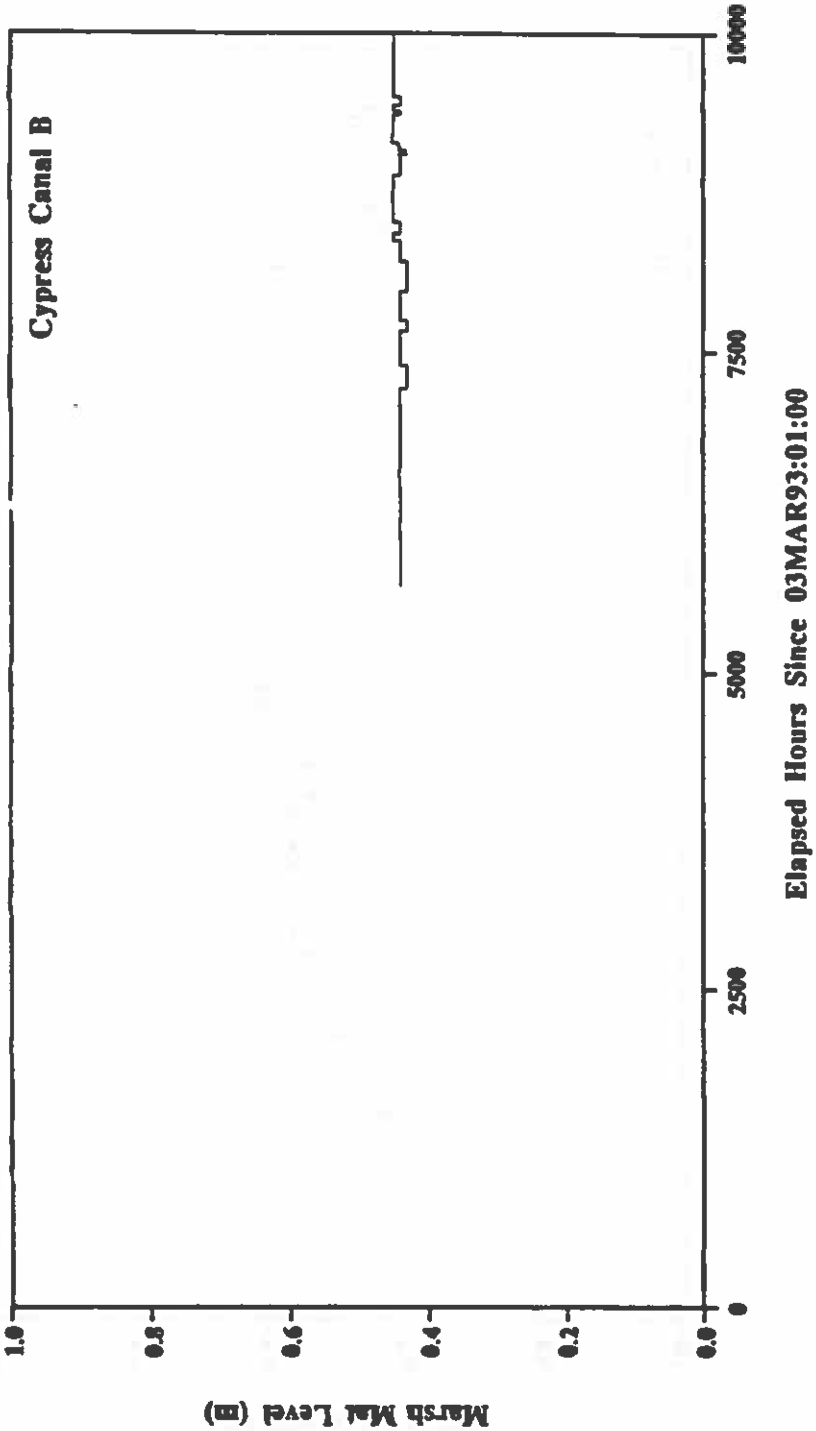

Figure A.25. Three hour means of marsh mat from Site 8 (Cypress Canal B).

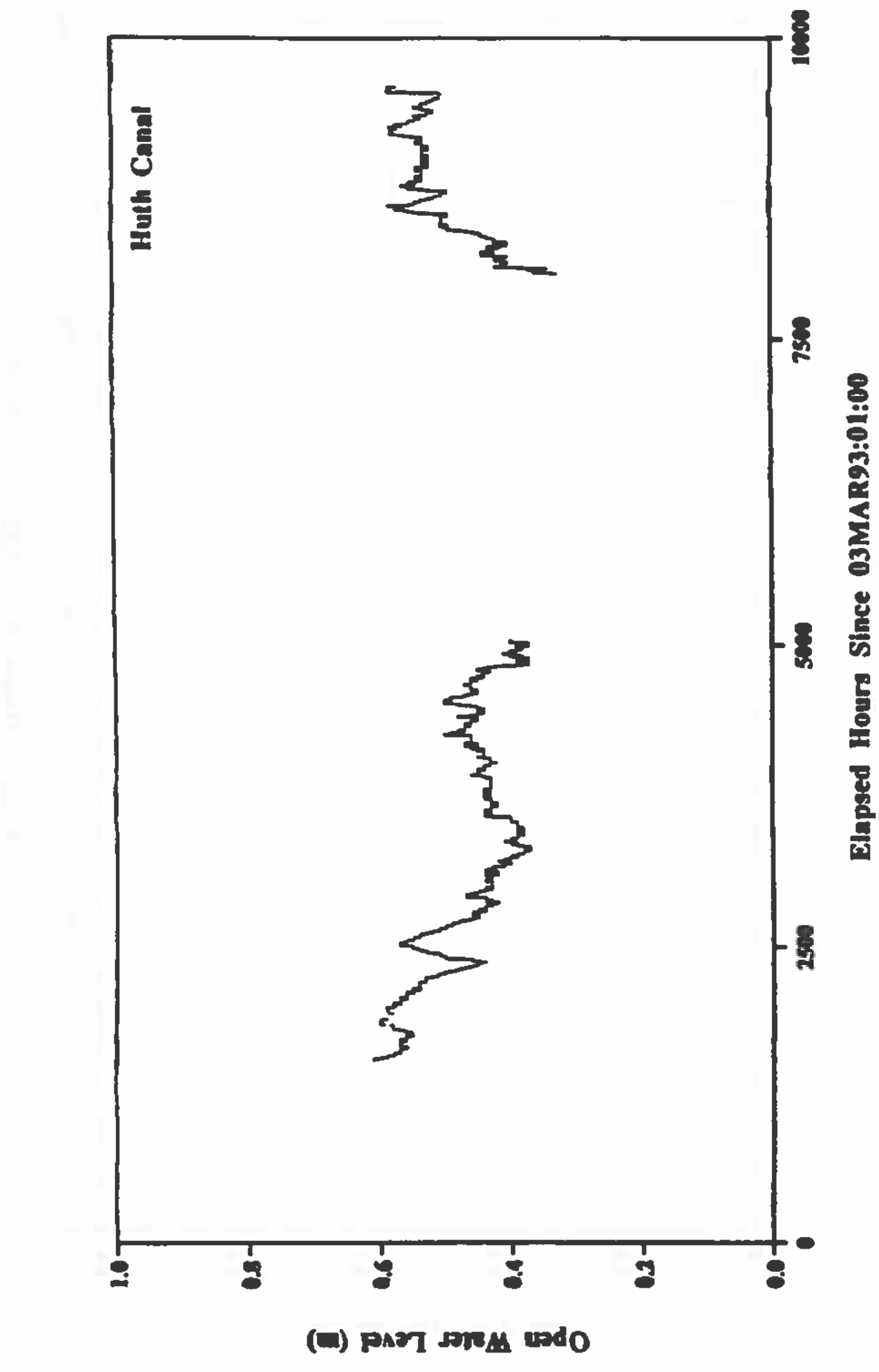

Figure A.26. Three hour means of open water from Site 9 (Huth Canal).

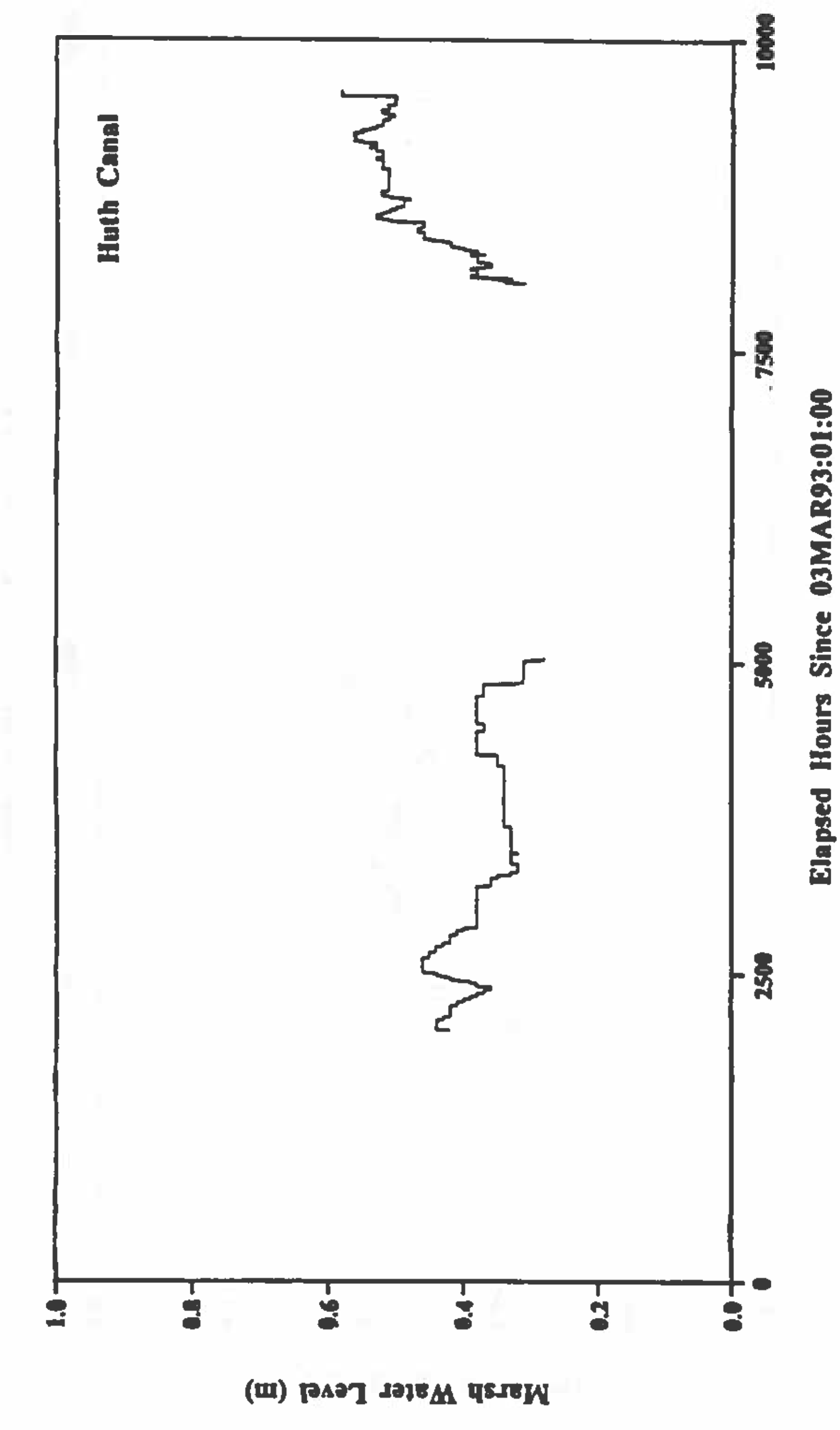

Figure A.27. Three hour means of marsh water from Site 9 (Huth Canal).

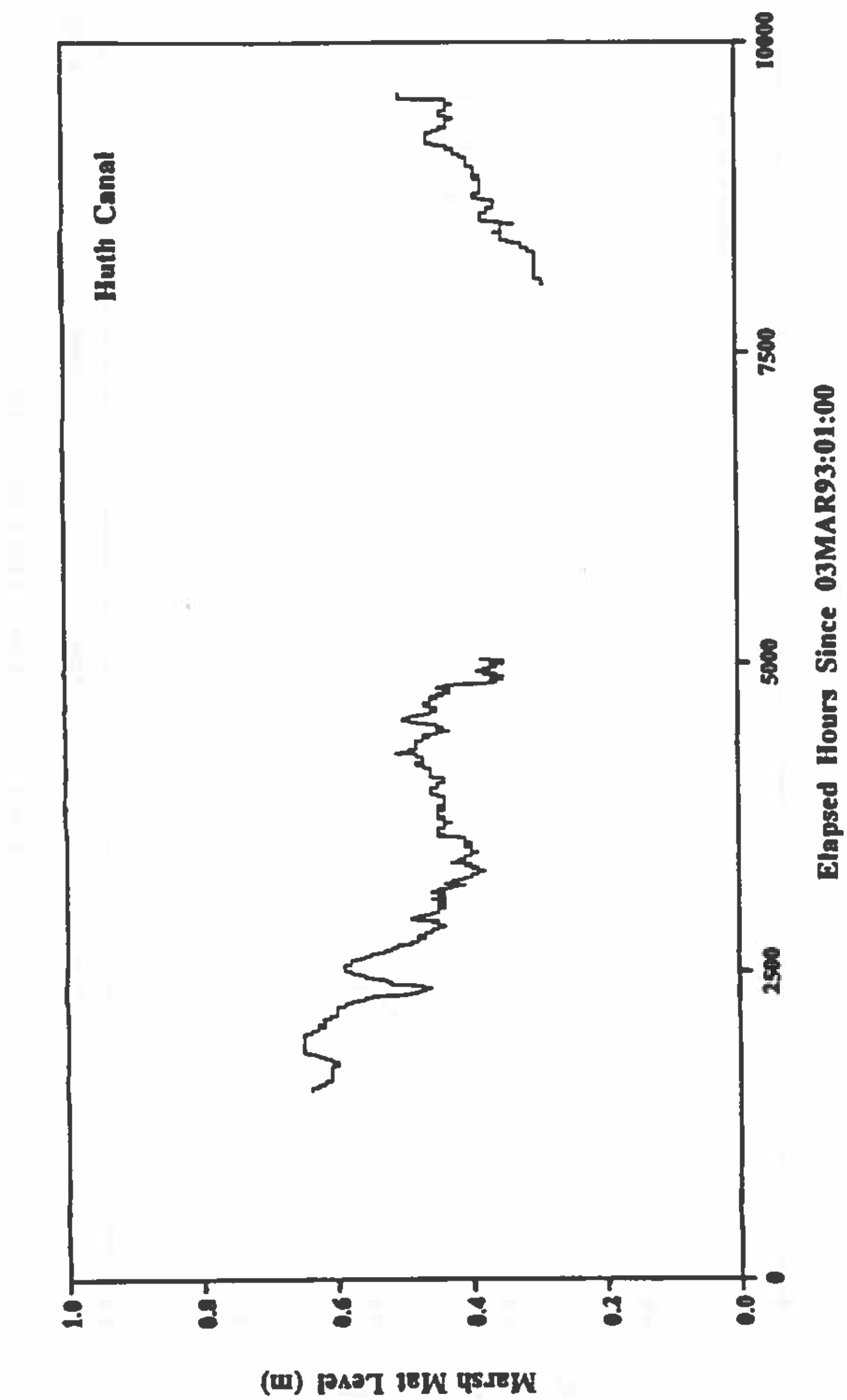

Figure A.28. Three hour means of marsh mat from Site 9 (Huth Canal).

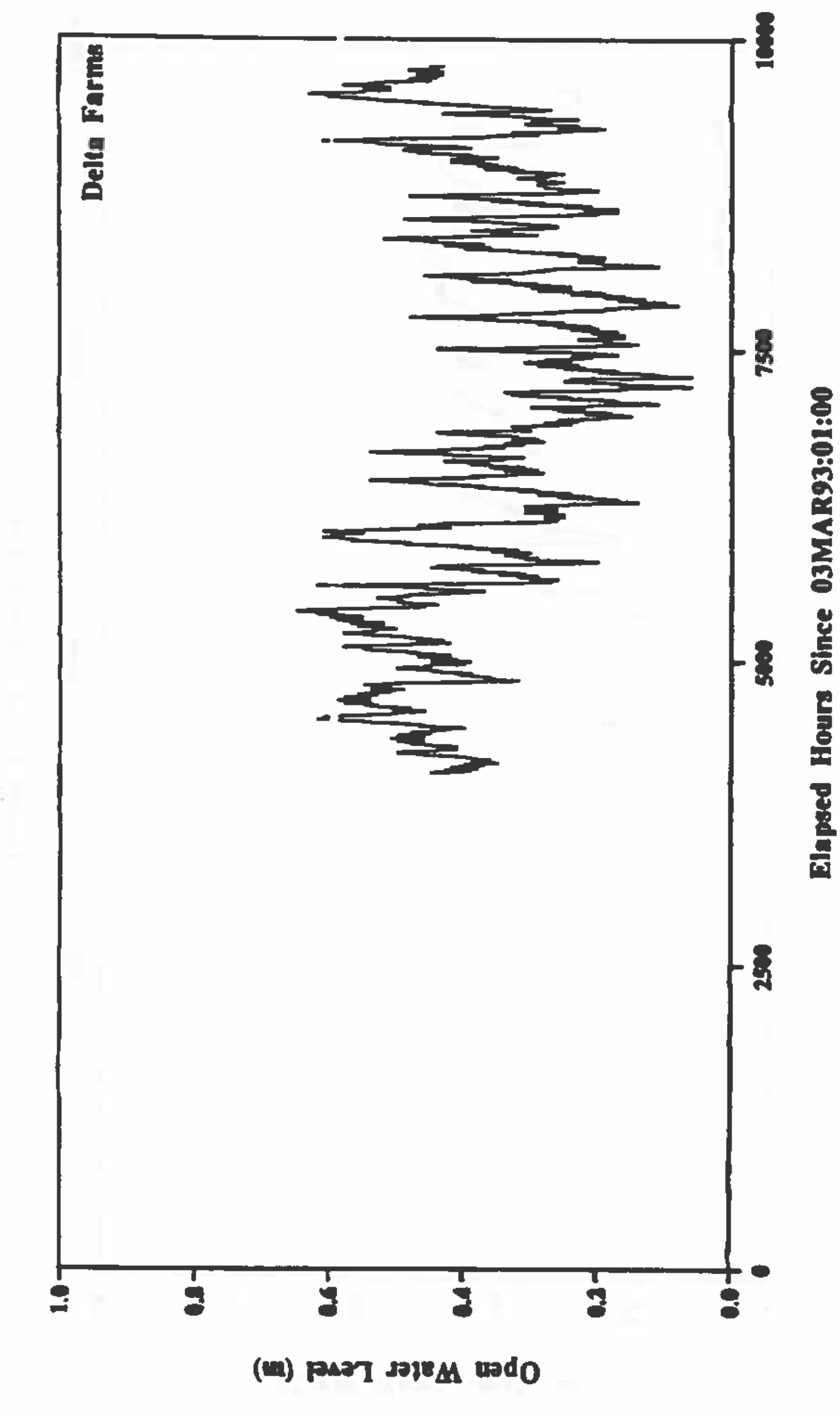

Figure A.29. Three hour means of open water from Site 10 (Delta Farms).

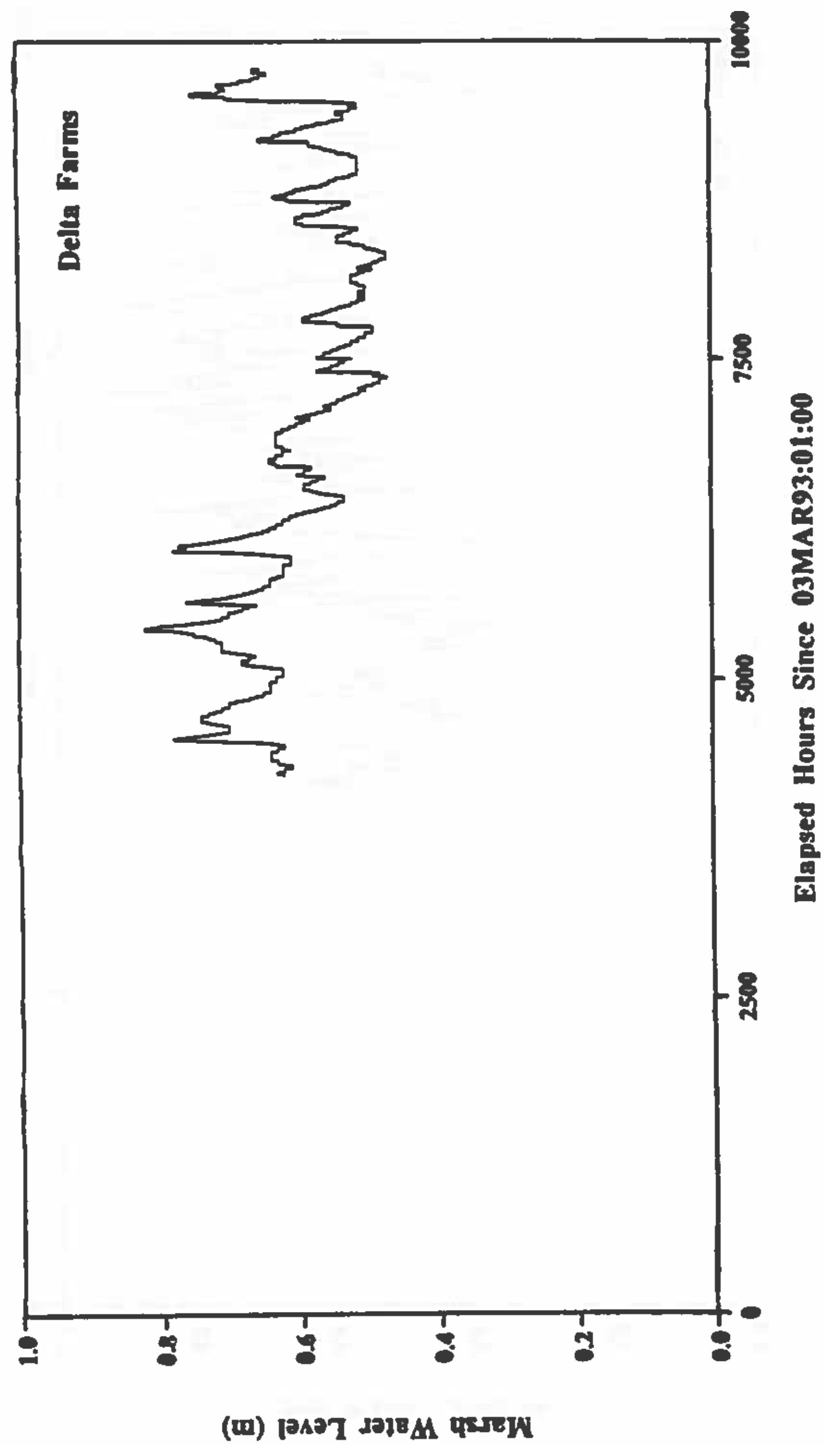

Figure A.30. Three hour means of marsh water from Site 10 (Delta Farms).

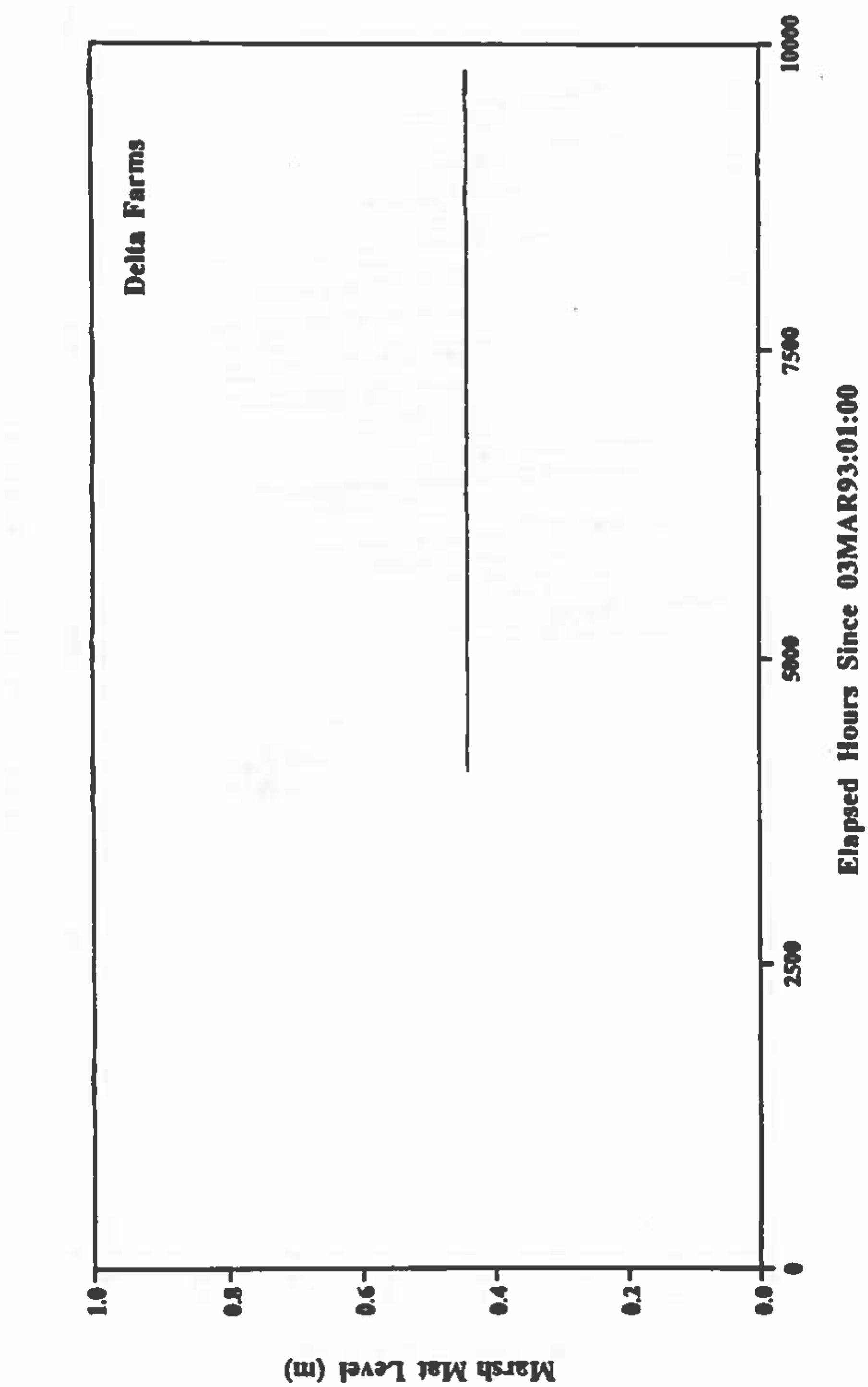

Figure A.31. Three hour means of marsh mat from Site 10 (Delta Farms).

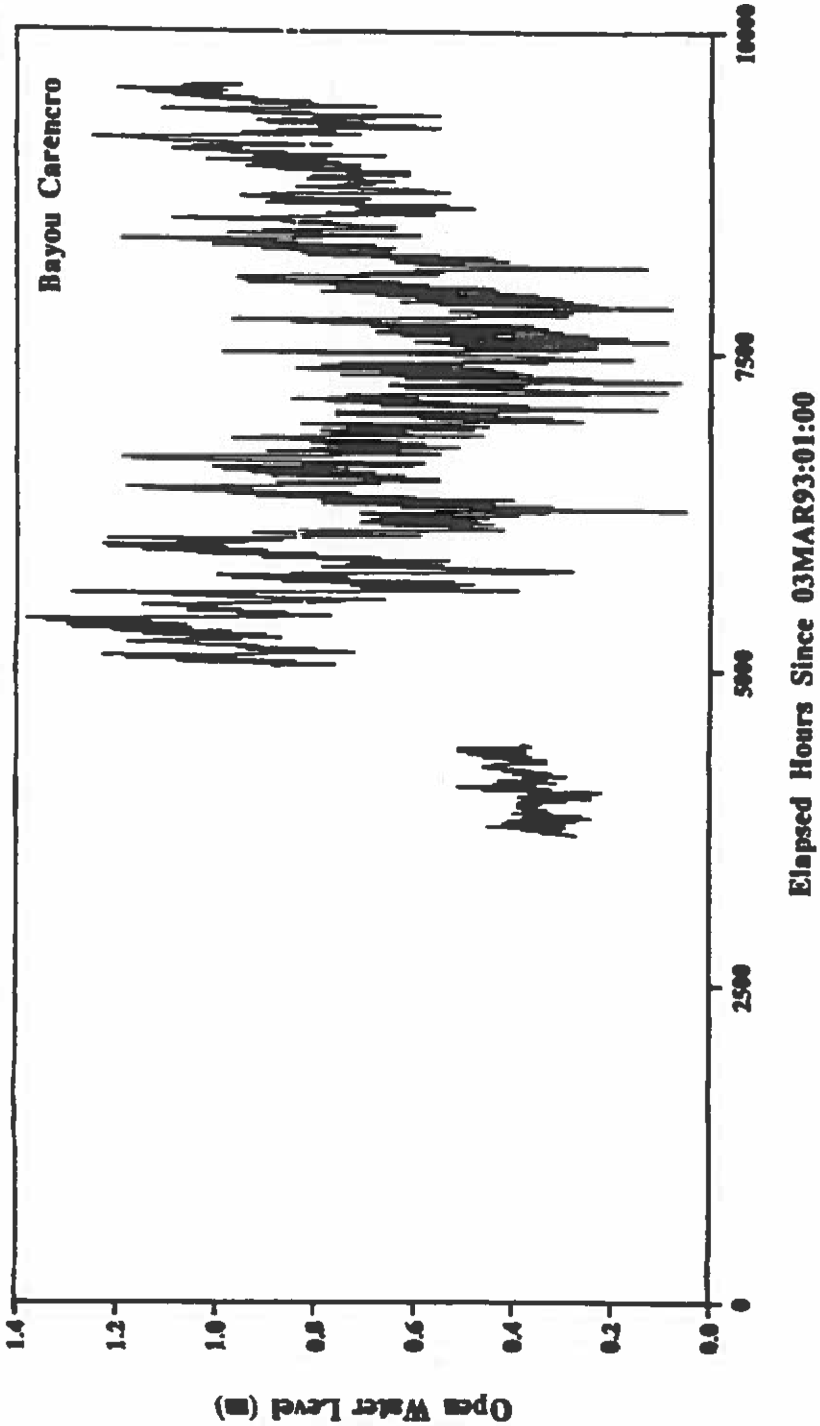

Figure A.32. Three hour means of open water from Site 11 (Little Bayou Carencro).

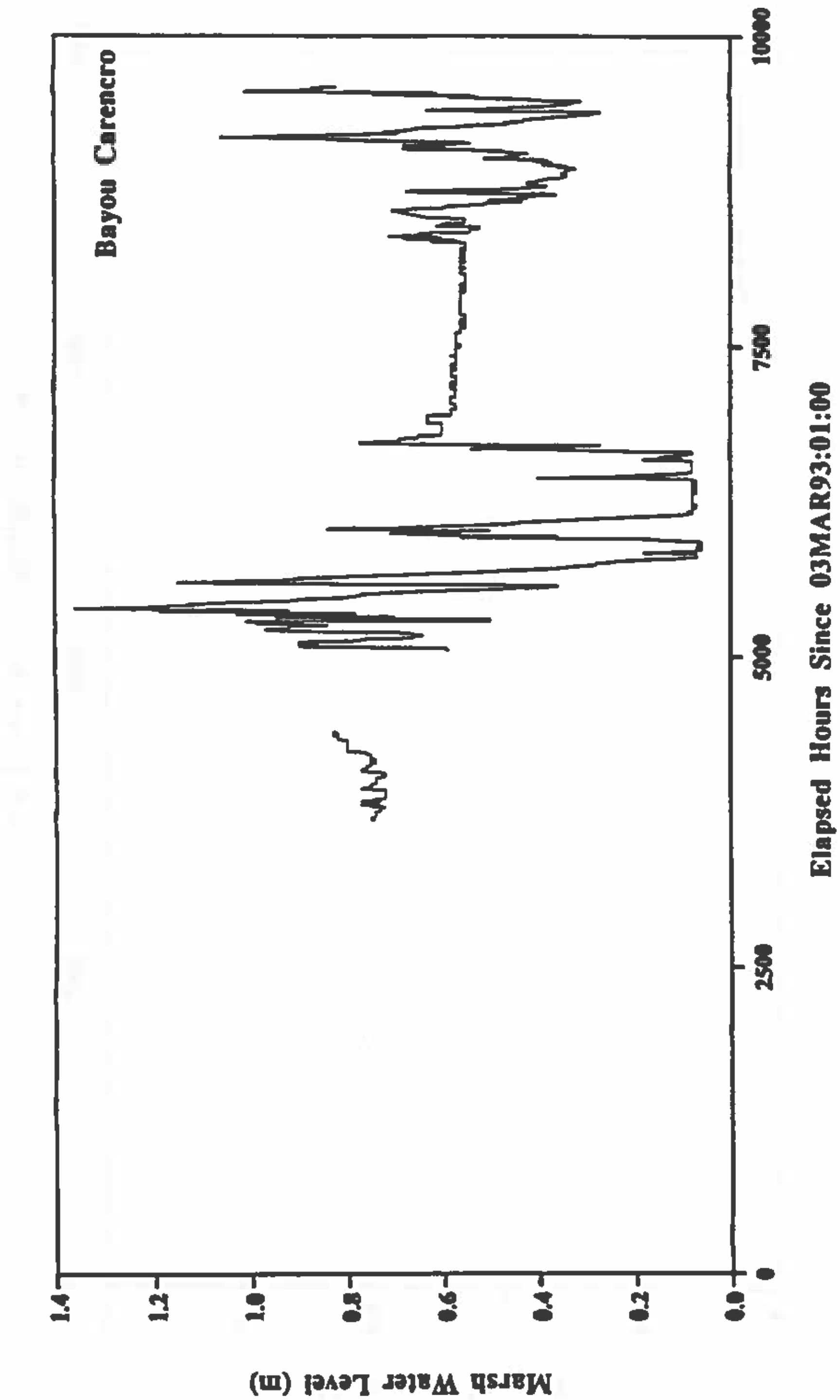

Figure A.33. Three hour means of marsh water from Site 11 (Little Bayou Carencro).

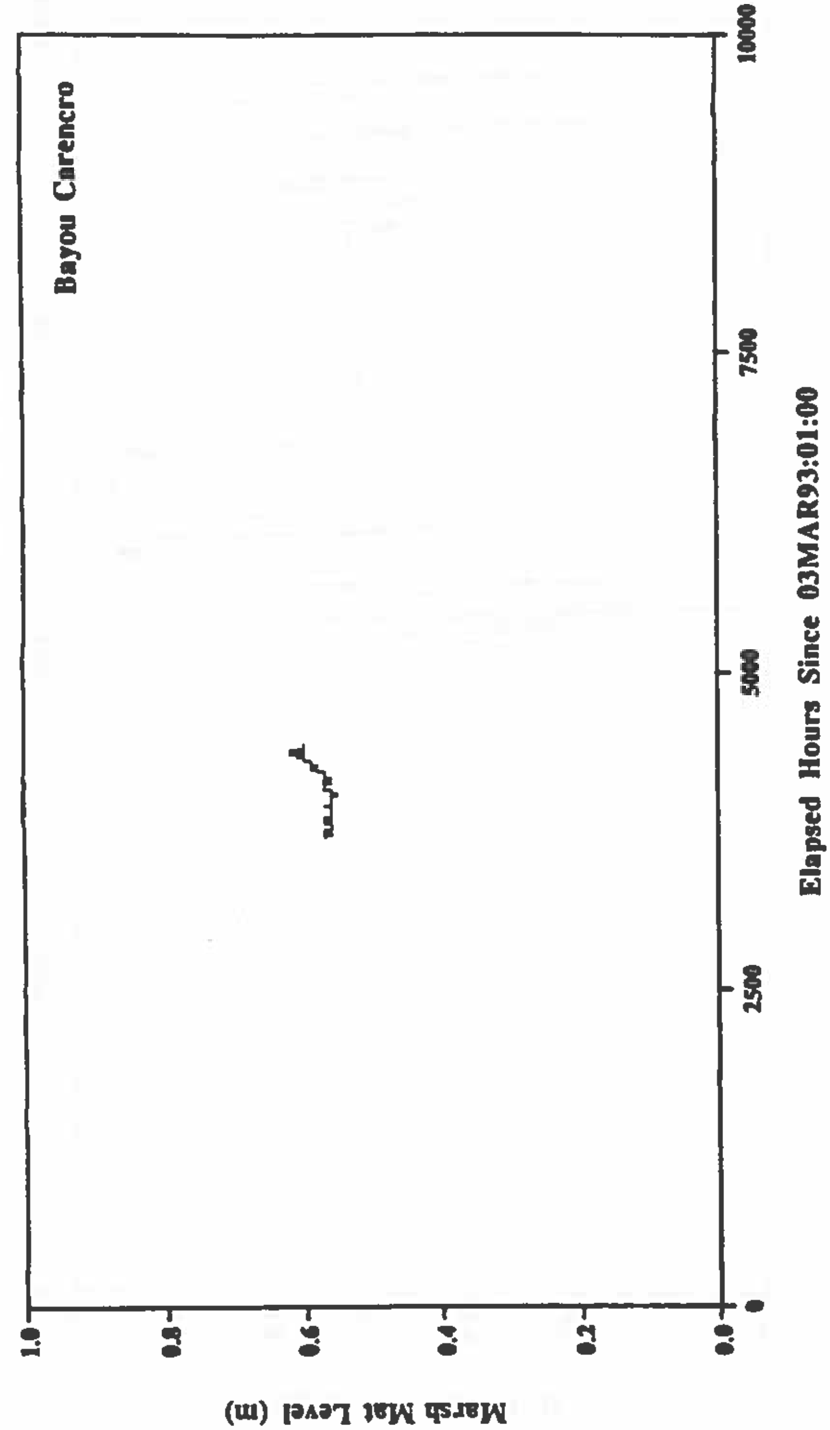

Figure A.34. Three hour means of marsh mat from Site 11 (Little Bayou Carencro).

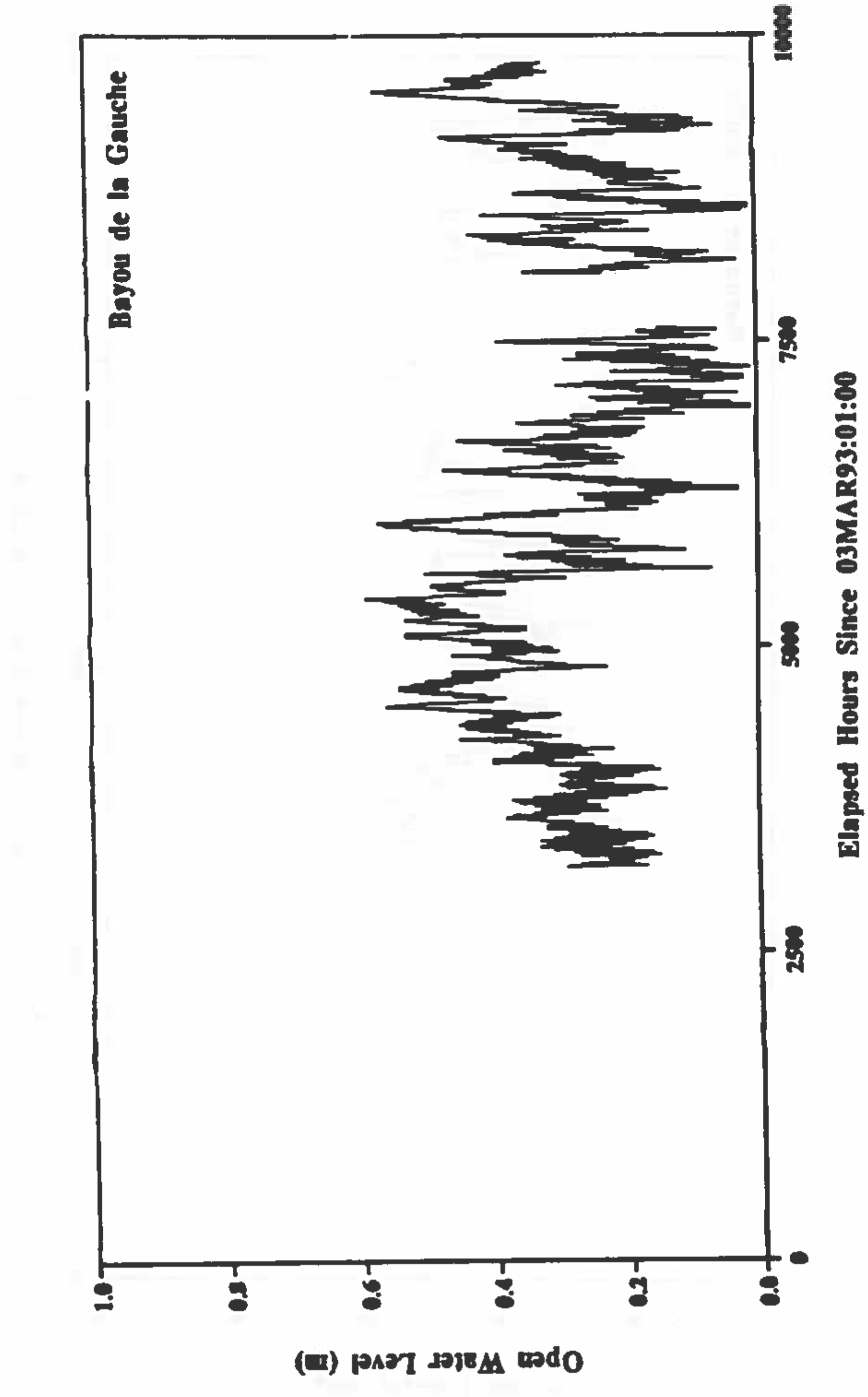

Figure A.32. Three hour means of open water from Site 12 (Bayou de la Gauche).

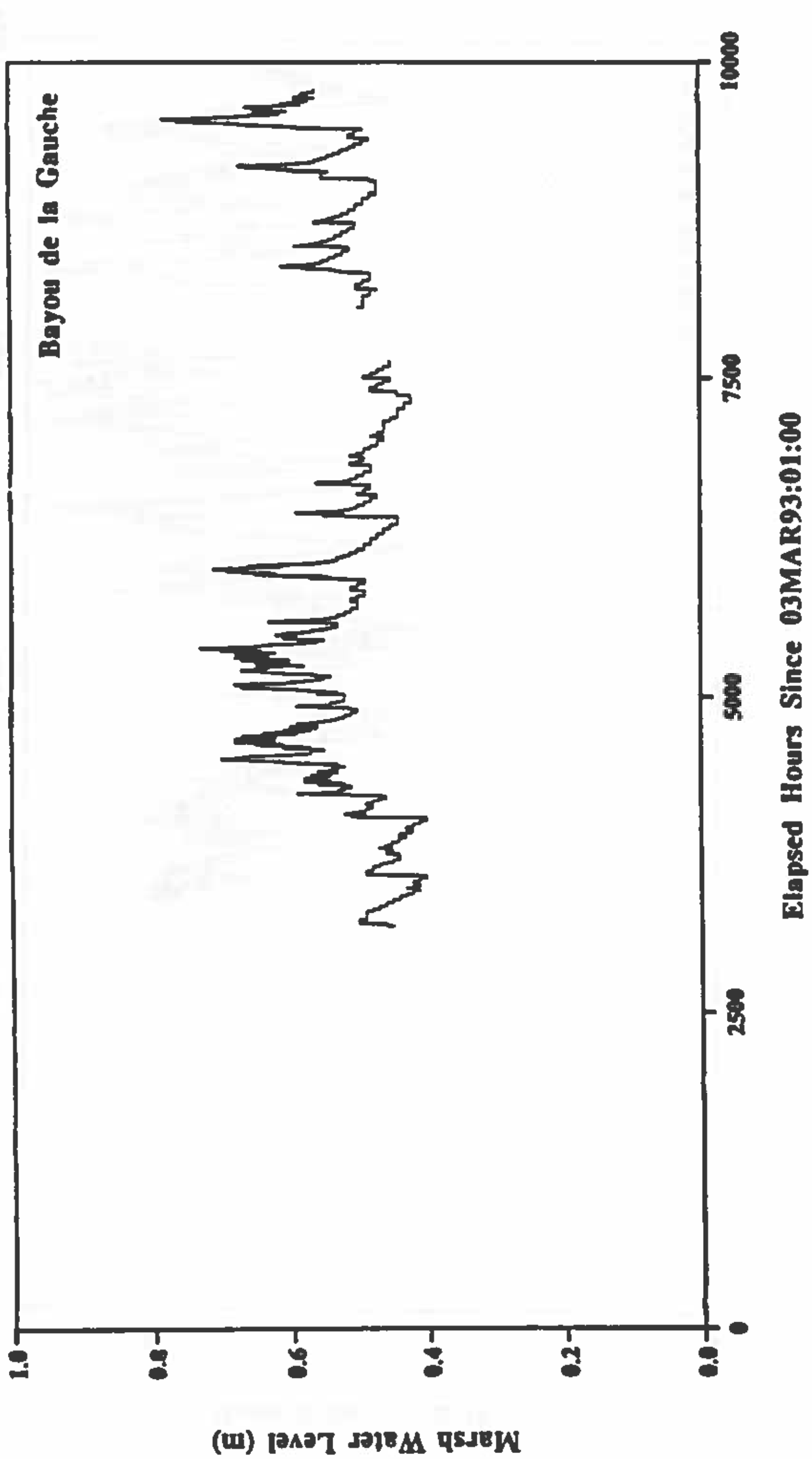

Figure A.33. Three hour means of marsh water from Site 12 (Bayou de la Gauche).

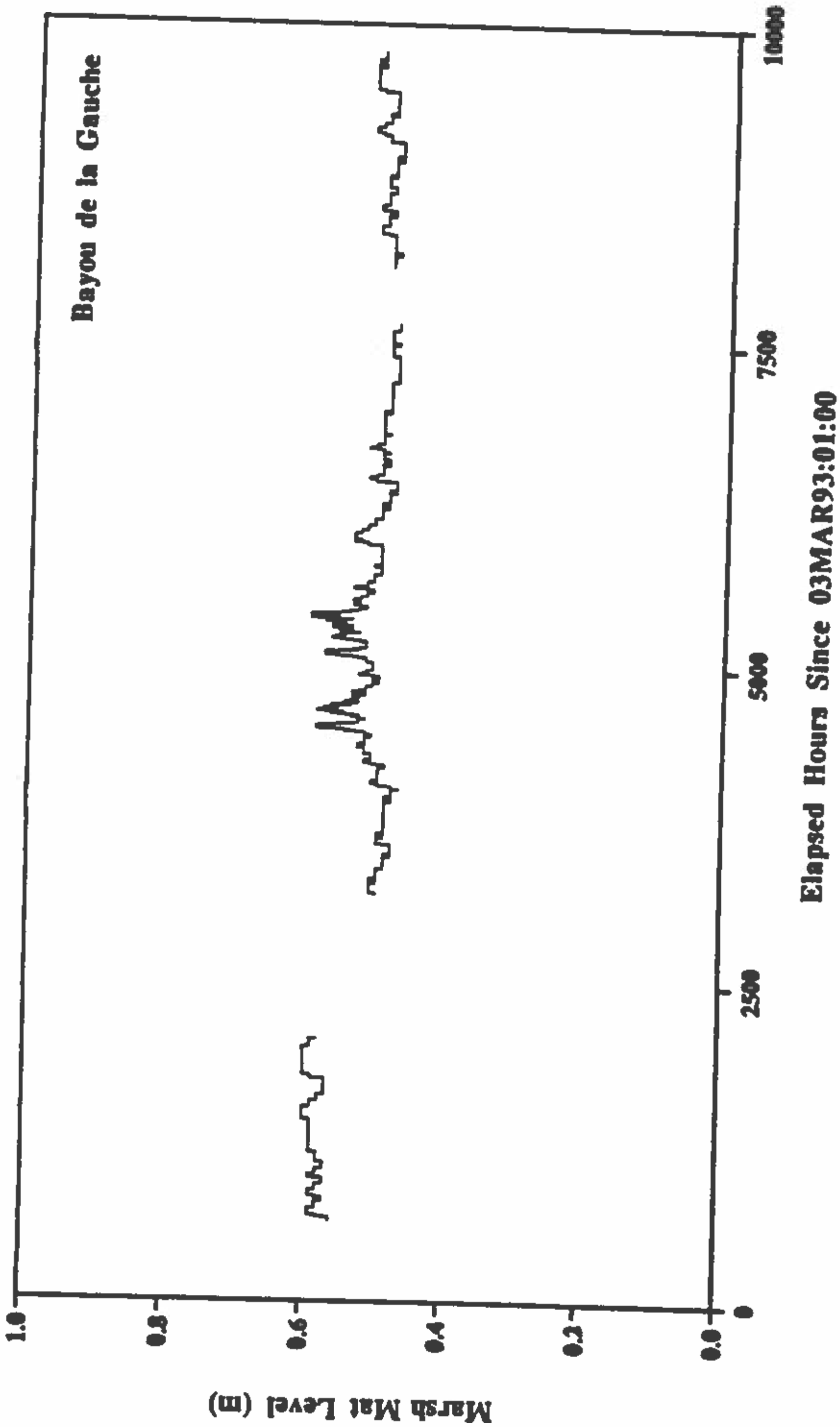

Figure A.37. Three hour means of marsh mat from Site 12 (Bayou de la Gauche).

APPENDIX B: RESULTS BY SITE

This appendix comprises a summary by station of vegetation, hydrology, and substrate data.

Site 1. Gallinule Canal

Gallinule Canal is a thin mat site dominated in the spring by *Eleocharis baldwinii* . In the fall, *E. baldwinii* was overtopped by *Aeschynomene indica* and *Sacciolepis striata*; nevertheless *E. baldwinii* contributed significantly to the total biomass. The mat did not support the weight of a person, even in the fall. Therefore, clip plots were taken on the edge of the mat. However, we think that the biomass and species composition of the clip plots are representative for the site. The site was very homogeneous in its appearance with patches having higher amounts of either *A. indica* or *S. striata*.

This site had the lowest number of species. The following species were absent from Gallinule Canal, but present in the other two *E. baldwinii* sites (North ICWW, Site 3; and Cypress Canal A, site 8a): *Sagittaria latifolia, Alternanthera philoxeroides, Polygonum punctatum, and Limnobium spongia.*

Gallinule Canal had a thinner mat and significantly lower belowground biomass than the other two *E. baldwinii* sites. Gallinule Canal showed a high buoyancy and was floating throughout the study period. Gallinule Canal is the northern station on the western Terrebonne transect and no tidal influence was detected. The high correlation between marsh water and open water at this site (R^2=0.99) shows that the water under the mat is hydrologically connected to the open water. Tidal influence at this site is small (<5 cm).

Table B.1. Species found at Gallinule Canal (site 1)

Aeschynomene indica L.	*Hydrocotyle* spp
Bidens laevis (L.) BSP.	*Ludwigia leptocarpa* (Nutt.) Hara
Cyperus odoratus L.	*Paspalum* spp.
Eleocharis albida Torr.	*Phyla lanceolata* (Michx.) Greene
Eleocharis baldwinii (Torr.) Chapman.	*Sacciolepis striata* (L.) Nash
Fuirena pumila (Torr.) Spreng.	*Triadenum virginicum* (L.) Raf.

Table B.2. Summary of vegetation, substrate, and hydrology for Gallinule Canal (site 1).

Parameter	Value	Units
Location	West Terrebonne Basin, North Station	
Vegetation		
Dominant species	*Eleocharis baldwinii*	
Species richness[1]	12	
Aboveground live biomass	367±57	$g \cdot m^{-2}$
Belowground live biomass	93±23	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	82±2	%
Bulk density	0.035±0.003	$g \cdot cm^{-3}$
Hydrology		
Mat buoyancy[2]	1.06	
Connectivity[3]	0.96	
Tidal amplitude (open water)	<5	cm
Total amplitude (open water)	40	cm
Total amplitude (marsh mat)	40	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 2. Victor Bayou

This marsh is homogeneous, although, due to the high species diversity co-dominants vary throughout the site. Victor Bayou (site 2) is the most diverse of the three *P. hemitomon/S. lancifolia* sites (Victor Bayou; Company Canal, site 7; and Delta farms, site 10), and contains the least *S. lancifolia*. In addition, it is the only *P. hemitomon/S. lancifolia* site with significant amounts of *Conoclinium coelestinum*. Other species found at this site but not at the other two *P. hemitomon/S. lancifolia* sites include: *Boehmeria cylindrica, Sagittaria latifolia, Thelypteris palustris*, and *Vigna luteola*. This site had the highest biomass both above and belowground of the three *P. hemitomon/S. lancifolia* sites; these differences were almost significant (p=0.07). The biomass at this site is more similar to the *P. hemitomon* -dominated sites than to the *P. hemitomon/S. lancifolia* sites.

The mat is very thick and is very similar to the mat at Company Canal. Victor Bayou and Company Canal had the highest bulk density and the lowest percentage organic matter of all the study sites. However, previous studies at Victor Bayou showed lower bulk density and higher percentage organic matter. This might be explained by the close proximity of the present samples to the spoilbank.

The mat at this site shows a high correlation between the marsh mat level and the marsh water level and a slope that is close to 1, indicating a high buoyancy of the mat. The correlation between open water and marsh water is low. However, the marsh water tracks the open water at higher water levels, which indicates that this site might be impounded. The open water at this site shows a strong tidal signal superimposed on long fluctuations.

Table B.3. Species found at Victor Bayou (site 2)

Andropogon virginicus L.	*Kosteletzkya virginica* (L.) Presl.
Boehmeria cylindrica (L.) Sw.	*Leersia oryzoides* (L.) Sw.
Colocasia esculenta (L.) Schott	*Mikania scandens* (L.) Willd.
Conoclinium coelestinum (L.) DC.	*Panicum hemitomon* Schult.
Cyperus polystachyos Rottb.	*Sacciolepis striata* (L.) Nash
Cyperus spp	*Sagittaria lancifolia* L.
Eleocharis albida Torr.	*Sagittaria latifolia* Willd.
Eleocharis rostellata Torr.	*Scirpus validus* Vahl
Erianthus giganteus (Walt.)Muhl.	*Thelypteris palustris* L.
Hibiscus spp	*Typha* spp
Hydrocotyle spp	*Vigna luteola* (Jacq.) Benth.

Table B.4. Summary of vegetation, substrate, and hydrology for Victor Bayou (site 2).

Parameter	Value	Units
Location	West Terrebonne Basin, South Station	
Vegetation		
Dominant species	*Panicum hemitomon/Sagittaria lancifolia*	
Species richness[1]	22	
Aboveground live biomass	980±218	$g \cdot m^{-2}$
Belowground live biomass	2614±803	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	47±5[2]	%
Bulk density	0.106±0.003[2]	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[3]	0.87	
Connectivity[4]	0.26	
Tidal amplitude (open water)	30	cm
Total amplitude (open water)	90	cm
Total amplitude (marsh mat)	30	cm

[1]Number of species observed at the site.

[2]Percentage organic matter is lower and bulk density is higher than previously reported for this site. This is probably due to the fact that samples were taken too close to the spoilbank.

[3]Slope between marsh water and marsh mat.

[4]Correlation between marsh water and open water.

Site 3. North ICWW

North ICWW is a thin mat site dominated by *E. baldwinii* in the spring. The mat almost supported the weight of a person in the fall, and *E. baldwinii* was present in very small quantities. In the fall, the mat consisted of patches dominated by *Scirpus cubensis*, and other patches with *Sagittaria latifolia* and *Cyperus odoratus* as co-dominants. This site had the highest species diversity of the three thin mat sites (North ICWW; Gallinule Canal, site 1; and Cypress Canal A, site 8a). Aboveground biomass at this site was significantly higher than at the other *E. baldwinii* dominated sites.

The mat was resting on a fluid ooze. Many thick white roots were suspended under the mat within this ooze. This mat was similar in thickness, percentage organic matter, and bulk density to the mat at Gallinule Canal (site 1).

This mat had the lowest buoyancy of the three *E. baldwinii* sites, but remained floating throughout the study period. North ICWW had a high correlation between marsh water and open water, indicating is hydrological connected to the open water. Tidal influence at this site was small.

Table B.5. Species found at North ICWW (site 3)

Alternanthera philoxeroides (Mart.) Griseb.	*Limnobium spongia* (Bosc.) Steud.
Bidens laevis (L.) BSP.	*Ludwigia leptocarpa* (Nutt.) Hara
Cyperus odoratus L.	*Phyla lanceolata* (Michx.) Greene
Eichhornia crassipes (Mart.) Solms	*Polygonum punctatum* Ell.
Eleocharis albida Torr.	*Sacciolepis striata* (L.) Nash
Eleocharis baldwinii (Torr.) Chapman.	*Sagittaria lancifolia* L.
Fuirena pumila (Torr.) Spreng.	*Sagittaria latifolia* Willd.
Hydrocotyle spp	*Scirpus cubensis* Poepp.
Leersia oryzoides (L.) Sw.	

Table B.6. Summary of vegetation, substrate, and hydrology for North ICWW (site 3).

Parameter	Value	Units
Location	East Terrebonne Basin, North Station	
Vegetation		
Dominant species	*Eleocharis baldwinii*	
Species richness[1]	16	
Aboveground live biomass	646±76	$g \cdot m^{-2}$
Belowground live biomass	339±63	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	85±1	%
Bulk density	0.029±0.001	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	0.51	
Connectivity[3]	0.94	
Tidal amplitude (open water)	10	cm
Total amplitude (open water)	45	cm
Total amplitude (marsh mat)	45	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 4. Bayou Penchant

This site is a highly diverse marsh dominated by *P. hemitomon*. All *P. hemitomon* dominated sites (Bayou Penchant; VD Canal, site 5; Lake Boeuf, site 6; and Huth Canal, site 9) had similar aboveground and belowground biomass. And there were no significant differences in bulk density and percentage organic matter of the substrate.

This site was floating in the summer and fall. The mat was solid, but had several holes through which the free water under the mat could be observed. We observed that the vegetation on the spoil bank on the edge of this marsh was also dominated by *P. hemitomon* but was much less diverse and definetly not floating. Cores in the spoil bank area showed extremely high clay content. During one early summer visit, there was aproximately 30 cm of water above the substrate on the spoil bank, when we reached the floating marsh the substrate showed a drastic incline, and the top of the mat was dry.

Table B.7. Species found at Bayou Penchant (site 4)

Boehmeria cylindrica (L.) Sw.	*Myrica cerifera* L.
Conoclinium coelestinum (L.) DC.	*Panicum hemitomon* Schult.
Cyperus odoratus L.	*Polygonum punctatum* Ell.
Eleocharis rostellata Torr.	*Sacciolepis striata* (L.) Nash
Fuirena pumila (Torr.) Spreng.	*Sagittaria lancifolia* L.
Hydrocotyle spp	*Saururus cernuus* L.
Kosteletzkya virginica (L.) Presl.	*Triadenum virginicum* (L.) Raf.
Leersia oryzoides (L.) Sw.	*Vigna luteola* (Jacq.) Benth.

Table B.8. Summary of vegetation, substrate, and hydrology for Bayou Penchant (site 4).

Parameter	Value	Units
Location	West Terrebonne Basin, Middle Station	
Vegetation		
Dominant species	*Panicum hemitomon*	
Species richness[1]	17	
Aboveground live biomass	755±138	$g \cdot m^{-2}$
Belowground live biomass	3295±655	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	91±1	%
Bulk density	0.051±0.003	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	0.80	
Connectivity[3]	0.76	
Tidal amplitude (open water)	10	cm
Total amplitude (open water)	25	cm
Total amplitude (marsh mat)	25	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 5. VD Canal

This site is a low diversity marsh dominated by *P. hemitomon*. Other species observed at this site included *Leersia oryzoides*, *Eleocharis rostellata*, and *Sagittaria lancifolia*.

The substrate at this site was very similar to the substrate at other *P. hemitomon* dominated sites (VD Canal; Bayou Penchant, site 4; Lake Boeuf, site 6; and Huth Canal, site 9), with high percentage organic matter and low bulk density.

This site was mostly a solid marsh with patches where clumps of vegetation were surrounded by ooze. Patches felt like they might be floating, while in the rest of the marsh the mat felt very solid. The measured marsh mat moved very little (<5 cm), while both marsh and open water moved 40 cm. There was no correlation between marsh mat and marsh water. However, cores revealed fluid ooze below 25–30 cm of densely rooted mat. It was extremely difficult to obtain a sample of this ooze. Marsh water was hydrologically connected to open water and tidal influence was minimal.

Table B.9. Species found at VD canal (site 5)

Cyperus polystachyos Rottb.
Eleocharis rostellata Torr.
Hydrocotyle spp
Leersia oryzoides (L.) Sw.
Panicum hemitomon Schult.
Sagittaria lancifolia L.

Table B.10. Summary of vegetation, substrate, and hydrology for VD Canal (site 5).

Parameter	Value	Units
Location	East Barataria Basin, North Station	
Vegetation		
Dominant species	*Panicum hemitomon*	
Species richness[1]	6	
Aboveground live biomass	964±199	$g \cdot m^{-2}$
Belowground live biomass	2417±428	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	85±1	%
Bulk density	0.049±0.003	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	nd[3]	
Connectivity[4]	0.77	
Tidal amplitude (open water)	<5	cm
Total amplitude (open water)	45	cm
Total amplitude (marsh mat)	5	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]not determined due to marsh mat sensor failure

[3]Correlation between marsh water and open water.

Site 6. Lake Boeuf

This site is the most diverse of all our gauge sites. This site is different from the other *P. hemitomon* sites due to the presence of *Polygonum sagittatum*, *Cyperus* spp, *Aster* spp., *Solidago sempervirens*, *Decodon verticillatus*, and *Sagittaria latifolia*. This site is a solid marsh, that is homogeneous in appearence other than patches dominated by *Myrica cerifera*.

The mat is thick and floats on a layer of free water. Bulk density and percentage organic matter are similar to the other *P. hemitomon* dominated sites.

This marsh is highly buoyant and is hydrologically connected to the open water. There is minimal tidal influence at this site.

Table B.11. Species found at Lake Boeuf (site 6)

Andropogon virginicus L.	*Lobelia cardinalis* L.
Aster spp	*Ludwigia leptocarpa* (Nutt.) Hara
Conoclinium coelestinum (L.) DC.	*Myrica cerifera* L.
Cyperus polystachyos Rottb.	*Panicum hemitomon* Schult.
Cyperus spp	*Polygonum punctatum* Ell.
Decodon verticillatus (L.) Ell.	*Polygonum sagittatum* L.
Eleocharis rostellata Torr.	*Sacciolepis striata* (L.) Nash
Eleocharis parvula (R. & S.) Link	*Sagittaria latifolia* Willd.
Galium tinctorium L.	*Solidago sempervirens* L.
Hydrocotyle spp	*Thelypteris palustris* L.
Juncus spp.	*Triadenum virginicum* (L.) Raf.
Kosteletzkya virginica (L.) Presl.	*Vigna luteola* (Jacq.) Benth.
Leersia oryzoides (L.) Sw.	

Table B.12. Summary of vegetation, substrate, and hydrology for Lake Boeuf (site 6).

Parameter	Value	Units
Location	West Barataria Basin, North Station	
Vegetation		
Dominant species	*Panicum hemitomon*	
Species richness[1]	24	
Aboveground live biomass	898±118	$g \cdot m^{-2}$
Belowground live biomass	2992±1301	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	89±2	%
Bulk density	0.050±0.007	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	0.90	
Connectivity[3]	0.99	
Tidal amplitude (open water)	<5	cm
Total amplitude (open water)	55	cm
Total amplitude (marsh mat)	50	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 7. Company Canal

Company Canal is very homogeneous. This site has the lowest species diversity of the three *P. hemitomon/S. lancifolia* sites (Company Canal; Victor Bayou, site 2; and Delta Farms, site 10). In addition to the dominants, *Leersia oryzoides* and *Eleocharis rostellata* were observed in all vegetation samples. The species composition at this site is similar to the species composition at VD Canal (site 5). However, this site was dominated by *S. lancifolia* in the spring, while VD Canal was dominated by *P. hemitomon* throughout the year.

Cores showed that the substrate contained some clay, and was similar to Victor Bayou (site 2) with high bulk density and low percent organic matter.

The mat was very solid and did not seem to be floating during our fall visit. This was confirmed by the hydrology data. Although there was a significant correlation between marsh water and marsh mat, the slope of the regression was very low (slope=0.13). The marsh mat only moved 5 cm while both marsh and open water moved 45 cm. This site was hydrologically conected to open water.

Table B.13. Species found at Company Canal (site 7)

Alternanthera philoxeroides (Mart.) Griseb.	*Panicum hemitomon* Schult.
Aster tenuifolius L.	*Phyla lanceolata* (Michx.) Greene
Cyperus spp	*Polygonum punctatum* Ell.
Eleocharis rostellata Torr.	*Sacciolepis striata* (L.) Nash
Hydrocotyle spp	*Sagittaria lancifolia* L.
Leersia oryzoides (L.) Sw.	*Vigna luteola* (Jacq.) Benth.
Mikania scandens (L.) Willd.	

Table B.14. Summary of vegetation, substrate, and hydrology for Company Canal (site 7).

Parameter	Value	Units
Location	West Barataria Basin, Middle Station	
Vegetation		
Dominant species	*Panicum hemitomon/Sagittaria lancifolia*	
Species richness[1]	13	
Aboveground live biomass	587±49	$g \cdot m^{-2}$
Belowground live biomass	893±182	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	48±3	%
Bulk density	0.110±0.005	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	0.13	
Connectivity[3]	0.91	
Tidal amplitude (open water)	10	cm
Total amplitude (open water)	50	cm
Total amplitude (marsh mat)	5	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 8b. Cypress Canal B

Cypress Canal B is located on Cypress Canal aproximately one mile east of Cypress Canal A (site 8a) yet in a very different habitat. Cypress Canal B was the only site dominated in the spring by *Sagittaria lancifolia*, that was not dominated by *P. hemitomon* in the fall. Instead, *S. lancifolia* remained dominant and *Sacciolepis striata* became co-dominant in the fall. Otherwise species composition was similar to that of the *P. hemitomon/S. lancifolia* sites. This site consisted of very solid marsh with patches that seemed to be floating. However, no difference in species composition between floating and solid areas were observed.

The substrate at this site had a high percentage of organic matter and low bulk density. Cores revealed a fluid ooze underneath the thick marsh mat.

This marsh was not buoyant and seemed to be impounded. The marsh mat moved <5 cm while the marsh and open water moved 70 cm. Marsh water tracks open water only at the higher water levels. There was a slight tidal component to the open water signal.

Table B.17. Species found at Cypress Canal B (site 8b)

Alternanthera philoxeroides (Mart.) Griseb.	*Galium tinctorium* L.
Aster tenuifolius L.	*Hydrocotyle* spp
Bidens laevis (L.) BSP.	*Leersia oryzoides* (L.) Sw.
Cyperus odoratus L.	*Phyla lanceolata* (Michx.) Greene
Cyperus polystachyos Rottb.	*Polygonum punctatum* Ell.
Eleocharis baldwinii (Torr.) Chapman.	*Sacciolepis striata* (L.) Nash
Eleocharis rostellata Torr.	*Sagittaria lancifolia* L.

Table B.18. Summary of vegetation, substrate, and hydrology for Cypress Canal B (site 8b).

Parameter	Value	Units
Location	East Barataria Basin, North Station	
Vegetation		
Dominant species	*Sagittaria lancifolia*	
Species richness[1]	14	
Aboveground live biomass	635±58	g•m^{-2}
Belowground live biomass	1678±319	g•m^{-2}
Substrate		
Percentage organic matter	91±1	%
Bulk density	0.047±0.001	g•cm^{-3}
Hydrology		
Buoyancy[2]	0.05	
Connectivity[3]	0.38	
Tidal amplitude (open water)	10	cm
Total amplitude (open water)	70	cm
Total amplitude (marsh mat)	<5	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 9. Huth Canal

This site is located on a small unnamed bayou connecting Huth Canal to Lake Penchant. Huth Canal is similar in species composition to Bayou Penchant (site 4), and Lake Boeuf (site 6). However, this highly diverse *P. hemitomon* dominated marsh is restricted to the natural levee of the small unnamed bayou. Vegetation diversity seems to decrease and the mat becomes extremely clumpy, although still dominated by *P. hemitomon* away from this bayou. The gauge is located in the highly diverse area, and we restricted our vegetation sampling to this area.

The substrate in this area contained a very dense root mat and was similar in percentage organic matter and bulk density to the other three *P. hemitomon* dominated sites (Bayou Penchant, site 4; VD Canal, site 5; and Lake Boeuf, site 6).

This marsh is floating and is hydrologically connected to the open water. Mat movement over the time of the study was 40 cm and the slope between marsh water and marsh mat was close to 1. Tidal influence at this site was fairly small.

Table B.19. Species found at Huth Canal (site 9)

Andropogon virginicus L.	*Leersia oryzoides* (L.) Sw.
Aster spp	*Ludwigia leptocarpa* (Nutt.) Hara
Boehmeria cylindrica (L.) Sw.	*Panicum hemitomon* Schult.
Conoclinium coelestinum (L.) DC.	*Phragmites australis* (Cav.) Trin. ex Steud.
Cyperus odoratus L.	*Sacciolepis striata* (L.) Nash
Cyperus polystachyos Rottb.	*Saururus cernuus* L.
Eleocharis rostellata Torr.	*Thelypteris palustris* L.
Hydrocotyle spp	*Triadenum virginicum* (L.) Raf.
Ipomoea sagittata Poir. in Lam.	*Typha* spp
Kosteletzkya virginica (L.) Presl.	*Zizania aquatica* L.

Table B.20. Summary of vegetation, substrate, and hydrology for Huth Canal (site 9).

Parameter	Value	Units
Location	East Terrebonne Basin, Middle Station	
Vegetation		
Dominant species	*Panicum hemitomon*	
Species richness[1]	20	
Aboveground live biomass	1067±174	$g \cdot m^{-2}$
Belowground live biomass	4770±626	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	79±2	%
Bulk density	0.056±0.003	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	0.88	
Connectivity[3]	0.82	
Tidal amplitude (open water)	5	cm
Total amplitude (open water)	50	cm
Total amplitude (marsh mat)	40	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.

Site 10. Delta Farms

This site was different from the other two *P. hemitomon/S. lancifolia* sites (Victor Bayou, site 2: and Company Canal, site 7), because it contained *Dichromena colorata, Eleocharis cellulosa,* and *E. baldwinii.* Delta Farms was not accessible by boat during our fall sampling, due to massive accumilation of water hyacinth (*Eichornia crassipes*) in the waterways. Therefore, no samples were taken to estimate belowground biomass.

Cores for bulk density and organic matter determinations were taken during a summer visit to the site. Bulk density of this substrate was significantly lower than at the other *P. hemitomon/S. lancifolia* sites, while percentage organic matter was significantly higher then at the other *P. hemitomon/S. lancifolia* sites.

The marsh mat gauge failed at this site and therefore buoyancy could not be determined. The low correlation between marsh water and open water seems to be caused by a slower drainage of the marsh compared with the open water.

Table B.21. Species found at Delta Farms (site 10)

Cladium jamaicense Grantz	*Erianthus giganteus* (Walt.)Muhl.
Cyperus polystachyos Rotth.	*Hydrocotyle* spp
Cyperus spp	*Juncus marginatus* Rostk.
Dichromena colorata (L.) Hitchc.	*Leersia oryzoides* (L.) Sw.
Eleocharis albida Torr.	*Panicum hemitomon* Schult.
Eleocharis baldwinii (Torr.) Chapman.	*Polygonum punctatum* Ell.
Eleocharis cellulosa Torr.	*Sagittaria lancifolia* L.
Eleocharis rostellata Torr.	*Typha* spp
Eleocharis parvula (R. & S.) Link	

Table B.22. Summary of vegetation, substrate, and hydrology for Delta Farms (site 10).

Parameter	Value	Units
Location	East Barataria Basin, South Station	
Vegetation		
Dominant species	*Panicum hemitomon/Sagittaria lancifolia*	
Species richness[1]	15	
Aboveground live biomass	527±40	$g \cdot m^{-2}$
Belowground live biomass	undetermined	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	91±1	%
Bulk density	0.047±0.003	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	nd[3]	
Connectivity[4]	0.37	
Tidal amplitude (open water)	15	cm
Total amplitude (open water)	50	cm
Total amplitude (marsh mat)	nd[3]	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]not determined due to failure of the marsh mat sensor

[4]Correlation between marsh water and open water.

Site 12. Bayou de la Gauche

Although this site had many species in common with the Little Carencro Bayou (site 11) site, this site was much more homogeneous. Bayou de la Gauche (site 12) was different in vegetation composition from Little Carencro Bayou (site 11) due to the presence of *Sagittaria lancifolia* and *Eleocharis rostellata*., and the more homogeneous distribution of all species.

The 20–25 cm thick mat rested on an organic ooze with some clay in it. Percentage organic matter and bulk density are similar to those found at the other *S. patens* dominated site (Little Carencro Bayou, site 11).

This site seemed to be floating, however the slope of the regression between marsh mat and marsh water was low (slope=0.28). The marsh mat moved only 15 cm, while the marsh water moved 80 cm. There is ample tidal influence at this site, however subtidal (several day) fluctuation appear to be the major contributor to the water level signal.

Table B.25. Species found at Bayou de la Gauche (site 12)

Amaranthus australis (Gray) Sauer	*Kosteletzkya virginica* (L.) Presl.
Andropogon virginicus L.	*Phyla lanceolata* (Michx.) Greene
Aster tenuifolius L.	*Polygonum punctatum* Ell.
Cyperus polystachyos Rottb.	*Sacciolepis striata* (L.) Nash
Distichlis spicata (L.) Greene	*Sagittaria lancifolia* L.
Echinochloa crusgalli (L.) Beauv.	*Scirpus olneyi* Gray
Eleocharis cellulosa Torr.	*Setaria geniculata* (Lam.) Beauv.
Eleocharis rostellata Torr.	*Solidago sempervirens* L.
Galium tinctorium L.	*Spartina patens* (Ait.) Muhl.
Hydrocotyle spp	*Vigna luteola* (Jacq.) Benth.

Table B.26. Summary of vegetation, substrate, and hydrology for Bayou de la Gauche (site 12).

Parameter	Value	Units
Location	West Barataria Basin, South Station	
Vegetation		
Dominant species	*Spartina patens*	
Species richness[1]	20	
Aboveground live biomass	1091±257	$g \cdot m^{-2}$
Belowground live biomass	1231±258	$g \cdot m^{-2}$
Substrate		
Percentage organic matter	60±4	%
Bulk density	0.068±0.003	$g \cdot cm^{-3}$
Hydrology		
Buoyancy[2]	0.28	
Connectivity[3]	0.59	
Tidal amplitude (open water)	25	cm
Total amplitude (open water)	60	cm
Total amplitude (marsh mat)	20	cm

[1]Number of species observed at the site.

[2]Slope between marsh water and marsh mat.

[3]Correlation between marsh water and open water.