Mon Louis Island Restoration
2020 Marsh Monitoring

Prepared for

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1.0 INTRODUCTION

The Mobile Bay National Estuary Program funded the project entitled “Mon Louis Island Restoration 2020 Marsh Monitoring” though a grant provided by the National Fish and Wildlife Gulf Environmental Benefit Fund, to restore the erosion-impacted northern tip of Mon Louis Island. The project is located at the mouth of East Fowl River, on the western shore of Mobile Bay, Alabama (Figure 1).

The restoration project began in July 2016, and included restoration and armoring of the receding shoreline, placement of dredged material to re-create eroded land, and creation of 4.8 acres of tidal marsh habitat. A 1,400-foot continuous rock breakwater was constructed roughly along the 1995 footprint of the island, completed in early September 2016. Sandy material was hydraulically pumped from the Fowl River Open Water Disposal Area in Mobile Bay to provide a suitable substrate for marsh creation. A channel was then created to provide tidal inundation into the site.

The restored marsh was initially prepared in March-April 2017 by planting nursery-grown stock of smooth cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*Spartina patens*), and black needlerush (*Juncus roemerianus*). Barry A. Vittor & Associates, Inc. conducted a qualitative survey of the restoration site in July 2017 and found that some areas of the site had suffered high transplant mortality, particularly the black needlerush. Additional transplants were obtained and installed. Based on an inspection of the re-planted areas in mid-September 2017, it was concluded that the planting was satisfactorily completed.

Thompson Engineering, Inc. sub-contracted Barry A. Vittor & Associates, Inc. to perform environmental monitoring of the Mon Louis Island restoration. The initial monitoring was performed in September 2018. This report provides Summer 2020 environmental survey data for Year 3 of the monitoring program.

2.0 METHODS

2.1 Sampling Plan

Sampling station locations are shown in Figure 1. The reference marsh is located on the north side of the mouth of East Fowl River, approximately 600 ft from the Mon Louis Island project site. Table 2-1 summarizes the number and types of samples collected during the 2020 survey.

Table 2-1. Number and type of samples collected at the Mon Louis Island restoration site and reference marsh, June 2020.

Site (No. Stations)	Vegetation Quadrat	Nekton Lift Nets	Macroinfauna Hand cores	Epifauna Quadrats	Sediment Texture/ TOC
Mon Louis Island (4)	N = 120	N = 12	N = 12	N = 12	N = 4
Reference (2)	--	N = 6	N = 6	N = 6	N = 2

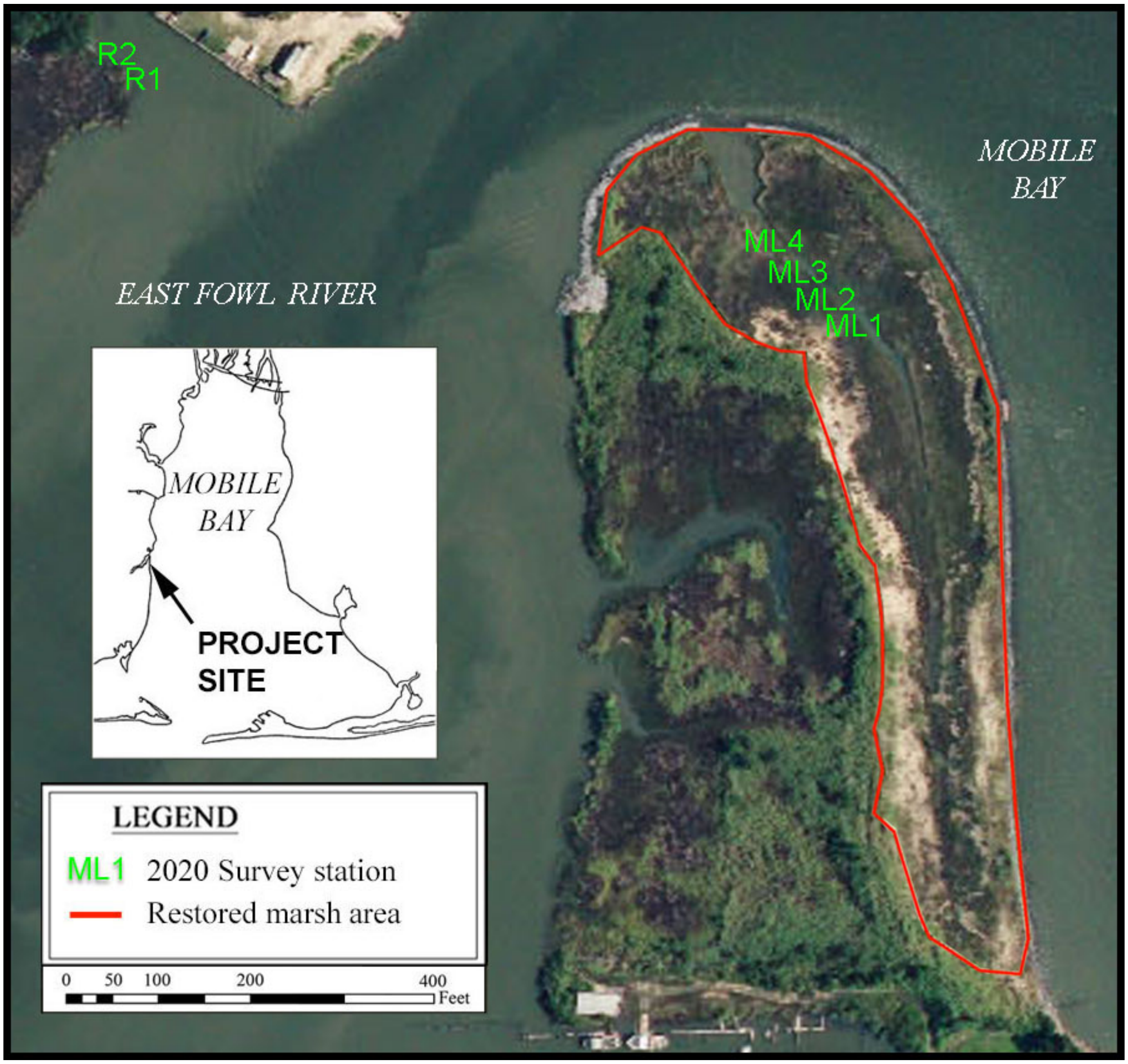

Figure 1. Location of the Mon Louis Island restoration project and faunal sampling stations.

2.2 Vegetation Coverage

Vegetation transects and quadrat locations are presented in Figure A-1 (Appendix A). Vegetation metrics were collected within standard 1-m^2 quadrats along 17 transects. The quadrat data collected included percent cover of individual species, average height of the vegetation, and an estimate of overall vegetative cover of vegetation. Typically, quadrat data were collected at the beginning of each transect and then approximately every 5 meters.

2.3 HGM Model Assessment

A detailed hydrogeomorphic (HGM) model methodology is presented in Appendix A. The HGM model is a collection of concepts and methods that uses mathematically derived indices to assess the capacity of wetlands to perform specific ecological, geochemical, and hydrological functions, in comparison to similar wetlands within the Mississippi/Alabama coast reference domain (Schafer et al., 2007). When an HGM model variable is within the range of conditions observed in reference standard wetlands a variable sub-index value of 1.0 is assigned. As the condition deviates from reference standards, the variable sub-index is assigned based on the observed relationship between model variable condition and functional capacity (on a scale of 0.0 to 1.0). HGM assessment metrics were measured in the field on June 10.

2.4 Nekton

A bottomless nylon lift net (6-m^2 area) was installed on the vegetated marsh surface at each survey station to sample nekton during tidal inundation. Lift nets were raised near high tide, and trapped nekton collected with dip nets. Lift net samples were collected June 3, 4, and 5.

Lift net contents were fixed in the field with 10% formalin, and subsequently washed and transferred to containers with 70% isopropanol. Nekton were identified to lowest practical identifiable level (LPIL) and counted. The number of individuals and number of taxa are reported for each station in Appendix B. Univariate summary statistics including number of taxa, number of individuals, density, Shannon's index of diversity (H') and Pielou's index of evenness (J') were calculated for each station.

Spatial patterns in the lift net data were examined using multivariate cluster analysis. The cluster analysis was performed on a similarity matrix constructed from a raw abundance data matrix consisting of taxa and samples. To weight the contributions of common and rare taxa, raw counts of each individual taxon in a sample (n) were transformed to logarithms [$\log_{10}(n+1)$] prior to similarity analysis. The similarity matrix was generated using the Bray-Curtis similarity index (Bray and Curtis, 1957). Species accounting for the observed nekton assemblage differences among sample groups and within sample groups were identified using SIMPER procedure. SIMPER determines the average contribution of each taxon to characterizing a sample group or discriminating between pairs of sample groups resolved by cluster analysis. These analyses (cluster analysis, SIMPER) were performed using PRIMER v6 package (Clarke and Gorely, 2006).

2.5 Macroinfauna

Three replicate samples for macroinfauna were collected at each station using a 4-inch diameter hand core (0.0079 m^2), concurrent with lift net sampling. Sample contents were fixed in 10% formalin in the field. In the laboratory, samples were washed through a 0.5-mm sieve and transferred to containers with 70% isopropanol with rose Bengal stain. Macroinfauna were identified and counted to the LPIL and counted. The number of individuals in each taxon is reported for each station (Appendix C). Macroinfaunal data are reported and analyzed using the univariate and multivariate methods described in Section 2.4.

In additions to hand core samples, three replicate 0.25-m^2 quadrats were assessed at each station to qualitatively document epibenthic macrofauna such as epibenthic snails not readily sampled with the hand core. Quadrats were haphazardly placed with blind, over-the-shoulder tosses. Quadrat data are reported in Appendix C.

2.6 Sediment Texture and Total Organic Carbon

One sediment sample (about 250 grams) for grain size analysis and percent total organic carbon (TOC) was collected with the hand core at each station, and stored on ice. Grain size analysis was conducted using combined sieve and hydrometer methods according to recommended American Society for Testing Materials (ASTM) procedures. Samples were washed in demineralized water, dried, and weighed. Coarse and fine fractions (sand/silt) were separated by sieving through a U.S. Standard Sieve Mesh No. 230 (62.5 μm). Sediment texture of the coarse fraction was determined at 0.5-phi intervals by passing sediment through nested sieves. Weight of materials collected in each particle size class was recorded. Boyocouse hydrometer analyses were used to analyze the fine fraction (<62.5 μm). Percentages of gravel, sand, silt, and clay were recorded for each sample.

TOC was measured using an EA 1112 Analyzer. For each sample, a silver sample capsule was tared on a microbalance, which was interfaced to the analyzer. Approximately 15-20mg of sample sediment was placed in the capsule and its weight recorded to 0.001 mg. Approximately 10 μl of concentrated nitric acid was added to the capsule and the sample was placed on a hot plate overnight at 80º C. The following day an additional 10 μl of concentrated nitric acid was added to the capsule and the sample was placed on a hot plate for at least one hour at 80º C, and then closed. A blank capsule was prepared for reference. Two standards of aspartic acid were weighed, and the sample and blank capsules were combusted with the chromatograph manually integrated to relate the instrument response to TOC concentration. After calibration, the percent carbon remaining in the sample was determined. Check standards and reference material were analyzed for quality control.

3.0 RESULTS

3.1 Vegetation Survey and HGM Model Analysis

A phylogenetic list of plant species and their percent cover in survey quadrats are presented in Appendix A. A total of 24 vascular plant species were identified. Vegetated coverage by all species was 53.0%, with native herbaceous cover at 49.3%. Smooth cordgrass (*Spartina alterniflora*) comprised an 27.0% of the vegetative over and occurred in 76% of the quadrats (Table 3-1). Salt meadow cordgrass (*Spartina patens*) was 12.8% of the coverage and occurred in 40% of the quadrats. Black needlerush (*Juncus roemerianus*) averaged 2.6% cover and was present in 21% of the sampled quadrats.

Table 3-1. Plant species with at least 0.4% average cover. († = exotic/invasive)		
Species	Average % Cover	No. of Quadrats (% of total)
Spartina alterniflora	27.0	76 (63)
Spartina patens	12.8	40 (33)
Bolboschoenus robustus	2.8	27 (23)
Juncus roemerianus	2.6	21 (18)
Phragmites mauritianus †	2.2	18 (15)
Distichlis spicata	1.6	7 (6)
Schoenoplectus pungens	1.1	7 (6)
Panicum repens †	0.8	14 (12)
Baccharis halimifolia	0.6	10 (8)
Paspalum vaginatum	0.4	4 (3)
Solidago mexicana	0.4	11 (9)

Table 3-2 lists individual and average Functional Capacity Index (FCI) scores for the five ecosystem functions evaluated in the HGM model assessment for 2018 through 2020. Except for Nekton Utilization Potential, which remained consistent since the 2018 assessment, FCI scores decreased from 2019 to 2020 due primarily to lower vegetative coverage. Year 1 monitoring in 2018 had a low score (0.20) for Plant Community Composition / Structure, and the site received an improved value of 0.60 in 2019, but decreased to 0.40 in 2020.

Table 3-2. Functional Capacity Index (FCI) scores for ecosystem functions evaluated by the tidal marsh HGM model.			
HGM Function	2018 FCI	2019 FCI	2020 FCI
Wave Energy Attenuation	0.62	0.67	0.65
Biogeochemical Cycling	0.53	0.77	0.67
Nekton Utilization Potential	0.92	0.92	0.92
Habitat for Tidal Marsh Dependent Wildlife	0.72	0.80	0.76
Plant Community Composition / Structure	0.20	0.60	0.40
	Ave. 0.60	Ave. 0.75	Ave. 0.68

The FCI score for Nekton Utilization potential (0.92) is the highest of the five functions, due to the extent of aquatic edge along the tidal creek, and a V_{HYDRO} value (0.75) indicating adequate site accessibility for nekton during high tides. The average of the five FCI scores decreased to 0.68 in 2020 from 0.75 in 2019.

3.2 Nekton

A phylogenetic list of nekton collected in lift nets and the station taxa counts are presented in Appendix B. Table 3-3 presents lift net community statistics. Lift nets at Stations ML3 and ML4 yielded 11 total taxa, with both stations averaging 6 taxa per sample, followed by ML2 and R2 (8 taxa each), averaging 5.0 and 5.7 taxa/sample, respectively. Stations ML1 and R1 each yielded 5 taxa total, and 3.7 and 4.3 taxa/sample, respectively.

Table 3-3. Nekton community statistics based on lift net contents at Mon Louis Island (ML) and reference (R) survey stations.

Station	Total Number of Taxa	Mean Number of Taxa (Std. Dev.)	Mean Density (Individuals/m^2) (Std. Dev.)	Shannon Diversity (H')	Pielou Evenness (J')
ML1	5	3.7 (1.2)	21.5 (17.3)	0.31	0.19
ML2	8	5.0 (0.0)	7.3 (5.2)	0.68	0.33
ML3	11	6.0 (1.7)	7.9 (4.7)	0.78	0.33
ML4	11	6.0 (2.6)	19.9 (9.5)	0.61	0.25
R1	5	4.3 (0.6)	2.8 (0.5)	1.33	0.82
R2	8	5.7 (0.6)	5.8 (1.5)	1.25	0.60

Mean nekton densities per were greatest at Stations ML1 (21.5 individuals/m^2) and ML4 (19.9), while Station R1 had the lowest mean density (2.8). Diversity ranged from 1.33 at R1 to 0.31 at ML1. Taxa evenness, a measure of the distribution of abundance among the sampled taxa, ranged from 0.82 at R1 to 0.19 at ML1.

Table 3-4 lists the most abundant taxa collected in lift nets. Grass shrimp (*Palaemonetes*) and blue crabs (*Callinectes sapidus*) were collected at all six stations. Grass shrimp were numerically dominant at all stations (Appendix Table B-2). Killifish (*Fundulus* [LPIL]), mullet (*Mugil* [LPIL]), and silverside (*Menidia beryllina*) were collected only at ML stations, whereas pipefish (*Syngnathus* [LPIL]), bay anchovy (*Anchoa mitchilli*), and brown shrimp (*Farfantepenaeus aztecus*) were collected only at R1 and R2.

Table 3-4. Most abundant nekton collected in lift nets at Mon Louis Island (ML) and reference (R) survey stations.

Taxonomic Name	Total Count	Station Occurrence
Palaemonetes (LPIL)	993	ML1 ML2 ML3 ML4 R1 R2
Callinectes sapidus	60	ML1 ML2 ML3 ML4 R1 R2
Fundulus (LPIL)	41	ML1 ML2 ML3 ML4
Menidia beryllina	14	ML2 ML3 R2
Syngnathus (LPIL)	13	R1 R2
Anchoa mitchilli	10	R1 R2
Farfantepenaeus aztecus	10	R1 R2
Mugil (LPIL)	9	ML1 ML2 ML3 ML4

The SIMPER procedure identified the taxa accounting for the observed assemblage differences within and among the sample groups identified by cluster analysis (Table 3-5). ML stations clustered at 74% average similarity, with relatively high abundances of grass shrimp and killifish. R stations grouped together at 69% similarity, due primarily to grass shrimp, blue crab, and pipefish.

Table 3-5. Average abundance of nekton taxa accounting for at least 50% of within group similarity in lift nets. Numbers in bold represent the overall similarity for each sample group.

Group	Stations	Taxonomic Name	Average Abundance	Average Similarity
A	ML1, ML2, ML3, ML4	*Palaemonetes* (LPIL)	4.20	41.22
		Fundulus (LPIL)	1.44	13.50
				74.11
B	R1, R2	*Palaemonetes* (LPIL)	2.66	27.24
		Callinectes sapidus	1.44	15.19
		Sygnathus (LPIL)	1.14	12.37
				69.11

3.3 Macroinfauna

A phylogenetic list of macroinfauna collected in hand cores and station taxa counts are presented in Appendix C. Table 3-6 presents macroinfauna community statistics. Stations ML4 and R1 each yielded 13 total taxa, with a sample mean of 7.0 and 10.0 taxa, respectively. Station ML3 yielded just 6 taxa, with a mean of 2.7 taxa per replicate.

Table 3-6. Macroinfaunal community statistics based on hand core contents at Mon Louis Island (ML) and reference (R) survey stations.

Station	Total Number of Taxa	Mean Number of Taxa (Std. Dev.)	Mean Density (Individuals/m^2) (Std. Dev.)	Shannon Diversity (H')	Pielou Evenness (J')
ML1	8	4.7 (1.2)	1,687.8 (1,015.3)	1.64	0.79
ML2	10	4.3 (0.6)	3,586.5 (2,668.3)	1.11	0.48
ML3	6	2.7 (1.0)	2,109.7 (2,300.6)	0.71	0.39
ML4	13	7.0 (2.1)	2,067.5 (889.1)	1.92	0.75
R1	13	10.0 (1.0)	8,945.1 (3,875.4)	1.73	0.67
R2	11	6.3 (2.5)	5,063.3 (438.5)	1.31	0.55

Mean density was greatest at R1 (8,945.1 individuals/m^2), while ML1 had the lowest mean density (1,687.8 individuals/m^2). Diversity ranged from 1.92 at ML4 to 0.71 at ML3. Taxa evenness ranged from 0.79 at ML1 to 0.39 at ML3.

Table 3-7 lists the most abundant macroinfauna collected. Unidentified oliochaetes (Naididae) were collected at all six stations. The polychaetes *Laeonereis culveri* and *Capitella capitata* and snail *Neritina usnea* were collected from both ML stations and R stations. The polychaetes *Hobsonia florida*, *Polydora cornuta*, and *Streblospio benedicti* were collected both R stations, but not at the ML stations (Table 3-7).

Table 3-7. Most abundant macroinfauna collected in hand cores at Mon Louis Island (ML) and reference (R) survey stations.

Taxonomic Name	Total Count	Station Occurrence
Naididae (LPIL)	174	ML1 ML2 ML3 ML4 R1 R2
Laeonereis culveri	123	ML1 ML2 ML4 R1 R2
Hargeria rapax	103	R1 R2
Capitella capitata	30	ML1 ML2 ML3 R1
Hobsonia florida	15	R1 R2
Polydora cornuta	15	R1 R2
Streblospio benedicti	14	R1 R2
Uca pugnax	11	ML2 ML3 ML4
Neritina usnea	9	ML2 ML4 R1 R2

Taxa accounting for the observed assemblage differences within and among the sample groups identified by cluster analysis are in Table 3-8. Reference stations (Group A) clustered at 62% similarity and had relatively high abundances of polychaetes *L. culveri*, *S. benedicti* and *H. florida* and naidid oligochaetes. Group B included the ML stations, which differed from Group A due to more abundant naidid oligochaetes and *C. capitata*. Group B stations clustered at just 47% similarity, due in part to relatively lower abundances of *L. culveri* at ML2 and ML3 and greater numbers of *C. capitata* at ML1 and ML4. ML2 and ML3 had an assemblage similarity of 69%.

Table 3-8. Average abundance of macroinfauna accounting for at least 50% of within group similarity. Numbers in bold represent average similarity for each sample group.

Group	Stations	Taxonomic Name	Average Abundance	Average Similarity
A	R1, R2	*Laeonereis culveri*	2.90	18.01
		Naididae (LPIL)	2.06	13.23
		Streblospio benedicti	1.20	7.88
		Hobsonia florida	1.19	6.07
		Neritina usnea	0.69	4.97
				61.61
B	ML1, ML2, ML3, ML4	Naididae (LPIL)	2.31	27.90
		Capitella capitata	0.93	5.27
		Uca pugnax	0.56	4.02
		Laeonereis culveri	0.55	2.89
		Ceratopogonidae (LPIL)	0.27	2.26
		Dicrotendipes (LPIL)	0.22	1.96
				47.13

Quadrat data are presented in Appendix C. Consistent with the 2018 and 2019 surveys, Stations R1 and R2 had numerous marsh periwinkles (*Littorina irrorata*). Periwinkles have recruited into the restored marsh and were included in quadrat counts at the ML stations (Appendix C).

3.4 Sediment Texture and Total Organic Carbon

Table 3-9 presents sediment texture and percent total organic carbon (TOC) data. ML stations had varying amounts of mud and sand, while R stations had mud and muddy sand mixed with gravel. There was a lower percent TOC at the ML stations and R1 compared to R2.

Table 3-9. Sediment texture and % total organic carbon (TOC) at Mon Louis Island and reference survey stations.

Station	Sediment Texture			% TOC
	% Gravel	% Sand	%Fines	
ML1	0.7	76.1	23.2	0.666
ML2	0.5	85.7	13.8	0.226
ML3	0.4	86.7	12.9	0.263
ML4	0.2	61.3	38.5	0.652
R1	2.6	88.1	9.3	0.650
R2	11.4	58.1	30.5	3.10

4.0 CONCLUSIONS

The average cover of native tidal marsh species at Mon Louis Island decreased to 49.3% in 2020 from 54.2% in 2019. The between-survey difference is attributed to the random nature of sampling and the use of cover class midpoints as surrogates for actual cover, as per the HGM methodology. Largely because of the measured decrease in average cover, the HGM Functional Capacity Index average declined to 0.68 in 2020 from 0.75 in 2019.

Of the species originally planted, salt meadow cordgrass (*Spartina patens*) increased to 12.8% of the 2020 coverage compared to 9.2% in 2019, and occurred in 40% of the 2020 quadrats compared to 29% in 2019. Black needlerush (*Juncus roemerianus*) coverage was consistent across surveys, averaging 2.6% cover and present in 21% of the sampled quadrats in both 2020 and 2019. Average cover of smooth cordgrass (*Spartina alterniflora*) decreased to 27.0% in 2020 coverage from 36.4% in 2019, but was more widespread, occurring in 76% of the 2020 quadrats compared to 69% in 2019.

Of the native species that have recruited naturally into the restoration site, several continued to increase their average cover in 2020, including narrowleaf loosestrife (*Lythrum lineare*), saltgrass (*Distichlis spicata*), common threesquare (*Schoenoplectus pungens*), and sturdy bulrush (*Bolboschoenus robustus*).

Average cover of exotic invasive plants was 3.0% in 2020, compared to 2.4% in 2019. Common reed (*Phragmites mauritianus*) accounted for 2.2% of the 2020 coverage, double its cover of 1.1% in 2019. Another invasive species, torpedo grass (*Panicum repens*), had 0.8% average cover in 2020. Because the invasive coverage is less than 5%, the site receives a fully functional value for the HGM exotic species sub-variable.

The Mon Louis Island lift nets yielded higher densities of nekton than the reference site, mostly due to high numbers of grass shrimp. Between-site differences in abundance might have been due in part to vegetation density, which was relatively sparse at the reference station lift nets. The landscape position of the reference site, directly on the Fowl River shoreline rather than bordering a tidal creek, may also contribute to between-site differences in nekton assemblage composition.

The differences in macroinfaunal assemblages between the restored marsh and reference site, and among stations within the restored marsh, could be a result of multiple factors including landscape position, hydrologic regime, sediment characteristics, vegetation density, and the recent construction of the restored marsh. Macroinfaunal taxa collected from Mon Louis Island are common in northern Gulf estuaries (e.g., Subrahmanyam et al., 1976; Stout, 1984; Whaley and Minello, 2002).

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Appendix A – Vegetation Data and Hydrogeomorphic Model Analysis

Figure A-1. Vegetation transect and quadrat placement at Mon Louis Island, July 2019.

Plant Species List - June 2020 (**†** = non-native, invasive exotic**)**

Order	Family	Species and Common Name
Poales	Juncaceae	*Juncus roemerianus* - black needlerush
Poales	Cyperaceae	*Bolboschoenus robustus* - sturdy bulrush
Poales	Cyperaceae	*Cyperus rotundus* - purple nutgrass †
Poales	Cyperaceae	*Fimbristylis castanea* - marsh frimby
Poales	Cyperaceae	*Schoenoplectus pungens* - common three square
Poales	Poaceae	*Distichlis spicatum* -saltgrass
Poales	Poaceae	*Panicum repens* - torpedo grass †
Poales	Poaceae	*Paspalum vaginatum* - seashore paspalum
Poales	Poaceae	*Phragmites mauritianus* - mauritius reed †
Poales	Poaceae	*Imperata cylindrical* - cogongrass †
Poales	Poaceae	*Spartina alterniflora* - smooth cordgrass
Poales	Poaceae	*Spartina patens* - salt meadow cordgrass
Fabales	Fabaceae	*Strophostyles helvula* - trailing fuzzy bean
Myrtales	Lythraceae	*Lythrum lineare* - narrowleaf loosestrife
Caryophyllales	Amaranthaceae	*Alternanthera philoxeroides* - alligatorweed †
Gentianales	Gentianaceae	*Sabatia stellaris* - rose of Plymouth
Lamiales	Plantaginaceae	*Bacopa monnieri* - herb of grace
Asterales	Asteraceae	*Baccharis halimifolia* - eastern baccharis
Asterales	Asteraceae	*Solidago mexicana* - southern seaside goldenrod
Asterales	Asteraceae	*Symphyotrichum tenuifolium* - perennial salt marsh aster
Asterales	Asteraceae	*Erechtites hieraciifolius* - fireweed
Apiales	Araliaceae	*Hydrocotyle bonariensis* - large-leaf pennywort
Apiales	Apiaceae	*Centella erecta* - erect centella
Apiales	Apiaceae	*Ptilimnium capillaceum* - mock bishopweed

Average percent cover of plants in quadrats - June 2020

Species	Average Cover	No. of Quadrats	% Occurrence
Alternanthera philoxeriodes	< 0.1	1	0.8
Baccharis halimifolia	0.6	10	8.3
Bacopa monnieri	< 0.1	1	0.8
Bolboschoenus robustus	2.8	27	22.5
Centella erecta	< 0.1	1	0.8
Cyperus rotundus	< 0.1	1	0.8
Distichlis spicata	1.6	7	5.8
Erechtites hieraciifolius	< 0.1	1	0.8
Fimbristylis castanea	< 0.1	2	1.7
Hydrocotyle bonariensis	< 0.1	3	2.5
Imperata cylindrica	< 0.1	1	0.8
Juncus roemerianus	2.6	21	17.5
Lythrum lineare	0.2	4	3.3
Panicum repens	0.8	14	11.7
Paspalum vaginatum	0.4	4	3.3
Phragmites mauritianus	2.2	18	15.0
Ptilimnium capillaceum	< 0.1	2	1.7
Sabatia stellaris	0.1	6	5.0
Schoenoplectus pungens	1.1	7	5.8
Solidago mexicana	0.4	11	9.2
Spartina alterniflora	27	76	63.3
Spartina patens	12.8	40	33.3
Strophostyles helvula	< 0.1	1	0.8
Symphyotrichum tenuifolium	0.1	5	4.2

Hydrogeomorphic (HGM) Model Analysis

Background

The Hydrogeomorphic (HGM) Approach is a collection of concepts and methods that uses mathematically derived indices to assess the capacity of a wetland to perform specific ecological, geochemical, and hydrological functions in comparison to similar wetlands within a geographic region. The HGM approach was originally developed to be used within the framework of the Federal Section 404 regulatory program permit review process to evaluate project alternatives, minimize project impacts, and determine compensatory mitigation requirements (Smith et al., 1995). Additional applications include the planning design and monitoring of habitat restoration projects outside the context of the Section 404 program.

The development of the HGM approach involves: 1) classification of wetlands within a defined region; 2) development of functional assessment models and indices, and 3) development and application of assessment protocols. The advantage of the HGM approach is that an individual site may be assessed for a suite of functions or a subset of functions, as determined by project management objectives. HGM is a rapid-assessment procedure designed to be implemented in a relatively short period of time at minimal expense (Shafer et al., 2007).

Classification

HGM classifies wetlands based on three separate criteria; geomorphic setting, water source, and hydrodynamics (Brinson, 1993). The classification criteria are used to group wetlands into five basic geomorphic classes at a continental scale (depressional, flat, slope, riverine and fringe wetlands). Flats can be further subdivided into organic and mineral flats, and fringe wetlands into lacustrine and tidal fringe. At a finer geographic scale, the three classification criteria are applied to identify regional wetland subclasses, which typically corresponds to existing, commonly recognized wetland types; for example oligohaline salt marsh along the Gulf of Mexico coastline (Shafer and Yozzo, 1998).

Reference Wetlands

In HGM, reference wetlands are sites selected to represent the variability that occurs within a regional wetland subclass. The reference domain is the geographic area represented by the reference wetlands. Ideally, the reference domain will mirror the geographic area encompassed by the regional wetland subclass; however, constraints on time, personnel, and fiscal resources, as well as agency jurisdictional boundaries often limit the size of a regional reference domain.

Reference wetlands establish the range and variability of conditions expressed by HGM model variables and provide data needed to calibrate HGM assessment models. Reference wetlands exhibiting the highest sustainable level of function across a suite of observed or documented functions are referred to as reference standard wetlands. When a model variable is within the range of conditions observed in reference standard wetlands a variable sub-index value of 1.0 is assigned. As the condition deviates from that observed in reference standard wetlands, the variable sub-index is assigned based on the observed relationship between model variable condition and functional capacity (on a scale of 0.0 to 1.0).

Assessment Protocol

The HGM assessment protocol is a series of tasks that allow the user to assess the functions of a particular wetland using the functional indices presented in a published Regional Guidebook. The first task in an HGM assessment is characterization, which involves describing the wetland and it's surrounding landscape, describing the proposed project and it's potential impacts, and identifying the wetland assessment areas (WAAs). The second task is collection of field data for model variables. The final task is analysis, which involves calculation of functional indices and units.

Models and Indices

An HGM assessment model is a simple representation of a wetland function. It defines the relationship among one or more wetland characteristics or processes (variables). Functional capacity is the ability of the wetland to perform a function relative the level of performance observed or measured in reference standard wetlands.

Variables are combined mathematically in a functional assessment model to produce a functional capacity index (FCI). The mathematical expressions used vary, depending on the type of interaction to be represented (e.g. fully or partially compensatory, cumulative, limiting, controlling, etc.). A complete discussion of variable interactions and model development is presented in Smith and Wakeley (2001). FCIs are multiplied by the wetland assessment area (typically in hectares) to produce functional capacity units (FCUs), which represent the "currency" used to determine mitigation ratios within the context of the Federal Section 404 regulatory program.

Mississippi/Alabama HGM Guidebook

The methodology employed in the data collection and HGM assessment generally follows the protocol described in the Mississippi/Alabama HGM Guidebook (Schafer et al., 2007). http://el.erdc.usace.army.mil/wetlands/guidebooks.cfm)

METHODS

Field Data Collection

Field assessment of the Mon Louis Island site was conducted in September 2018. Transects were generally aligned perpendicular to the shoreline edge along the hydrologic gradient of decreasing elevation (following Schafer et al., 2007).

Vegetation metrics used in the HGM assessment were collected within meter-squared quadrats. Data recorded included the average height of vegetation (recorded in centimeters up to one meter), and the combined overall percent cover of native wetland vegetation occurring within the quadrat. Estimates of percent cover were made using cover class categories presented in **Table B-2** (modified from Schafer et al., 2007).

Table B-2. Cover classes and midpoint values for percent cover estimates in quadrats.

Class	% Cover Estimate	Midpoint Value Assigned
1	<5	2.5%
2	5-25	15.0%
3	25-50	37.5%
4	50-75	62.5%
5	>75	87.5%

Desktop/GIS Assessment Variables

The HGM assessment procedure is twofold. First, site information is gathered and assessed in a GIS during the "desktop" component of the procedure. Wetland assessment areas (WAAs) are identified from maps and air photos (color infra-red is preferred, but high-quality true color air photos are acceptable, and were used in the current evaluations). A standardized scale is critical, and the methodology requires that all air photo work be conducted using a scale of 1:4800 (1 in. = 400 ft.). The following HGM variables were assessed during the desktop procedure:

V_{SIZE} (Wetland Patch Size): The size of the contiguous wetland patch within which the WAA occurs.

$V_{LANDUSE}$ (Adjacent Land Use): The proportion of the wetland perimeter occupied by various land use types.

V_{WIDTH} (Mean Marsh Width): The distance (m) that wind and vessel-generated waves must travel across intervening tidal fringe wetland (distance from the shoreline)

V_{EXPOSE} (Wave Energy Exposure): A qualitative classification of the potential for a wetland to attenuate wind and vessel-generated wave energy based on geomorphic setting and fetch distance – unitless.

V_{EDGE} (Aquatic Edge): The length (m) of vegetated tidally connected marsh/water interface or edge expressed as a proportion of total WAA area (ha).

V_{HYDRO} (Hydrologic Regime): The degree of alteration to the normal tidal hydrology typical of the subclass – unitless.

Field Assessment Variables

The HGM approach also incorporates site-specific information on vegetation metrics and habitat diversity collected in the field. The field assessments generated data on the following HGM variables:

V_{NHD} (Nekton Habitat Diversity): A measure of the heterogeneity of the site, based on comparison of the number of habitats actually present at a site relative to the number of possible habitats known to occur in the regional subclass.

V_{WHD} (Wildlife Habitat Diversity): A measure of the occurrence of habitat types known to support selected marsh-dependent wildlife species within the WAA.

V_{COVER} (Mean Percent Cover Emergent Marsh Vegetation):The mean total percent cover of native non-woody plant species with a wetland indicator status of OBL or FACW

V_{HEIGHT} (Vegetation Height): The most frequently occurring height of the plants within the tallest zone of the emergent marsh plant community.

V_{EXOTIC} (Percent Cover of Invasive or Exotic Species): The proportion of the site that is covered by non-native or invasive plant species.

V_{WOODY} (Percent Cover by Woody Plant Species): The proportion of the site that is covered by shrub-scrub or other woody plant species.

V_{WIS} (Wetland Indicator Status): The ratio of percent cover of FAC and FACU plants to the cover of emergent herbaceous wetland (OBL or FACW) plants.

Ecosystem Functions (FCIs and FCUs)

The data collected during the desktop and field assessments (i.e., the thirteen variables listed above) are combined using various mathematical expressions to estimate five ecosystem functions attributed to tidal fringe wetlands in the AL/MS Gulf coast reference domain (Schafer et al., 2007):

Wave Attenuation: Ability of a wetland to attenuate wind and vessel-generated wave energy based on geomorphic setting and fetch distance

Biogeochemical Cycling: The ability of a tidal wetland to receive, transform, and export various elements and compounds through natural biogeochemical processes.

Nekton Utilization: The potential utilization of a marsh by resident and seasonally occurring non-resident adult or juvenile fish and macrocrustacean species.

Provide Habitat for Tidal Marsh Dependant Wildlife: The capacity of a tidal marsh to provide critical life requisites to selected components of the vertebrate wildlife community.

Maintain Characteristic Plant Community Structure: The ability of a tidal marsh to support a native plant community of characteristic species composition and structure.

Calculation of FCIs

A Microsoft Excel file provided by USACE-ERDC was used to facilitate data entry and to calculate FCIs for each of the functions assessed. Formulas used to calculate FCIs were:

Functional Capacity Equations	
Wave Energy Attenuation	$FCI = [(3V_{WIDTH} + V_{COVER}) / 4 X V_{EXPOSE}]^{1/2}$
Biogeochemical Cycling	$FCI = [V_{HYDRO} X V_{COVER} X V_{LANDUSE}]^{1/3}$
Nekton Utilization Potential	$FCI = (V_{EDGE} + V_{HYDRO} + V_{NHD}) / 3$
Provide Habitat for Tidal Marsh Dependent Wildlife Species	FCI = [VSIZE X {(VHEIGHT + VCOVER)/2} X {(VEDGE + VWHD) / 2}] 1/3
Maintain Plant Community Composition and Structure	FCI = (Minimum (V_{COVER} or V_{EXOTIC} or V_{WIS} or V_{WOODY})

FCI and FCU Calculations for the Tidal Fringe HGM Regional Subclass in the North Central Gulf of Mexico (Version of 04/2007)

Project:	**Mon Louis Island 2020**		
WAA		**Area (ha):**	**1.95**

Variable	Metric Value	Units	Subindex
V_{COVER}	49.3	%	0.400
V_{EDGE}	High	Qualitative	1.000
V_{EXPOSE}	Moderate	NA	0.600
V_{EXOTIC}	3	%	1.000
V_{HEIGHT}	90	cm	0.760
V_{HYDRO}	Minor	NA	0.750
$V_{LANDUSE}$	100%	%	1.000
V_{NHD}	7	EA	1.000
V_{SIZE}	1.95	ha	0.750
V_{WIS}	0.7	%	1.000
V_{WOODY}	0.6	%	1.000
V_{WHD}	4	EA	1.000
V_{WIDTH}	50.7	m	0.800

Function	Functional Capacity Index (FCI)	Functional Capacity Units (FCU)
Wave Energy Attenuation	0.65	1.264
Biogeochemical Cycling	0.67	1.305
Nekton Utilization Potential	0.92	1.788
Provide Habitat for Tidal Marsh Dependent Wildlife Species	0.76	1.478
Maintain Plant Community Composition and Structure	0.40	0.780
Overall Average	0.68	6.614

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Appendix B – Nekton Data

Table B-1. Lift Net Taxa List

Class	Order	Family	Taxon Name
Malacostraca	Decapoda	Palaemonidae	*Palaemonetes* (LPIL)
Malacostraca	Decapoda	Penaeidae	*Farfantepenaeus aztecus*
Malacostraca	Decapoda	Portunidae	*Callinectes sapidus*
Actinopterygii			Actinopterygii (LPIL)
Actinopterygii	Atheriniformes	Atherinopsidae	*Menidia beryllina*
Actinopterygii	Clupeiformes	Engraulidae	*Anchoa mitchilli*
Actinopterygii	Cyprinodontiformes	Fundulidae	*Fundulus* (LPIL)
Actinopterygii	Cyprinodontiformes	Fundulidae	*Fundulus grandis*
Actinopterygii	Cyprinodontiformes	Fundulidae	*Fundulus jenkinsi*
Actinopterygii	Cyprinodontiformes	Fundulidae	*Fundulus pulvereus*
Actinopterygii	Cyprinodontiformes	Fundulidae	*Fundulus xenicus*
Actinopterygii	Cyprinodontiformes	Fundulidae	*Lucania parva*
Actinopterygii	Cyprinodontiformes	Poecillidae	*Poecilia latipinna*
Actinopterygii	Gobiiformes	Eleotridae	*Dormitator maculatus*
Actinopterygii	Perciformes	Gobiidae	Gobiidae (LPIL)
Actinopterygii	Perciformes	Mugilidae	*Mugil* (LPIL)
Actinopterygii	Perciformes	Sciaenidae	Sciaenidae (LPIL)
Actinopterygii	Perciformes	Sparidae	*Lagodon rhomboides*
Actinopterygii	Syngnathiformes	Syngnathidae	*Syngnathus* (LPIL)

[1]LPIL = lowest possible identification level

Table B-2. Lift Net Taxa Counts

Station ML1

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Palaemonetes (LPIL)	111	28	222	361
Callinectes sapidus	3	1	11	15
Fundulus (LPIL)	3	1	4	8
Mugil (LPIL)	2	0	0	2
Gobiidae (LPIL)	1	0	0	1
				Total 387

Station ML2

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Palaemonetes (LPIL)	19	19	74	112
Fundulus (LPIL)	3	2	2	7
Mugil (LPIL)	2	1	2	5
Callinectes sapidus	0	2	1	3
Poecilia latipinna	2	0	0	2
Menidia beryllina	0	1	0	1
Fundulus grandis	1	0	0	1
Fundulus xenicus	0	0	1	1
				Total 132

Table B-2. Lift Taxa Counts (Cont'd)

Station ML3

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Palaemonetes (LPIL)	60	45	13	118
Fundulus (LPIL)	5	2	1	8
Callinectes sapidus	1	3	1	5
Menidia beryllina	1	2	0	3
Fundulus jenkinsi	2	0	0	2
Fundulus pulvereus	0	0	1	1
Fundulus xenicus	0	1	0	1
Lucania parva	1	0	0	1
Poecilia latipinna	1	0	0	1
Gobiidae (LPIL)	0	0	1	1
Mugil (LPIL)	1	0	0	1
				Total 142

Station ML4

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Palaemonetes (LPIL)	156	55	100	311
Fundulus (LPIL)	6	2	10	18
Callinectes sapidus	7	6	4	17
Fundulus xenicus	3	0	0	3
Lucania parva	1	0	2	3
Sciaenidae (LPIL)	2	0	0	2
Fundulus jenkinsi	1	0	0	1
Fundulus pulvereus	0	1	0	1
Poecilia latipinna	1	0	0	1
Dormitator maculatus	0	0	1	1
Mugil (LPIL)	1	0	0	1
				Total 359

Station R1

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Palaemonetes (LPIL)	9	6	8	23
Callinectes sapidus	3	7	3	13
Syngnathus (LPIL)	6	1	1	8
Farfantepenaeus aztecus	1	3	2	6
Anchoa mitchilli	1	0	0	1
				Total 51

Table B-2. Lift Net Taxa Counts (Cont'd)

Station R2

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Palaemonetes (LPIL)	16	19	33	68
Menidia beryllina	0	6	4	10
Anchoa mitchilli	6	2	1	9
Callinectes sapidus	2	2	3	7
Syngnathus (LPIL)	2	3	0	5
Farfantepenaeus aztecus	1	0	3	4
Lagodon rhomboides	0	0	1	1
Osteichthyes (LPIL)	1	0	0	1
				Total 105

Appendix C – Macroinfaunal Data

Table C-1. Macroinfaunal Taxa List

Phylum	Class	Order	Family	Taxonomic Name
Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)
Annelida	Polychaeta	Phyllodocida	Nereididae	*Laeonereis culveri*
Annelida	Polychaeta	Phyllodocida	Nereididae	*Nereis succinea*
Annelida	Polychaeta	Scolecida	Capitellidae	*Capitella capitata*
Annelida	Polychaeta	Scolecida	Capitellidae	*Mediomastus* (LPIL)
Annelida	Polychaeta	Spionida	Spionidae	*Polydora cornuta*
Annelida	Polychaeta	Spionida	Spionidae	*Streblospio benedicti*
Annelida	Polychaeta	Terebellida	Ampharetidae	*Hobsonia florida*
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogonidae (LPIL)
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus* (LPIL)
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes* (LPIL)
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum* (LPIL)
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum scalaenum* grp.
Arthropoda	Insecta	Diptera	Dulichopodidae	*Rhaphium* (LPIL)
Arthropoda	Insecta	Diptera	Ephydridae	Ephydridae (LPIL)
Arthropoda	Insecta	Diptera	Ephydridae	*Notiphila* (LPIL)
Arthropoda	Insecta	Diptera		Diptera (LPIL)
Arthropoda	Malacostraca	Amphipoda	Corophiidae	*Apocorophium* (LPIL)
Arthropoda	Malacostraca	Amphipoda	Corophiidae	*Apocorophium louisianum*
Arthropoda	Malacostraca	Decapoda	Ocypodidae	*Uca pugnax*
Arthropoda	Malacostraca	Decapoda	Sesarmidae	*Armases cinereum*
Arthropoda	Malacostraca	Isopoda	Idoteidae	*Edotia triloba*
Arthropoda	Malacostraca	Isopoda	Sphaeromatidae	*Cassidinidea ovalis*
Arthropoda	Malacostraca	Tanaidacea	Leptocheliidae	*Hargeria rapax*
Mollusca	Bivalvia	Veneroida	Cyrenoididae	*Cyrenoida floridana*
Mollusca	Gastropoda	Mesogastropoda	Hydrobiidae	Hydrobiidae (LPIL)
Mollusca	Gastropoda	Neritopsina	Neritidae	*Neritina usnea*

[1]LPIL = Lowest practical identification level

Table C-2. Macroinfaunal Station Data

Station ML1

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Capitella capitata	1	10	6	17
Naididae (LPIL)	0	3	6	9
Armases cinereum	0	4	1	5
Laeonereis culveri	2	0	1	3
Ephydridae (LPIL)	1	1	0	2
Diptera (LPIL)	0	2	0	2
Ceratopogonidae (LPIL)	1	0	0	1
Dicrotendipes (LPIL)	0	1	0	1
				Total 40

Table C-2. Macroinfaunal Station Data (Cont'd)

Station ML2

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Naididae (LPIL)	33	27	0	60
Capitella capitata	0	10	1	11
Uca pugnax	4	1	0	5
Cyrenoida floridana	2	0	0	2
Laeonereis culveri	0	0	1	1
Dicrotendipes (LPIL)	1	0	0	1
Rhaphium (LPIL)	1	0	0	1
Diptera (LPIL)	0	0	1	1
Neritina usnea	0	0	1	1
				Total 83

Station ML3

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Naididae (LPIL)	1	29	11	41
Uca pugnax	0	5	0	5
Capitella capitata	0	1	0	1
Ceratopogonidae (LPIL)	0	1	0	1
Cyrenoida floridana	1	0	0	1
Hydrobiidae (LPIL)	0	1	0	1
				Total 50

Station ML4

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Naididae (LPIL)	12	1	9	22
Laeonereis culveri	2	1	4	7
Hydrobiidae (LPIL)	0	2	2	4
Mediomastus (LPIL)	2	0	1	3
Notiphila (LPIL)	3	0	0	3
Ceratopogonidae (LPIL)	1	1	0	2
Neritina usnea	1	1	0	2
Chironomus (LPIL)	1	0	0	1
Dicrotendipes (LPIL)	0	1	0	1
Apocorophium (LPIL)	0	0	1	1
Apocorophium louisianum	0	1	0	1
Uca pugnax	1	0	0	1
				Total 48

Table C-2. Macroinfaunal Station Data (Cont'd)

Station R1

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Hargeria rapax	51	47	3	101
Laeonereis culveri	11	8	15	34
Naididae (LPIL)	5	17	4	26
Polydora cornuta	3	8	2	13
Hobsonia florida	4	2	5	11
Polypedilum scalaenum group	2	2	3	7
Streblospio benedicti	1	3	2	6
Apocorophium (LPIL)	3	2	0	5
Neritina usnea	0	3	0	3
Nereis succinea	0	1	1	2
Polypedilum (LPIL)	1	0	1	2
Capitella capitata	0	1	0	1
Mediomastus (LPIL)	1	0	0	1
				Total 212

Station R2

Taxonomic Name	Rep 1	Rep 2	Rep 3	Total
Laeonereis culveri	29	33	16	78
Naididae (LPIL)	4	1	11	16
Streblospio benedicti	1	0	7	8
Hobsonia florida	0	3	1	4
Mediomastus (LPIL)	2	1	0	3
Neritina usnea	0	0	3	3
Polydora cornuta	0	0	2	2
Edotia triloba	0	0	2	2
Hargeria rapax	1	0	1	2
Nereis succinea	0	0	1	1
Cassidinidea ovalis	1	0	0	1
				Total 120

Table C-3. Quadrat Data

Station ML1

Taxonomic Name	Common Name	ML1-1	ML1-2	ML1-3	Total
Littorina irrorata	Marsh periwinkle	4	3	3	10

Station ML2

Taxonomic Name	Common Name	ML2-1	ML2-2	ML2-3	Total
Littorina irrorata	Marsh periwinkle	2	5	1	8

Station ML3

Taxonomic Name	Common Name	ML3-1	ML3-2	ML3-3	Total
Littorina irrorata	Marsh periwinkle	0	1	0	1

Station ML4

Taxonomic Name	Common Name	ML4-1	ML4-2	ML4-3	Total
Littorina irrorata	Marsh periwinkle	3	2	1	6

Station R1

Taxonomic Name	Common Name	R1-1	R1-2	R1-3	Total
Littorina irrorata	Marsh periwinkle	3	0	3	6

Station R2

Taxonomic Name	Common Name	R2-1	R2-2	R2-3	Total
Littorina irrorata	Marsh periwinkle	10	10	12	32