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Population Biology, Ecology, and Ecosystem Contributions of the Eastern Oyster (Crassostrea virginica) from Natural and Artificial Habitats in Tampa Bay, Florida

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Population Biology, Ecology, and Ecosystem Contributions of the Eastern Oyster (*Crassostrea virginica*) from Natural and Artificial Habitats in Tampa Bay, Florida

by

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ABSTRACT

The objective of this project was to document the status of oysters, *Crassostrea virginica*, from non-reef habitats throughout Tampa Bay, Florida, and assess the ecosystem contributions of those populations relative to reef-dwelling oysters. The aspects of oyster ecology studied here include condition, prevalence and intensity of disease (*Perkinsus marinus* - dermo), reproductive activity (including stage, fecundity, and juvenile recruitment), adult oyster density, and the faunal community associated with the oysters.

The predominant source of variation was seasonal, with lesser contributions among sites, and in most cases, little or no effect of the habitat type. Oysters populations from each habitat recruit juvenile oysters, produce mature individuals, and contribute viable gametes at the same magnitude with similar seasonality. The associated faunal communities were also largely similar between habitats at any given site. Measures of oyster density, combined with estimates of the total available habitat, suggest that natural oyster reefs may represent only a small portion of the total oyster community in Tampa Bay, while oysters associated with mangrove habitats and seawalls are probably the most abundant in the bay. Additional mapping and quantification of these habitats would help to define their bay-wide ecosystem-services value. Restoration projects, though small in size relative to other habitats, do provide alternative and additional habitat with comparable value to other oyster-bearing habitats.

INTRODUCTION

The eastern oyster (*Crassostrea virginica*) was harvested for food and various other uses prior to European colonization of the North American continent, and the species continues to support important commercial and recreational fisheries throughout its range along the Gulf of Mexico and Atlantic coasts (MacKenzie et al., 1997). Eastern oysters also function as ecosystem engineers, and have been identified as a valued ecosystem component in all estuaries in which they occur due to their many ecological roles (Beck et al., 2001). These roles include providing habitat for a variety of economically and ecologically important species, catalyzing the transfer of nutrients between the water column and benthos, and reducing eutrophication and shoreline erosion (Bahr and Lanier, 1981).

Most studies of *C. virginica* have focused on populations occurring within the framework of an oyster reef. This is entirely sensible because reefs are considered to be the predominant natural habitat for oysters throughout their range. However, oysters also naturally occur on the roots of red mangroves (*Rhizophora mangle*) and contribute both habitat and production as members of the mangrove community. The specific contributions of oysters to the mangrove community have been poorly studied, and there is even less information available on the ecological contributions of oysters inhabiting man-made habitats such as seawalls, bridge pilings, and substrate deposited for oyster restoration. These are important oversights relative to efforts to understand habitat connectivity, nutrient cycling, and the effectiveness of oyster-reef restoration programs, particularly when considering the continually increasing occurrence of these habitats within the coastal zone.

In the Tampa Bay estuary, there are an estimated 550 linear kilometers of seawall and other solid man-made structures, as well as approximately 1,132 linear kilometers of mangrove periphery (FFWCC-FWRI, Center for Spatial Analysis), available for oyster colonization (Figure 1). If we estimate the width of the intertidal range available for oyster colonization in both of these habitats to be approximately 0.5 m, we find that there are approximately 841 km^2 of oyster habitat unaccounted for in a previous oyster mapping study (O'Keife et al., 2006). In comparison to linear seawalls, mangroves would appear to provide far more surface area for oyster colonization due to their intricate root structure. Therefore this estimation of 841 km^2 is undoubtedly substantially lower than the real value. Nevertheless, it is evident that the ecosystem contributions of oysters living on mangroves and man-made substrates may far exceed those contributions from the 0.16 km^2 of oyster reef present in the Tampa Bay estuarine system (O'Keife et al., 2006). In addition, there have also been over 100 oyster restoration projects in the bay, although some of these projects may represent multiple efforts at a single site (Figure 1). Within Tampa Bay, those oyster restoration projects have mainly been implemented using two different substrates: concrete domes, also known as reef balls, and planted shell or cultch usually bound in mesh bags. The gross ecological contributions of oysters living on restoration substrates are also not well understood.

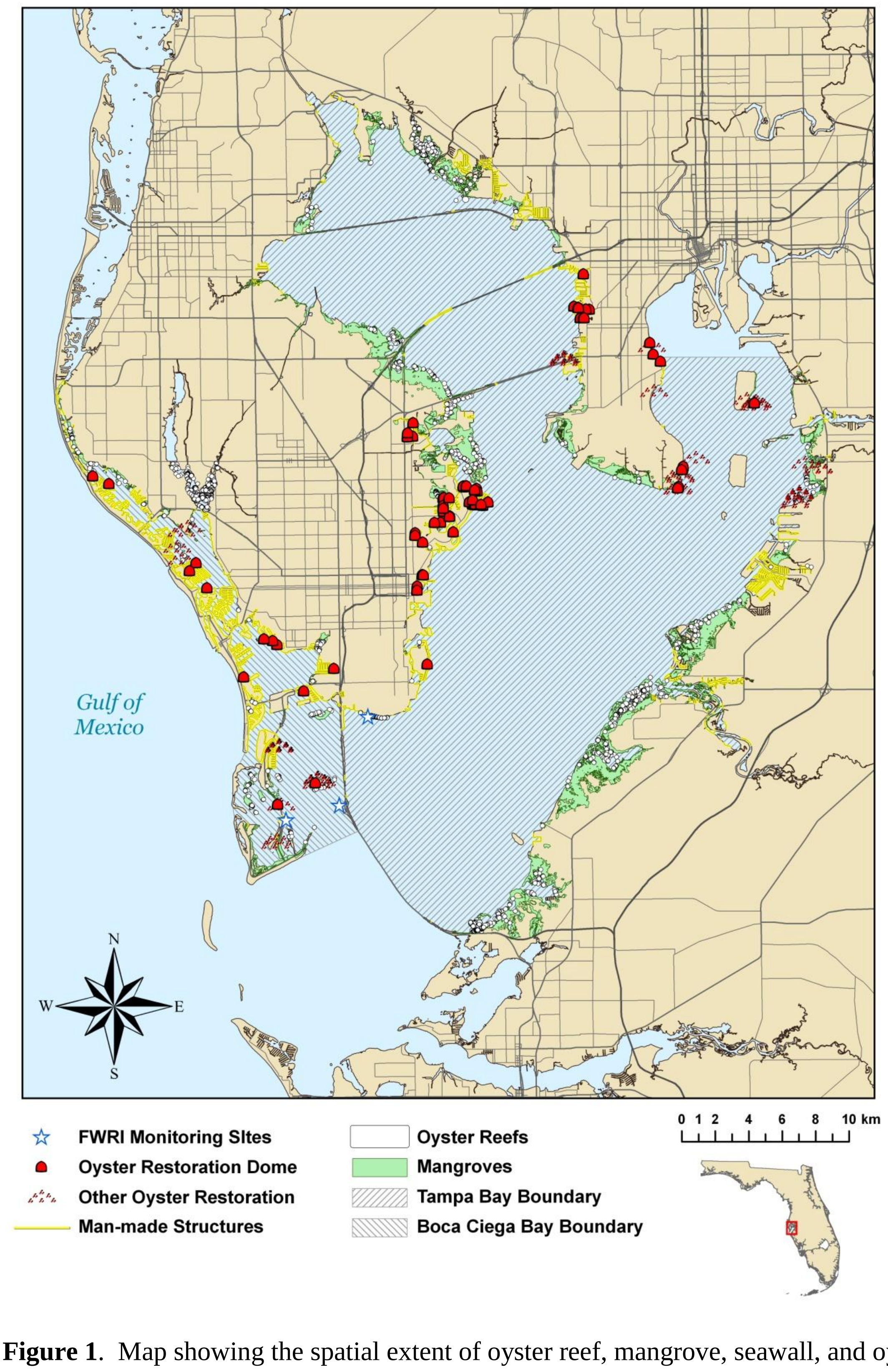

Figure 1. Map showing the spatial extent of oyster reef, mangrove, seawall, and oyster restoration locations in Tampa Bay, Florida.

To better understand the contributions of non-reef dwelling oysters to local estuarine ecology, basic biological and ecological information on oysters growing within typical reef habitat, as well as on seawalls, mangroves, and restoration substrate, was collected from several sites within Tampa Bay. Measures of oyster physiological condition, parasitic infection intensity and prevalence, reproductive development, juvenile recruitment, and oyster density have been used in several long term oyster monitoring projects throughout Florida (Arnold et al., 2008; Tolley et al., 2005; Volety et al., 2009; Wilson et al., 2005) and the methods are well established. Data from those studies span over six years and include observations from most of the major estuaries in southern Florida including Tampa Bay, and served as a baseline for comparison to the data collected in the present study. In addition to the parameters already mentioned, oyster fecundity and community composition of the meiofauna inhabiting each of the oyster habitats were also determined. Physiological condition, parasitic infection intensity and prevalence, reproductive development, fecundity, and juvenile recruitment were measured monthly, while density and community composition were estimated on a single occasion. The resultant data were used to determine population level differences in basic biological function and ecological distribution of oysters dwelling on reefs, mangroves, seawalls, and restoration substrates throughout Tampa Bay.

Monthly Parameters

Condition Index

Condition index is a measure of the physiological condition of an animal. In terms of bivalves, it is an indication of the extent to which the oyster has utilized the volume of its shell for tissue growth and is an efficient method for measuring physiological change over time. This index has been used to estimate a number of factors in bivalves including commercial meat yield, seasonal lipid content associated with gametogensis (Austin et al., 1993; Abbe and Albright, 2003), and variations in the El Nino Southern Oscillation (Schoener and Tufts, 1987). Patterns in condition index have been linked to both gametic and somatic metabolic processes (Walne, 1969; Lucas and Beninger, 1985), but may be confounded by several stressors, including the parasitic protozoan *Perkinsus marinus* (Chu and Volety, 1997), the commensal mud worm *Polydora* sp. (Wargo and Ford, 1993), the pea crab *Zaops ostreum*, previously *Pinnotheres ostreum* (Mercado-Silva, 2005), food limitation (Mercado-Silva, 2005), and pollution (Lawrence and Scott, 1982).

Several methods of measuring the condition index of bivalves have been used in previous studies and all are based on the premise that cavity contents and shell growth will follow a standard ratio in a healthy oyster (Lawrence and Scott, 1982). Differences arise in terms of how to most effectively measure oyster growth. This can be done using shell height, shell weight, and the interior volume of the shell. A comparison of the different methods used to determine condition index and the resultant ratios are described by Mercado-Silva (2005). The method used in this study follows that of Rainer and Mann (1992), and compares the dry tissue weight to the dried shell weight. Condition index, regardless of the method used, provides an inexpensive and reliable measurement of oyster physiological condition and change over time.

Perkinsus marinus (Dermo)

Perkinsus marinus, a protozoan parasite that causes the dermo disease in *C. virginica*, has been attributed to widespread mortalities throughout the range of the eastern oyster. The disease was first detected in the Gulf of Mexico (Ray, 1952) and has since spread up the Atlantic coast into Canada. Temperature and salinity strongly influence the prevalence and distribution of the parasite, although the disease persists across a wide range of latitudes and can be found from the mouth to the upper reaches of an individual estuary (Soniat, 1985). The seasonal patterns and parasitic load of several reefs in Tampa Bay have been monitored for the past several years and no major mortality events due to dermo have been detected (Arnold et al., 2008). However, it is reasonable to speculate that one of the alternate habitats could possess a functional advantage or disadvantage to the inherent health of the oysters, and resulting parasitic load, as influenced by differences in vertical location, density, water quality, or other unexplained factors.

Reproductive Development

Oysters possess an evolutionarily simple, yet highly variable reproductive cycle. An individual can reach sexual maturity within the same season in which they settle, potentially as early as three months after settlement (Hayes and Menzel, 1981). Reproductive development has been shown to be highly dependent on water temperature, with gametogenesis occurring most efficiently at 25°C and inhibited in waters below 10°C (Loosanoff and Davis, 1952). The initiation of gametogenesis has been identified as a main source of variability in the physiology of oysters and can potentially be detected with changes in condition index (Fisher et. al., 1996).

The reproductive stages of the gonads in *C. virginica* were first characterized by Kennedy and Battle (1964) and are classified into three major periods: developing, spawning, and post-spawned gonad. A developing gonad consists of several stages and can be identified by the presence of undifferentiated germinal epithelium, the presence of Leydig cells, and narrow to indistinguishable follicles distributed around the periphery of the gonadal area. These stages are followed by the sexual differentiation stages marked by an expansion of the area occupied by the follicles, allowing the sex of the individual to be determined. After sexual differentiation gametogensis will progress and produce mature spermatozoa or oocytes. Mature gametes will then expand in size in preparation for spawning. The discharge of large numbers of mature gametes during the spawning stage leaves the center of the follicles devoid of mature gametes, follicle walls lined with maturing gametes, and a fully distended follicle area. As the gonad approaches the post-spawned and quiescent stages, follicle walls begin to shrink, ultimately resulting in atrophy of the gonadal ducts, follicles, and remaining gametogenic cells. Staging of gametogenic development was standardized by Fisher et al. (1996) by grading histological sections of the oyster gonad on a 0-10 scale with 0 representing a gonad in the resting stage, 1-5 representing the progression of pre-spawning stages, and 6-10 representing the post-spawning stages.

Fecundity

In addition to reproductive stage, which provides a measure of the timing of spawning events, the fecundity of oysters was also measured to estimate the intensity of those spawning events from each habitat throughout the bay. Unlike the mass spawning events experienced in northern latitudes, researchers have reported a critical spawning temperature for *C. virginica* around 20°C (Loosanoff and Nomejko, 1951, Loosanoff, 1968). Much of *C. virginica*'s southern range, beginning in Cape Canaveral and ranging throughout Gulf of Mexico, contains shallow-water estuaries with water temperatures that remain above this threshold for a large portion of the calendar year (Hayes and Menzel, 1981). Consequently, oysters have been shown to spawn throughout the year and an individual oyster may spawn repeatedly in a given year in this same region (Hayes and Menzel, 1981, Kennedy, 1996). As a result, single sampling events may severely underestimate the reproductive output of southern *C. virginica* populations over an entire year. For these reasons, fecundity, like the other biological metrics mentioned here, was sampled on a monthly basis for an entire year.

Recruitment

Oyster densities have decreased substantially in Tampa Bay and other southern estuaries over the past 100 years. Since oysters are gregarious in nature, the declining presence of adult oysters throughout Tampa Bay means there is less available substrate for new recruits to settle. As reported by O'Beirn et al. (1995), oyster recruitment appears to be substrate limited rather than limited by the total reproductive output of the adult population in southern estuaries. Mean juvenile densities reaching as high as 50 spat per oyster shell per month have been observed in Tampa Bay (Arnold et al., 2008). The majority of oyster recruitment within Tampa Bay and other southern estuaries occurs between June and October (Kenny et al., 1990; Michener and Kenny, 1991 O'Beirn et al., 1995; Arnold et al., 2008). Recruitment rates are intrinsically related to gametogensis and fecundity; however, neither has satisfactorily predicted recruitment (Ingle, 1952). Larval oysters settle onto hard substrates such as existing oyster shell, the roots of mangroves, and man-made substrates such as cement and metal barriers. However, different substrates have been shown to recruit oysters at different rates, as well as affect survival and mortality rates (Michener et al., 1995). No previous studies have compared the spatfall rates and the resultant adult densities of those alternate habitats.

Single-Event Parameters

Size and Density

Previous studies have estimated the total acreage of oyster reefs in Tampa Bay (O'Keife et al., 2006) and the mean density of oysters in the southern portion of the bay (Arnold et al., 2008). However, no effort has been made to estimate the density or biomass of oysters dwelling on mangroves, seawall, and restoration substrates despite their overwhelming presence throughout the bay. Initial estimates suggest that these alternate habitats may have larger overall contributions to ecosystem function in Tampa Bay.

Community Composition

The biogenic habitat created by oyster reefs creates a three-dimensional structure that provides food, habitat, and refuge for a variety of motile and sessile organisms. Studies performed throughout the southeast reveal a diverse oyster-reef community with over 300 associated species (Wells, 1961; Dame, 1979; Bahr and Lanier, 1981; Zimmerman et al., 1989) and, as a result, oyster reefs are designated as essential fish habitat for a number of species (Coen et. al, 1999).

While several studies have investigated the ecological contributions of anthropogenic habitats including bridge pilings, seawalls, and offshore drilling platforms, most of these efforts have focused on rocky intertidal shorelines (Glasby and Connell, 1999; Connell, 2001; Ponti et al., 2002; Moreira et al., 2006). There is some disagreement as to whether these artificial substrates act as surrogates to their natural counterparts or whether they support different communities (Bulleri, 2005). The community composition of both natural and artificial substrates, including mangrove, oyster reef, restoration substrates, and seawalls, was investigated in this study.

Summary

In summary, the biological and ecological data reported here will provide a full suite of complimentary data regarding the entirety of oyster populations throughout Tampa Bay. Furthermore, for the first time, the contributions of oysters from non-reef habitats to both population and ecosystem function will be investigated. This study will be applicable in the development of shoreline conservation and mitigation strategies to best preserve and restore the critical ecosystem benefits provided by oysters within Tampa Bay.

METHODS

Study Sites

Tampa Bay is a large shallow subtropical open water estuary that opens to the Gulf of Mexico. The basin is influenced tidally and by four rivers, the Hillsborough and Alafia Rivers to the northeast and the Manatee and Little Manatee Rivers to the southeast, which all contribute substantial freshwater flow to the bay. The shoreline of Tampa Bay is dominated by mangroves and seawalls, both of which serve as habitat for oyster recruitment. With an area-weighted depth of about 4 m (Weisberg and Zheng, 2006), the entire bay is subject to large fluctuations of salinity and temperature within the intertidal zone, about 1.25 m (Weisberg and Zheng, 2006), where oysters typically reside. Study sites were selected throughout Tampa Bay based on the presence of oysters growing on reefs (RF), mangroves (MG), seawalls (SW), and restoration substrates (RS) in close proximity to one another (Figure 2). Those sites were stratified as upper (UE), middle (ME), and lower (LE) estuary according to their relative distance from the mouth of Tampa Bay to account for differences in salinity regimes. Since there were two predominant substrates (oyster domes and bagged shell) used for oyster restoration in Tampa Bay prior to initiation of this study, two study sites within each stratum were selected: one with oyster domes (D) and one with bagged oysters shell (S) to serve as the restoration substrate within each site. For the purposes of this study, documenting the status of oysters from each type of habitat as a whole, both types of restoration substrate were treated as a single type of habitat and are referred to with the generic term "restoration" throughout this document. The letters D and S are used only as site identifiers, and have no statistical implications. As a result of this design, a total of six study sites, each containing reef, mangrove, seawall, and restoration habitat were established throughout Tampa Bay. For the remainder of this document, "site" or "study site" will represent one of the blocks containing all four habitats, and "station" will refer to the oysters from a specific habitat within a given study site (Appendix 1).

Monthly Parameters

Water Quality

Monthly water-quality sampling was conducted in conjunction with field sampling at all stations within each study site. Salinity and temperature were recorded using a YSI 85 instrument when available. No water-quality data were recorded for months when YSI was not available. Measurements were taken on a single occasion during oyster collections at each station during each month.

Condition Index

Twenty-four individual oysters were collected from each station, within each study site, on a monthly basis from October 6, 2008, to September 10, 2009. Of those oysters collected from each station, eight were haphazardly selected for condition-index analysis and the remaining oysters held for other biological measurements. All oysters were scraped clean of fouling organisms and thoroughly scrubbed to remove any excess debris.

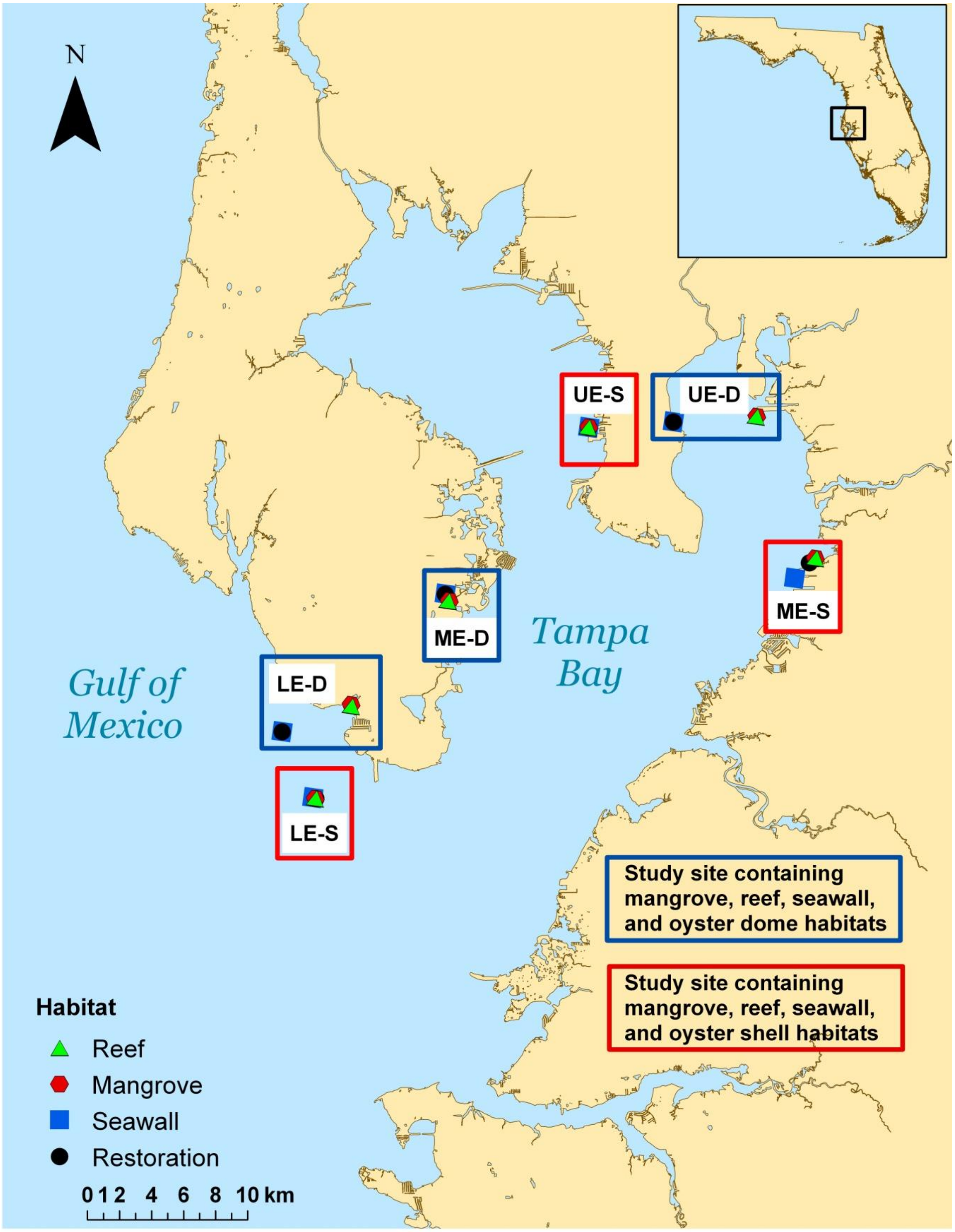

Figure 2. Map showing the location of each of the six study sites, and the location of the four representative habitats/stations within each site**,** in Tampa Bay, Florida.

Once completely clean, shell height (mm) and total wet weight (g) of each individual was measured. Oysters were then shucked and the oyster tissue was placed in a pre-weighed aluminum tare pan and weighed. Both the oyster tissues and shells were dried at 60° for a minimum of 48 hours and then dry tissue and dry shell weights were recorded. Condition index was calculated as the ratio of dry tissue mass to dry shell mass for each individual. Mean condition index was calculated at each habitat within each study site for every month.

Perkinsus marinus (Dermo)

The prevalence and intensity of *Perkinsus marinus* (dermo) was diagnosed from eight individuals collected from each station, within each study site, using Ray's fluid thioglycollate media (RFTM) method as described by Bushek et al. (1994). The shell height of each oyster was recorded and the oyster was shucked with a sterile oyster knife. Small 1-cm^2 pieces of mantle and gill were clipped from each individual using sterile surgical scissors, placed in 9.5 mL of RFTM treated with antibiotics and antifungals, and incubated for seven days in dark, room-temperature conditions. After the incubation period, tissues were placed on a microscope slide, macerated with sterile razor blades, and stained with Lugol's solution. Mantle and gill tissues were then examined at 40x magnification for the presence of hypnospores, i.e., enlarged cells, stained with Lugol's solution. Parasite density (infection intensity) was ranked according to the Mackin scale (Table 1; Mackin, 1962) which ranges from 0 (uninfected) to 5 (heavy infection). The mean infection intensity for each oyster was calculated as the average of the infection intensity from the mantle and gill tissues. Mean infection intensity and the percent of oysters infected with the disease were calculated at each habitat within each study site for every month.

Table 1. Mackin (1962) scale showing different stages of *Perkinsus marinus* (dermo) infection intensity

Stage	Category	Cell Number	Notes
0	Uninfected	No cells detected	
0.5	Very light	<10 cells in entire preparation	
1	Light	11-100 cells in entire preparation	Cells scattered or in localized clusters of 10-15 cells
2	Light-moderate		Cells distributed in local concentrations of 24-50 cells; or uniformly distributed so that 2-3 cells occur in each field at 100X
3	Moderate	3 cells in all fields at 100X	Masses of 50 cells may occur
4	Moderate-heavy	Cells present in high numbers in all tissues	Less than half of tissue appears blue-black macroscopically
5	Heavy	Cells in enormous numbers	Most tissue appears blue-black macroscopically

Reproductive Development

The remaining oyster tissues from the individuals used in the disease analysis were preserved in Dietrich's solution for estimates of reproductive development. Oyster tissues were allowed to fix in Dietrich's solution for a minimum of two days on a shaker set on low speed. Once fixed, a cross section was taken approximately half-way between the adductor muscle and the anterior margin, to include the gonad, using a microtome blade. Cross sections were placed in histological tissue cassettes and rinsed in tap water overnight. Tissue cassettes were then placed in 70% ethanol and sent to the Fish and Wildlife Research Institute histology lab (St. Petersburg, FL) for preparation.

Histological preparation consisted of dehydrating each oyster tissue in 95% ethanol for a minimum of three hours, then embedding the tissue in paraffin. Cross sections of gonad no thinner than 60 µm (the approximate maximum diameter of an oocyte) were cut using a microtome blade. The gonad sections were then stained with hematoxylin and eosin, and mounted onto glass slides for analysis. Histological cross sections were examined at 200-400X magnification to determine gender if possible and to assign a reproductive stage according to the classification scheme from Arnold et al. (2008) (Table 2). For statistical analyses, the classification scale was folded from a 0-10 to a 0-5 scale with 0 representing the neuter or resting phase, and 5 the pre- and post-initial spawning phase where the gonad is most fecund as described by Wilson et al. (2005). Mean reproductive stage was calculated at each habitat within each study site for every month.

Fecundity

Oyster fecundity was estimated using the method described by Cox and Mann (1992), varying only in that fresh oysters were used to estimate fecundity instead of frozen individuals. Eight randomly selected individuals from each station were sexed by slicing into the gonad using a razor blade and blotting the tissue onto a slide. The slide was then inspected at up to 1,000x for the presence of eggs or sperm, although eggs could be discerned at lower magnification. If any females were collected, the first three females from each station were used to estimate fecundity. Female oysters were initially assigned a rank of 1 (watery gonad), 2 (milky gonad, digestive gland visible), or 3 (milky gonad, digestive gland barely visible). The entire female oyster tissue was then macerated using razor blades and blended in a Waring Commercial blender

Table 2. Reproductive staging criteria for oysters collected from Florida waters

Initial	Folded	Stage Description
0	0	Neuter or resting stage with no visible signs of gametes
1	1	Gametogenesis has begun with no mature gametes
2	2	First appearance of mature gametes
3	3	Follicles have equal proportions of mature and developing gametes
4	4	Follicles dominated by mature gametes
5	5	Follicles distended and filled with ripe gametes, limited gametogenesis, ova compacted into polygonal configurations, and sperm have visible tails
6	5	Active emission (spawning) occurring
7	4	Follicles one-half depleted of mature gametes
8	3	Gonadal area is reduced, follicles two-thirds depleted of mature gametes
9	2	Only residual gametes remain, some cytolysis evident
10	1	Gonads completely devoid of gametes, and cytolysis is ongoing

(model 51BL31) for 30 seconds on the "low-1" setting in 200 mL of filtered seawater. The suspension was then sieved through a 180 µm and 25 µm sieve stack and rinsed with approximately 500 mL of filtered seawater into a 50 mL falcon tube. The condensed filtrate was then diluted to a total volume of 50 mL with filtered seawater. Three replicate 1-mL aliquots were drawn from each sample and placed in a 1 mL Sedgwick Rafter counting cell. A Sedgwick Rafter cell holds exactly 1 mL of liquid, and is divided into 1µL squares which allow unbiased extrapolations of oocytes at high densities.

Oocytes were enumerated under 40x magnification and the total number of oocytes per oyster extrapolated from the replicate mean. Mean fecundity was calculated at each habitat within each study site for every month.

Recruitment

Oyster recruitment was monitored monthly at each station using oyster spat collection arrays. Each array consisted of six axenic oyster shells, each with a hole drilled in the center, strung on 18-gauge galvanized wire. Oyster shells were oriented with the interior margin, or smooth side, of the shell facing downwards. Spat arrays were initially deployed at each station on August 29, 2008. At each station, arrays were placed at approximately the midpoint of the vertical distribution of oysters and left to soak for a month. Target soak time was approximately 4 weeks and actual soak time varied between 19-41 days at which point the arrays were replaced with new ones. Soaked spat arrays were taken back to the laboratory and the number of oyster spat settled on the underside of each individual shell was enumerated. In accordance with Arnold et al. (2008), top and bottom shells on the shell string were excluded from results since those shells experienced different levels of exposure than those in the middle of the shell string. Mean recruitment was calculated at each habitat within each study site for every month.

Single-Event Parameters

Size, Density, and Biomass

The live oyster density, proportion of live oysters, and the mean shell height of oysters was determined by assessing 15 replicate 0.25-m^2 surface area samples (quadrats) at each station for a total of 360 samples (6 sites x 4 habitats x 15 samples). Density sampling was completed at each station during March 2009. The total number of live and dead (articulated shell) oysters within each replicate was counted and the first 15 live oysters counted from each replicate were measured for shell height (SH=the maximum linear distance from umbo to the ventral shell margin). The vertical height (m) of oyster habitat in each replicate was also measured from the lowest point of live oyster excavation. All living or recently dead oysters were counted regardless of size, and every 0.25 m^2 replicate was considered oyster habitat if it contained at least one oyster. Since the oyster habitats vary considerably in shape, size, and orientation, an appropriate sampling strategy was applied to each habitat. Oyster reefs were sampled using haphazardly placed 0.25-m^2 quadrats and excavated to a depth where no live oysters could be found. The appropriate survey area of seawall stations was determined by measuring the entire width (tidal range) of the oyster band and taking the necessary horizontal length of seawall to equal 0.25 m^2. Mangrove roots were sampled by haphazardly choosing a location along the mangrove perimeter and measuring the surface area of the individual roots around that location. In all cases, multiple prop roots were required to achieve a total surface area of 0.25 m^2. The survey area of oyster domes was determined by methods similar to that of the seawall stations, while survey areas chosen at shell bag restoration stations were determined by the quadrat used for reef stations.

To estimate the relative biomass of oyster populations from these four types of habitat, a power function was developed based on a sample size of 2304 individual's shell height and dry tissue weights, measured in conjunction with condition index.

Community Composition

Oyster habitat was excavated from each station to assess differences in the community structure each type of habitat supports. Two duplicate samples of equivalent surface area were taken from each station within each study site. The standard surface area collected within each study site was determined by scraping a 10-cm band of seawall spanning the entire width of oyster habitat. The surface area scraped in this 10-cm band was then measured and equivalent surface areas were collected from each of the other three habitats within a given study site (Table 3). Tidal height, measured from mean low water, was also recorded at the time of collection. Once collected, oyster clumps were broken up using an oyster knife, and rinsed through a 2mm and 500 μm sieve stack with filtered seawater. Every living animal retained on both sieves, including oysters, was collected and preserved in a 10% buffered formalin solution with filtered seawater. Samples were allowed to fix for seven days, rinsed, transferred to 70% ethanol, and lightly stained with Rose Bengal.

Large samples were split to a standard volume of oyster shell using an oversized plankton splitter adapted from a smaller version described by Motoda (1959). All organisms were identified to the lowest possible taxon and enumerated, including those dwelling inside the oysters such as pea crabs and *Polydora* worms. Organism abundance was standardized to one square meter of surface area, based on the area sampled as well as the number of splits required.

Statistical Analyses

All data were analyzed using generalized linear mixed models in SAS version 9.2 (SAS Institute Inc., Cary, NC) unless otherwise noted. Monthly parameters including condition index, *Perkinsus marinus* (dermo) infection intensity and prevalence, reproductive development, fecundity, and recruitment were analyzed by ANOVA with several factors including habitat, study site, month, and the interaction of habitat and time. The single-sample event parameters, density and community diversity, were analyzed by similar methods with the exclusion of the repeated measure (month). All data were tested for normality using residual analysis. Natural log transformations of the data were required to satisfy the model assumptions for recruitment and density parameters. A suitable transformation to fit the general ANOVA used in the other parameters could not be established for fecundity (oocyte counts), so an analysis of variance was performed on the ranked data. Post-hoc analysis of all of the factors included in the ANOVA was performed using least square means pair-wise comparisons. All significance was established at the $P<0.05$ level. Graphic representations of all the data are displayed as the untransformed data regardless of the analysis used.

Community composition data were further analyzed using Plymouth Routines In Multivariate Ecological Research (PRIMER) software package (PRIMER-E Ltd., Plymouth, UK). The total organism abundance from each station was subject to a square - root transformation and the cluster and multi-dimensional scaling plots were generated from a Bray-Curtis similarity matrix of the transformed data. Statistically significant clusters of stations were determined using a SIMPROF test, assuming no *a priori* structure to the station mean abundances.

Table 3. Total area sampled for community composition analysis at each station. Upper, Mid, and Lower-Estuary Strata are abbreviated by UE, ME, and LE, respectively. Habitats are abbreviated seawall (SW) mangrove (MG) reef (RF) and restoration (RS)

Strata	Habitat	Site	Date Sampled	Band Width (cm)	Sample Area per Rep (cm^2)
UE	SW	D	9/17/2008	50	500
UE	MG	D	9/17/2008	50	500
UE	RF	D	9/17/2008	50	500
UE	RS	D	9/17/2008	50	500
UE	SW	S	9/16/2008	38	380
UE	MG	S	9/16/2008	38	380
UE	RF	S	9/16/2008	38	380
UE	RS	S	9/16/2008	38	380
ME	SW	D	9/3/2008	34	340
ME	MG	D	9/3/2008	34	340
ME	RF	D	9/3/2008	34	340
ME	RS	D	9/3/2008	34	340
ME	SW	S	9/15/2008	38	380
ME	MG	S	9/15/2008	38	380
ME	RF	S	9/15/2008	38	380
ME	RS	S	9/15/2008	38	380
LE	SW	D	9/3/2008	25	250
LE	MG	D	9/3/2008	25	250
LE	RF	D	9/3/2008	25	250
LE	RS	D	9/3/2008	25	250
LE	SW	S	8/28/2008	25	250
LE	MG	S	8/29/2008	25	250
LE	RF	S	8/29/2008	25	250
LE	RS	S	8/28/2008	25	250

RESULTS

Monthly Parameters

Water Quality

Over the course of the study, salinity remained high at all sites, varying from 21 to 38 ppt, and never falling below levels that would be considered stressful (10 ppt) to oysters (Figure 3). Salinity at the upper estuary stations was near or above 30 ppt during most summer months, but did fall into the mid 20s during September 2008 and again in August and September 2009. Salinity at the middle estuary dome site fell to just above 20 ppt in October 2008, but salinities at the middle estuary shell site remained near 30 ppt. Both middle estuary sites remained near or above 30 ppt until June 2009, then dropped and remained in the low 20s throughout the remainder of the study. During all months, salinity at both of the lower estuary sites remained above 30 ppt.

Temperatures exhibited typical seasonal patterns in each of the estuarine strata over the course of the study ranging from 10 to 33^{o}C over the 12 months (Figure 4). Temperature at the onset of the study was near 30^{o}C at all sites, and fell during fall and winter to lows of 10-15^{o}C in February 2009. Temperatures had climbed to near 30^{o}C again by June at all sites and remained high for the remainder of the study.

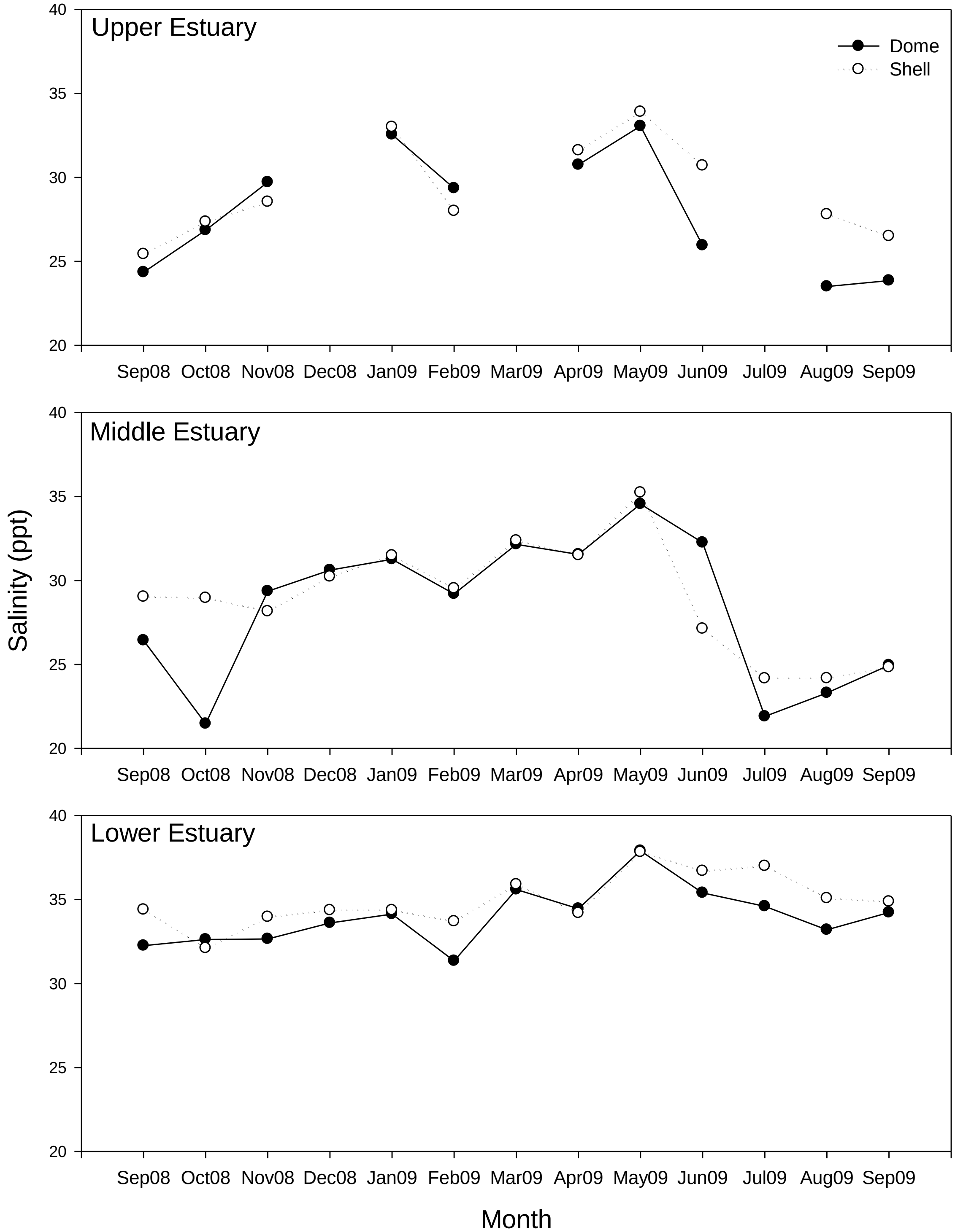

Figure 3. Salinity in each of three Tampa Bay estuarine strata.

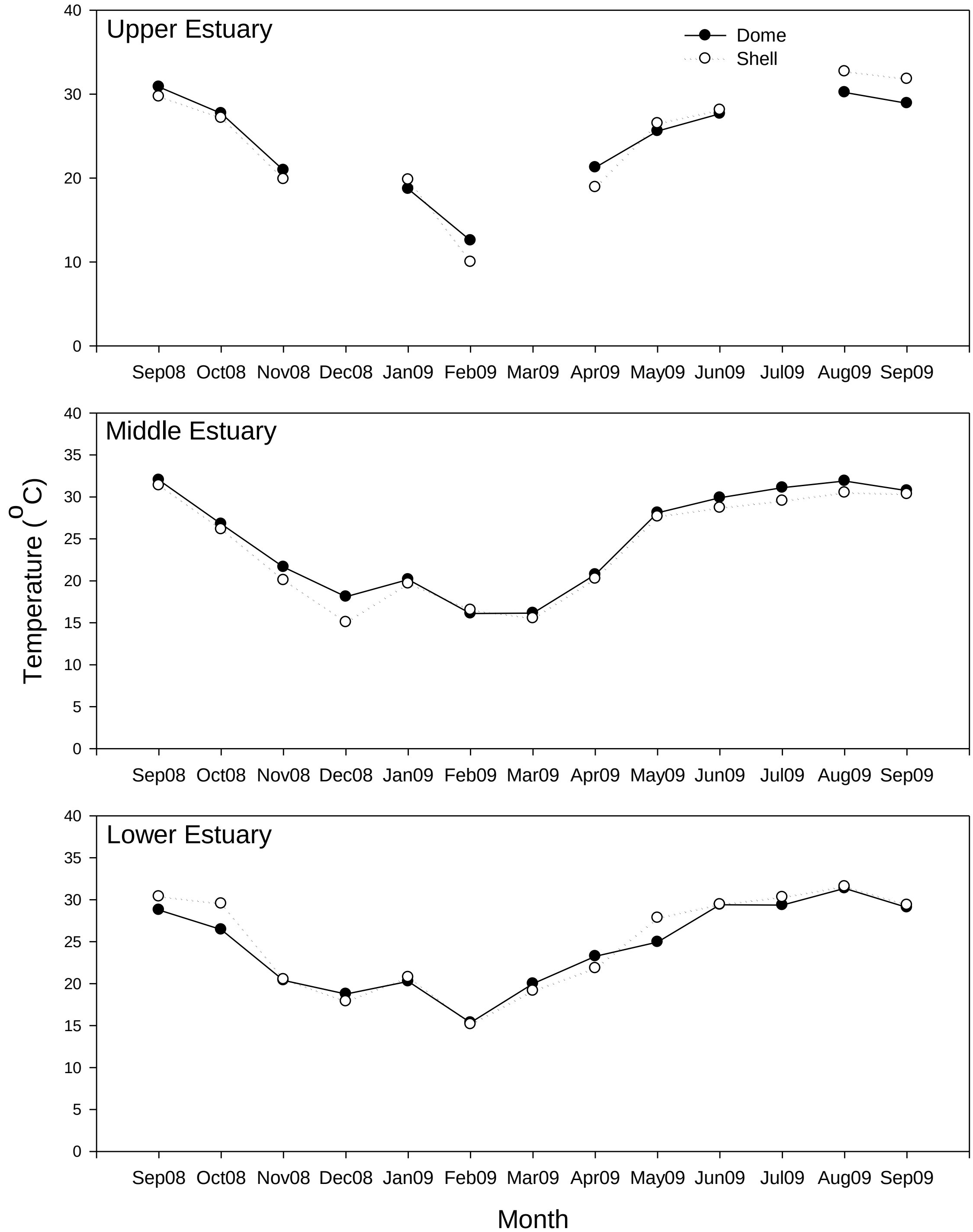

Figure 4. Temperature in each of three Tampa Bay estuarine strata.

Condition Index

Condition index did not vary significantly between habitats or the interaction of habitat and month, but did display significant monthly (P<0.0001) and site to site (P<0.0001) variations (Table 4). Oysters collected from each of the four habitats between January and June 2009 typically had higher mean condition indices compared to those collected between October and December 2008 or July and September 2009 (Figure 5). The seasonal trends in condition index varied between sites (Figure 6). At the ME-D study site, there was a pronounced peak during the months of January through June in all four habitats, although the mean condition index for the reef oysters during February and March was slightly lower than that of the other habitats within that site. Both lower estuary sites (LE-D and LE-S) experienced a marked increase in condition index between January and February in all four habitats within each respective site. The two upper estuary sites (UE-D and UE-S) and the ME-S site did not experience similar peaks in mean condition index during the early months of 2009, although the standard deviation was noticeably greater in March for the reef stations in the UE-D and UE-S sites.

Table 4. Tests of fixed effects on condition index measured as the ratio of dry tissue weight to dry shell weight of individuals. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	Num DF	Den DF	F Value	Pr > F
Habitat	3	462	2.04	0.1079
Month	11	734	17.39	<0.0001
Site	5	446	16.31	<0.0001
Habitat*Month	33	731	1.05	0.3997

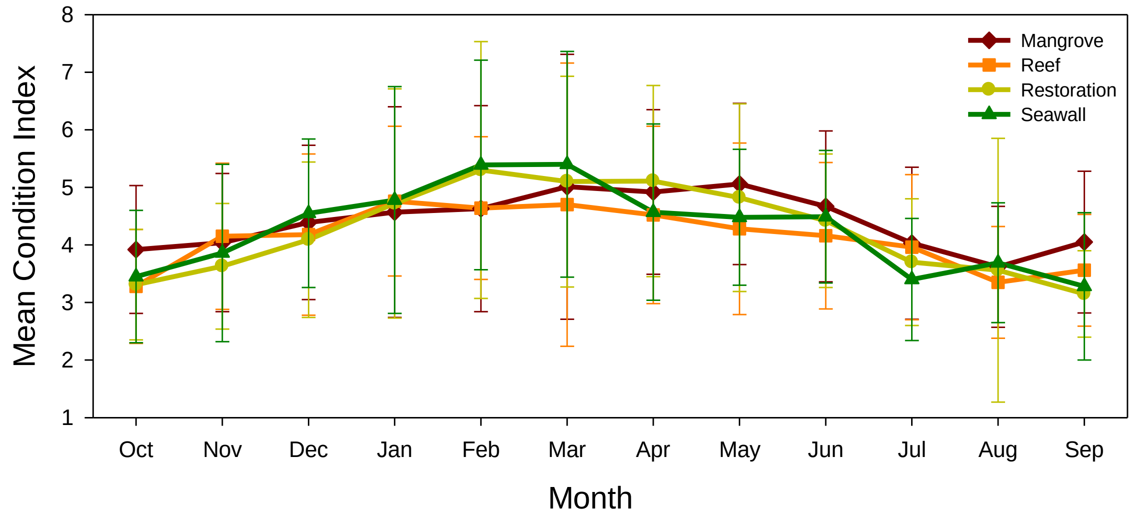

Figure 5. Mean condition index (± SD) of oysters collected from mangrove, reef, restoration, and seawall substrates over a 12-month period from October 2008 to September 2009.

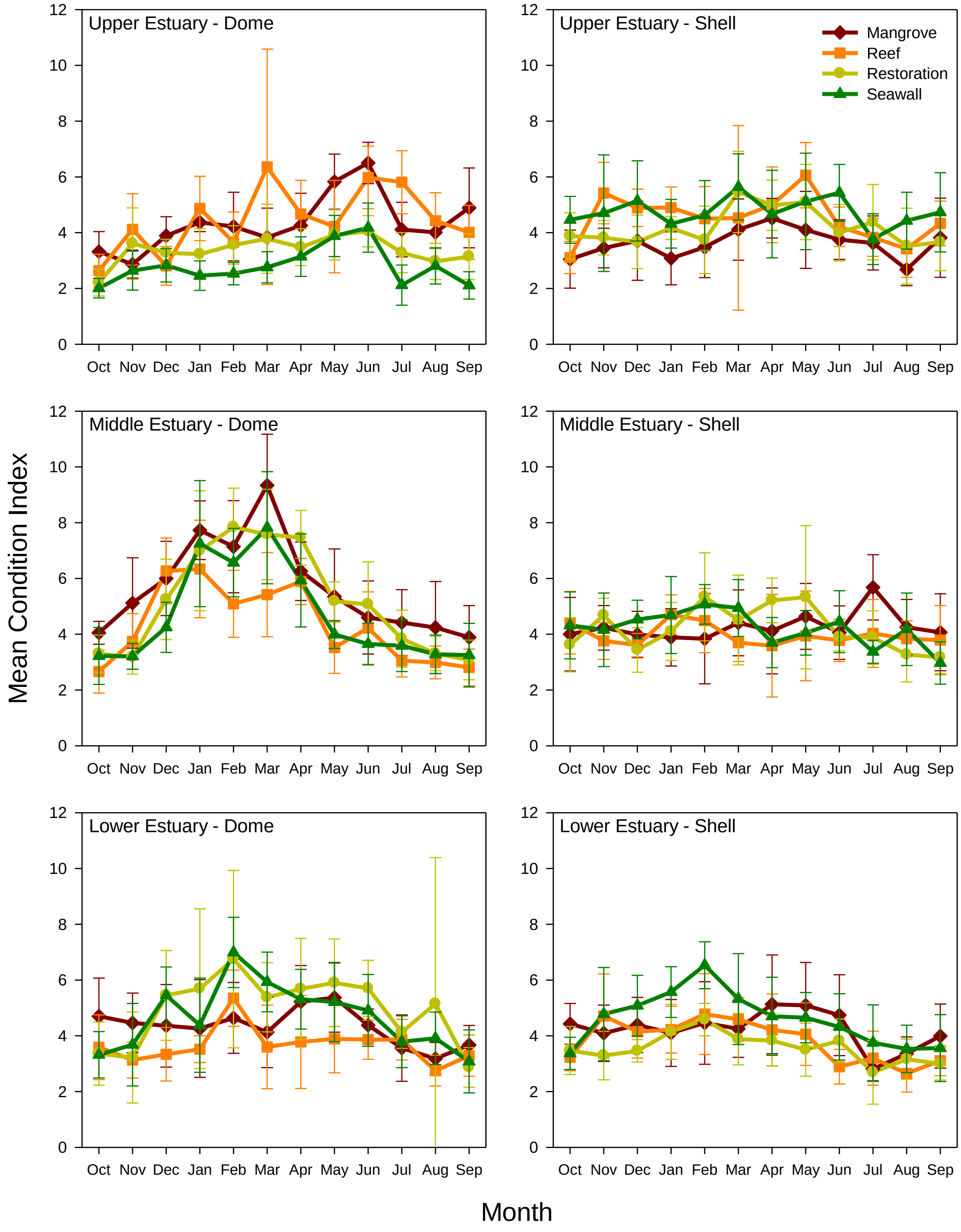

Figure 6. Mean condition index (± SD) of oysters collected from each habitat/station over a 12-month period from October 2008 to September 2009.

Perkinsus marinus (Dermo)

Dermo-infection prevalence varied significantly between habitat (P<0.001), month (P<0.001), and site (P<0.001), but the interaction term was not significant (Table 5). Infection intensity was highest in oysters collected from natural reefs (59%). Seawall (45%) and mangrove (42%) oysters had fewer infected oysters, while restoration site oysters (38%) had the least number of infected oysters. Seasonally, dermo prevalence was highest in oysters collected in the fall (September – November; average of 60.5%), lowest in the spring (April – May; average = 32.8%), and intermediate at other times (Figure 7a). When comparing sites, significant variation was observed, but no discernable pattern could be detected (Figure 8). Mean dermo prevalence was nearly 70% at the upper estuary dome site but less than 50% at all other sites, ranging from 32 to 47% of oysters bearing detectable levels of dermo.

Table 5. Tests of fixed effects on dermo-infection prevalence measured as the proportion of oysters with a detectable level of dermo. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F-value (F Value), and corresponding probability (Pr > F) are displayed

Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Habitat	3	845.6	17.52	<0.0001
Month	11	655	7.03	<0.0001
Site	5	620.6	22.07	<0.0001
Habitat*Month	33	828.6	1.14	0.2669

Like dermo-infection prevalence, infection intensity also varied significantly between habitat, month, and site (P<0.001), while the interaction term was not significant (Table 6). In addition, intensity levels above one were rare, indicating few oysters would be critically impaired by their level of infection (typically assumed to be a level of three or higher). Mean dermo intensity was higher in oysters collected on natural reefs (0.67) than from other habitats. Seawall oysters (0.53) had lower infection levels and were similar to mangrove oysters (0.49) but greater than restoration site oysters (0.39). Seasonally, dermo intensity was highest in oysters collected in fall samples (September – November; average intensity of 0.81), lowest in the winter and spring (January - June; average of 0.34), and intermediate at other times (Figure 7b). When comparing sites, significant variation was observed, but no discernable pattern could be detected. Intensity was highest (though still low overall) at the upper estuary dome site (0.86) but very low at all other sites, with an average intensity of 0.45 (Figure 9).

Table 6. Tests of fixed effects on dermo-infection intensity measured in accordance with the Mackin scale (Mackin, 1962). Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Habitat	3	844	14.37	<0.0001
Month	11	652	11.2	<0.0001
Site	5	616	23.62	<0.0001
Habitat*Month	33	827	1.14	0.2708

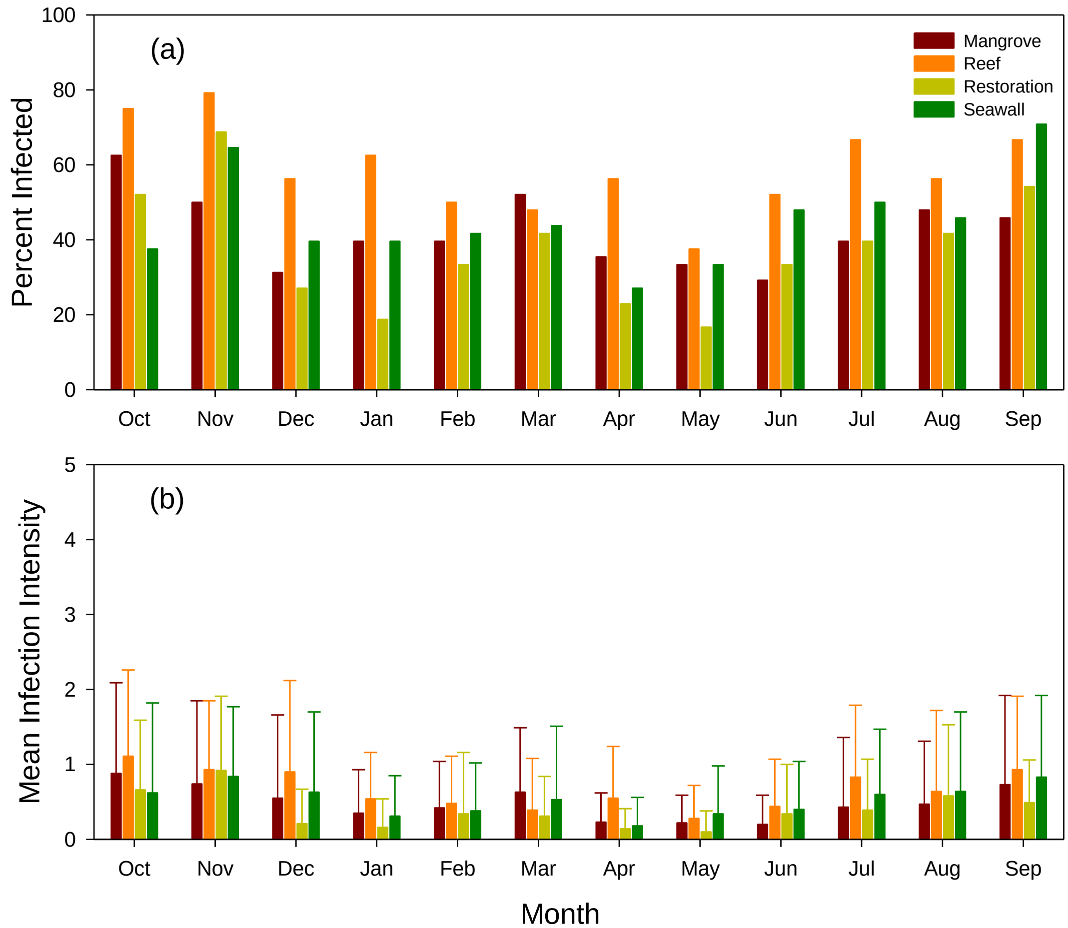

Figure 7. Mean dermo (a) prevalence and (b) intensity (± SD) of oysters collected from mangrove, reef, restoration, and seawall substrates over a 12-month period from October 2008 to September 2009.

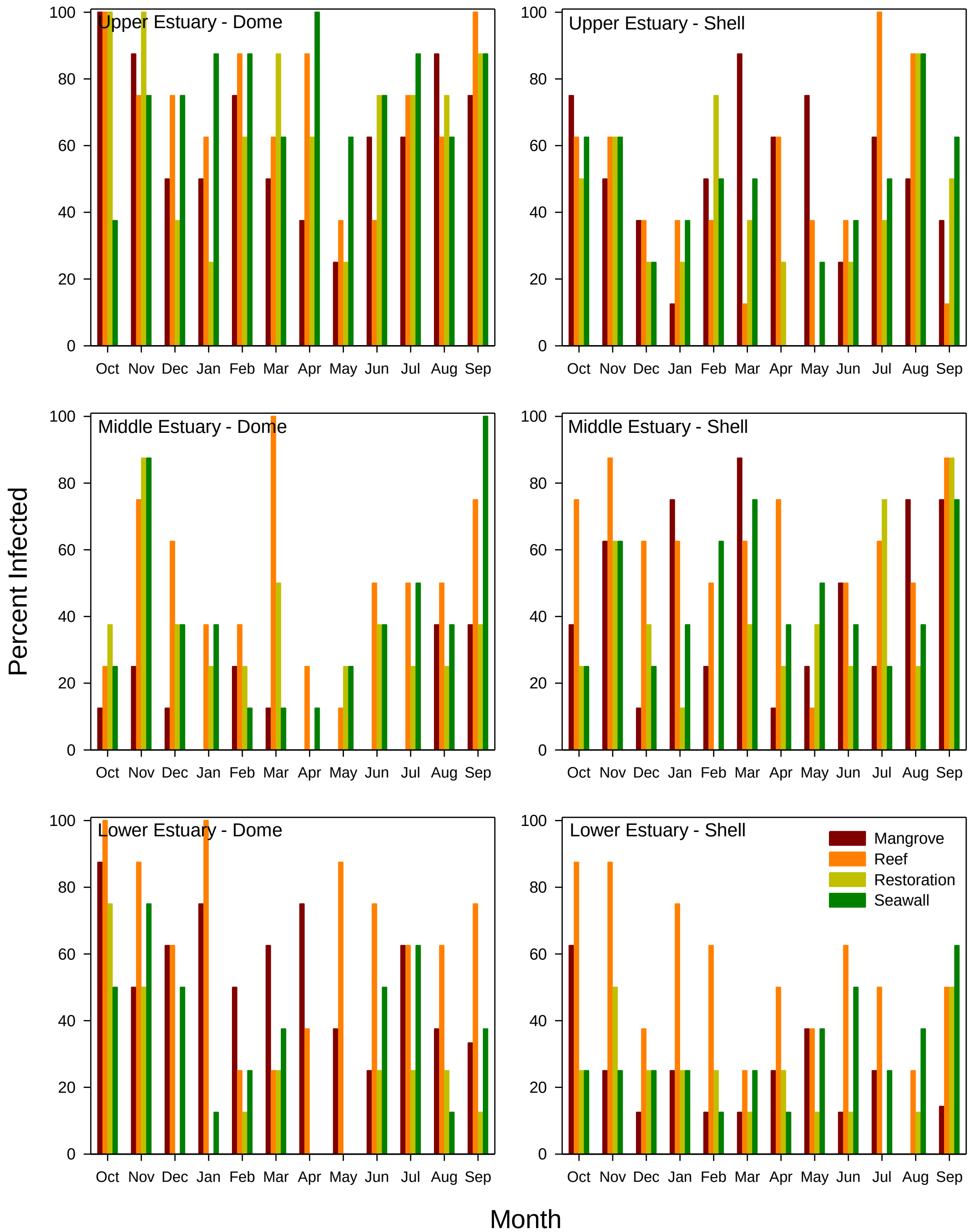

Figure 8. Mean dermo prevalence of oysters collected from each habitat/station over a 12-month period from October 2008 to September 2009.

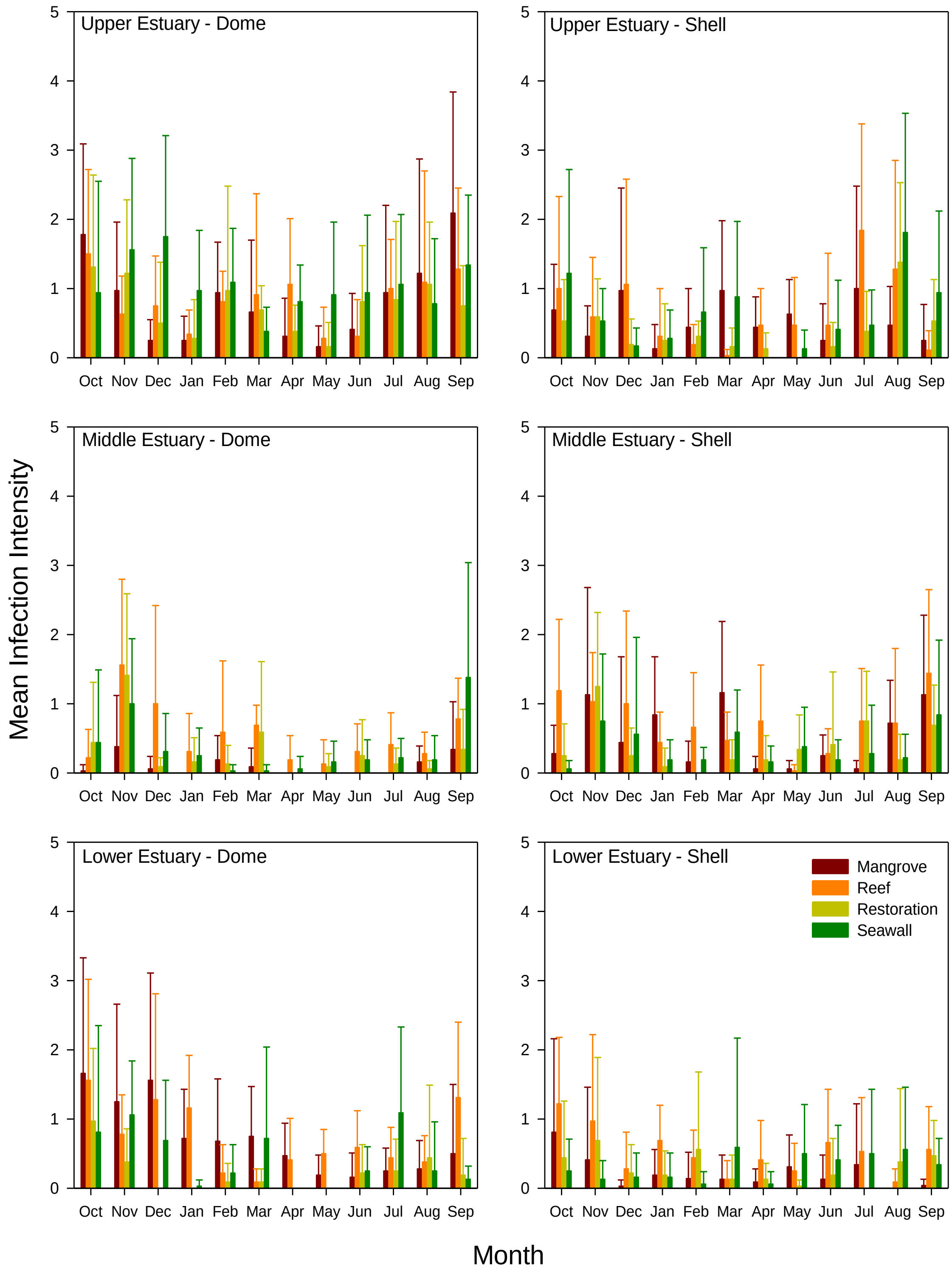

Figure 9. Mean dermo intensity (± SD) of oysters collected from each habitat/station over a 12-month period from October 2008 to September 2009.

Reproductive Development

Mean reproductive stage was not found to vary significantly between habitats but did vary significantly by month, site and the interaction of month and habitat ($P<0.0001$; Table 7). The seasonality of reproductive stage was sharply divided by a rapid increase in the mean reproductive stage from March (1.28) to April (3.96). Once this shift occurred, mean reproductive stage remained fairly high for the remainder of the study (April – September average of 3.86). During the fall of 2008, reproductive stage was intermediate in October (2.39), then fell and remained low until spring (November to March average of 0.99; Figure 10). Mean monthly reproductive stage of oysters from the LE-S study site was 2.87, significantly higher than all other sites ($P >0.05$) for the entire 12-month study period. Mean reproductive stage of oysters from the UE-D site was significantly lower (2.12) when compared to the remaining four sites which did not vary significantly among each other across the entire 12 months (Figure 11).

Table 7. Tests of fixed effects on reproductive stage scored from histological cross sections in accordance with the methods proposed by Wilson et al. (2005). Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Habitat	3	510	0.42	0.7367
Month	11	735	181.1	<0.0001
Site	5	496	11.13	<0.0001
Habitat*Month	33	733	2.27	<0.0001

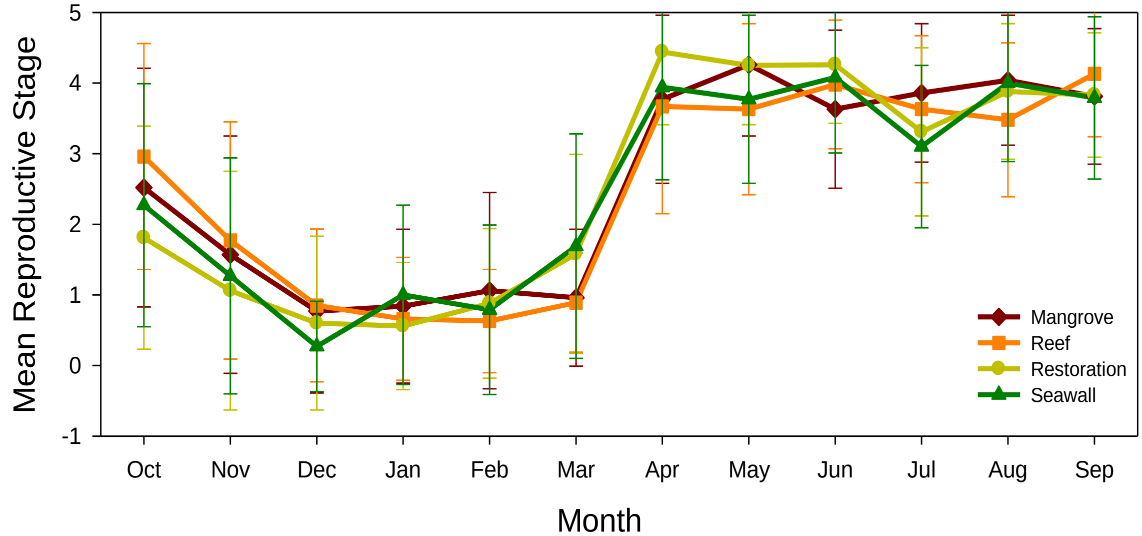

Figure 10. Mean reproductive stage (± SD) of oysters collected from mangrove, reef, restoration, and seawall substrates over a 12-month period from October 2008 to September 2009.

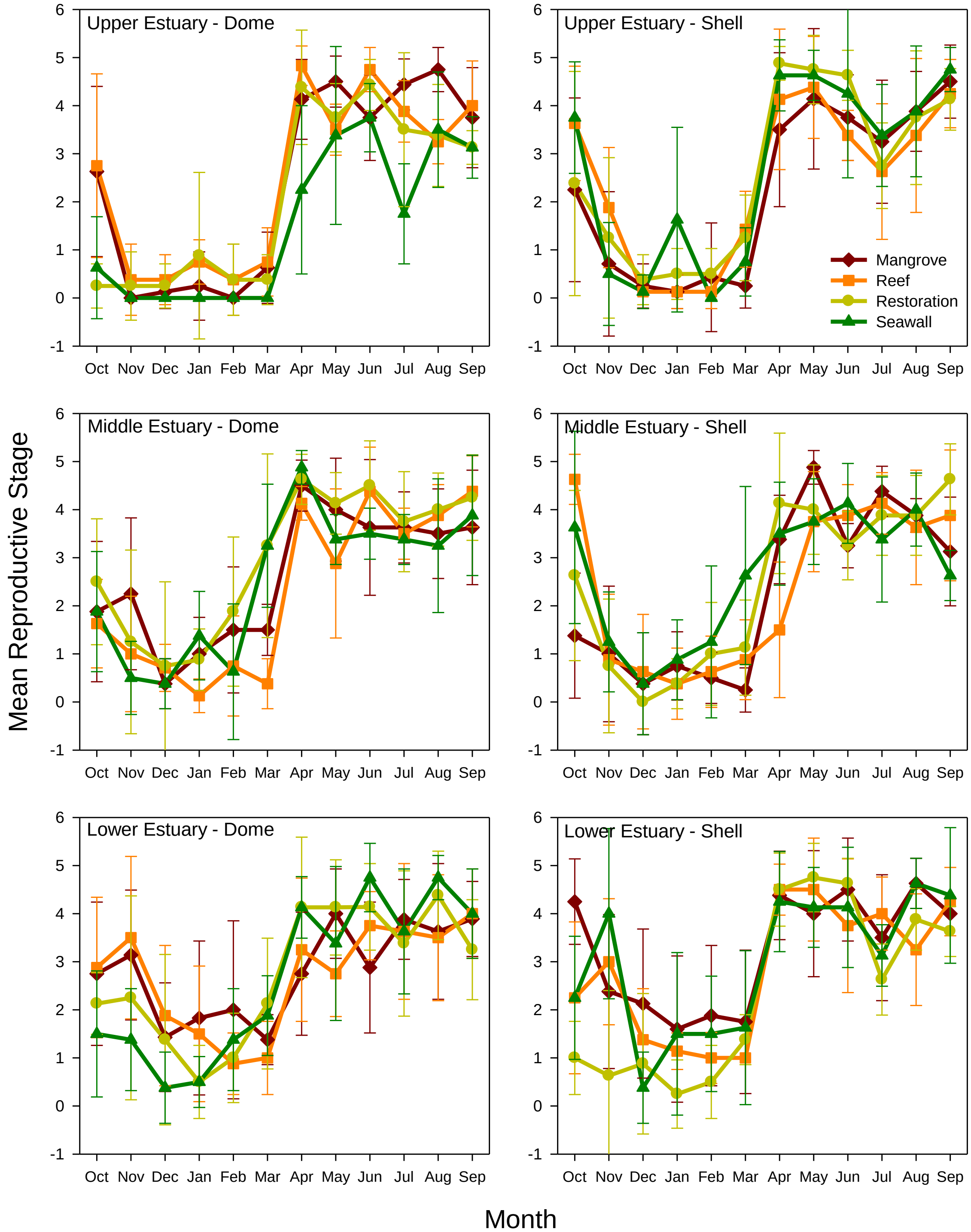

Figure 11. Mean reproductive stage (± SD) of oysters collected from each habitat/station over a 12-month period from October 2008 to September 2009.

Fecundity

Oyster fecundity was highly variable between individual oysters collected within each station. Month (P<0.001), site (P=0.0005), and the interaction of habitat and month (P=0.0153) were all found to have a significant effect on oyster fecundity (Table 8). No significant differences in mean fecundity were detected between habitats (P=0.2304). Fecundity generally dropped from intermediate values at the onset of the study through January, though the pattern for individual habitats was quite variable (Figure 12). The overall mean in all habitats was highest for the period from April through June, followed by a drop in fecundity in oysters from all habitats, then a gradual increase again through the end of the study in September. The upper estuary sites appeared to have a longer winter resting period, with almost no eggs detected in females for the months of December through March (Figure 13). The middle and lower estuary sites had comparatively shorter winter periods when no females had detectable numbers of eggs. A 2L:1 ratio of female to male oysters was found to be largely similar between habitat types.

Table 8. Tests of fixed effects fecundity measured as the mean number of oocytes per individual. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	Num DF	Den DF	F Value	Pr > F
Habitat	3	530	1.44	0.2304
Month	11	172	10.98	<0.0001
Site	5	103	4.81	0.0005
Habitat*Month	32	444	1.65	0.0153

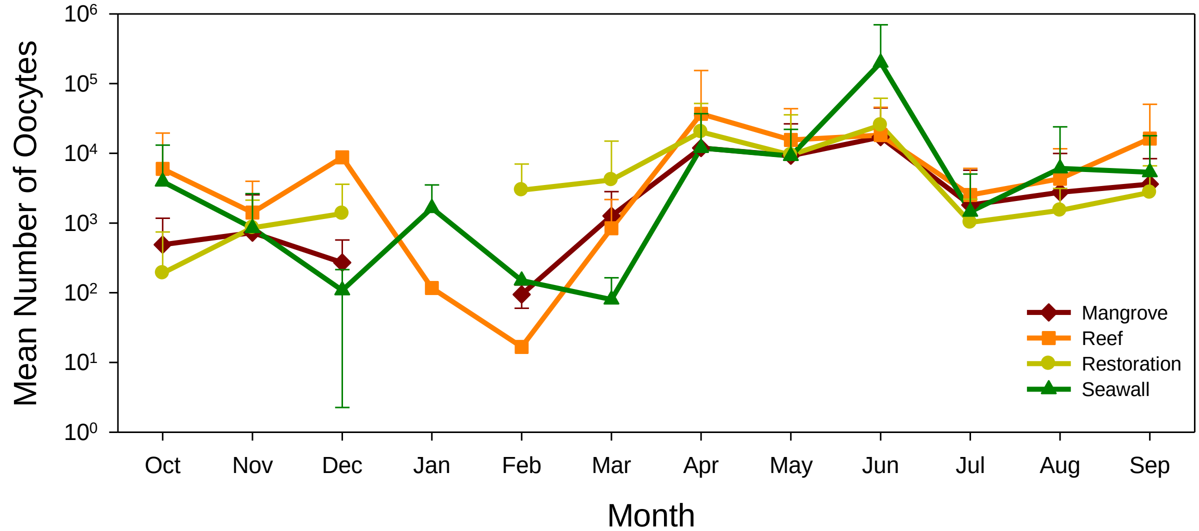

Figure 12. Mean fecundity (± SD) of oysters collected from mangrove, reef, restoration, and seawall substrates over a 12-month period from October 2008 to September 2009. Gaps in data are associated with the lack of mature females from any given habitat and month and coincide with low mean reproductive stage (Figure 10).

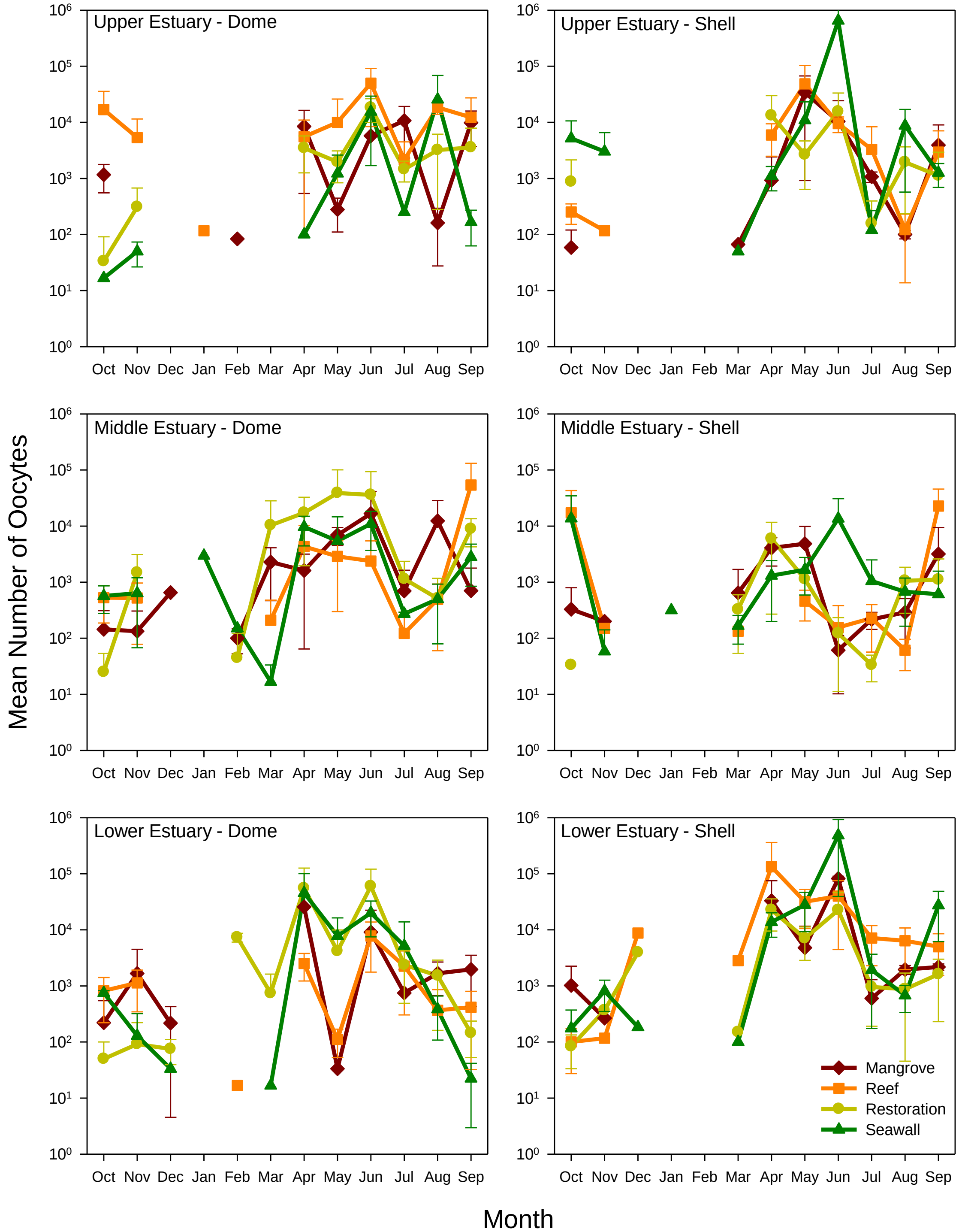

Figure 13. Mean fecundity (± SD) of oysters collected from each habitat/station over a 12-month period from October 2008 to September 2009. Gaps in data are associated with the lack of mature females from any given site and month and coincide with low mean reproductive stage (Figure 11).

Recruitment

Recruitment was significantly different among sites (P=0.0020) and months (P<0.0001) (Table 9). No significant differences were detected between habitats and the interaction of habitat and time. Recruitment rates (number spat/shell/month) were statistically similar and highest in the mangrove (6.20), reef (5.62), and seawall (6.79) habitats but lower at the restoration stations (3.68). Seasonally, recruitment rates peaked in all four habitats during the month of July (Figure 14). At the onset of the study (September-October), all habitats had some recruitment, though the level was low. Recruitment continued to decline until no spat were detected on stringers retrieved in January, February and March from any of the habitats. Seawall and restoration sites had few spat (<1 spat per shell) on stringers retrieved during the month of April but all four habitats experienced some level of recruitment during the month of May. The mean number of spat per shell increased from the May through July retrievals. Peak recruitment rates for each habitat during the month of July were 16.5 ± 18.0 (mangrove), 14.9 ± 21.0 (reef), 13.1 ± 16.0 (restoration), and 17.0 ± 22.2(seawall) spat per shell. A sharp decline in observed spat per shell occurred during August in the mangrove, reef, and restoration sites while seawall recruitment only declined slightly to 15.2 ± 20.9 spat per shell. Recruitment dropped below five spat per shell in all four habitats during September. When comparing sites, significant variation was observed, but no discernable pattern could be detected (Figure 15). Highest levels of mean recruitment were observed in the upper estuary dome site (9.0) while lowest rates occurred in the upper estuary shell site (2.4). All of the sites followed the basic pattern of low numbers of recruits in the fall, no recruits in the winter, followed by increasing numbers of recruits in late spring until recruitment peaked in early summer.

Table 9. Tests of fixed effects of recruitment measured as the mean number of spat per azoic oyster shell. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	Num DF	Den DF	F Value	Pr > F
Habitat	3	141	1.28	0.2828
Month	11	756	36.88	<0.0001
Site	5	126	4.03	0.0020
Habitat*Month	33	750	1.13	0.2806

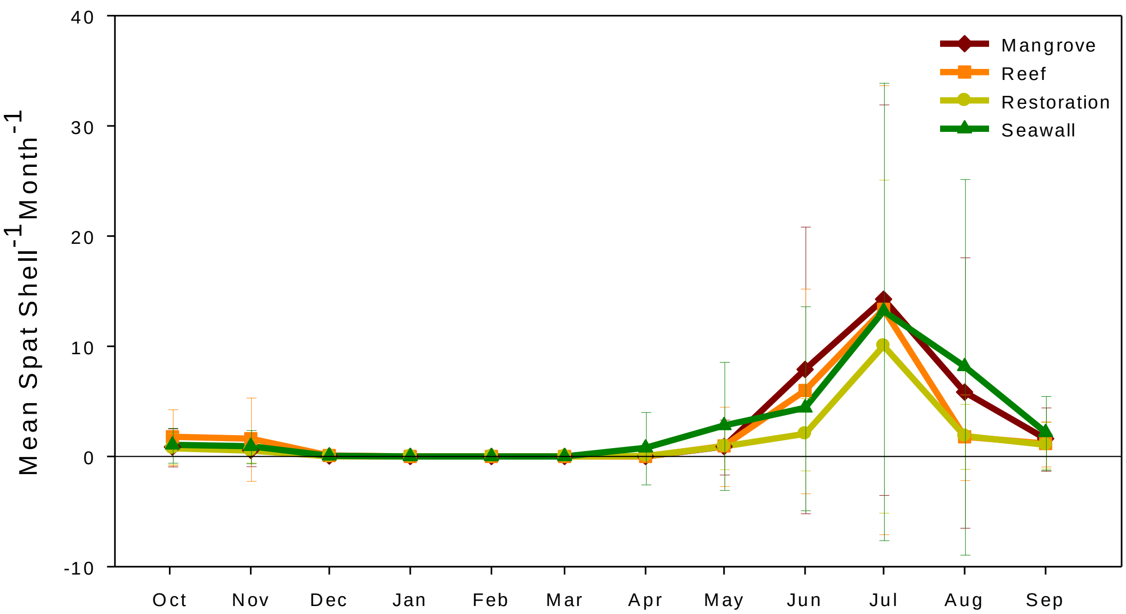

Figure 14. Oyster recruitment, measured as mean spat per shell (± SD) collected over approximately four week intervals, from spat arrays placed in mangrove, seawall, restoration, and reef habitats over a 12-month period from October 2008 to September 2009.

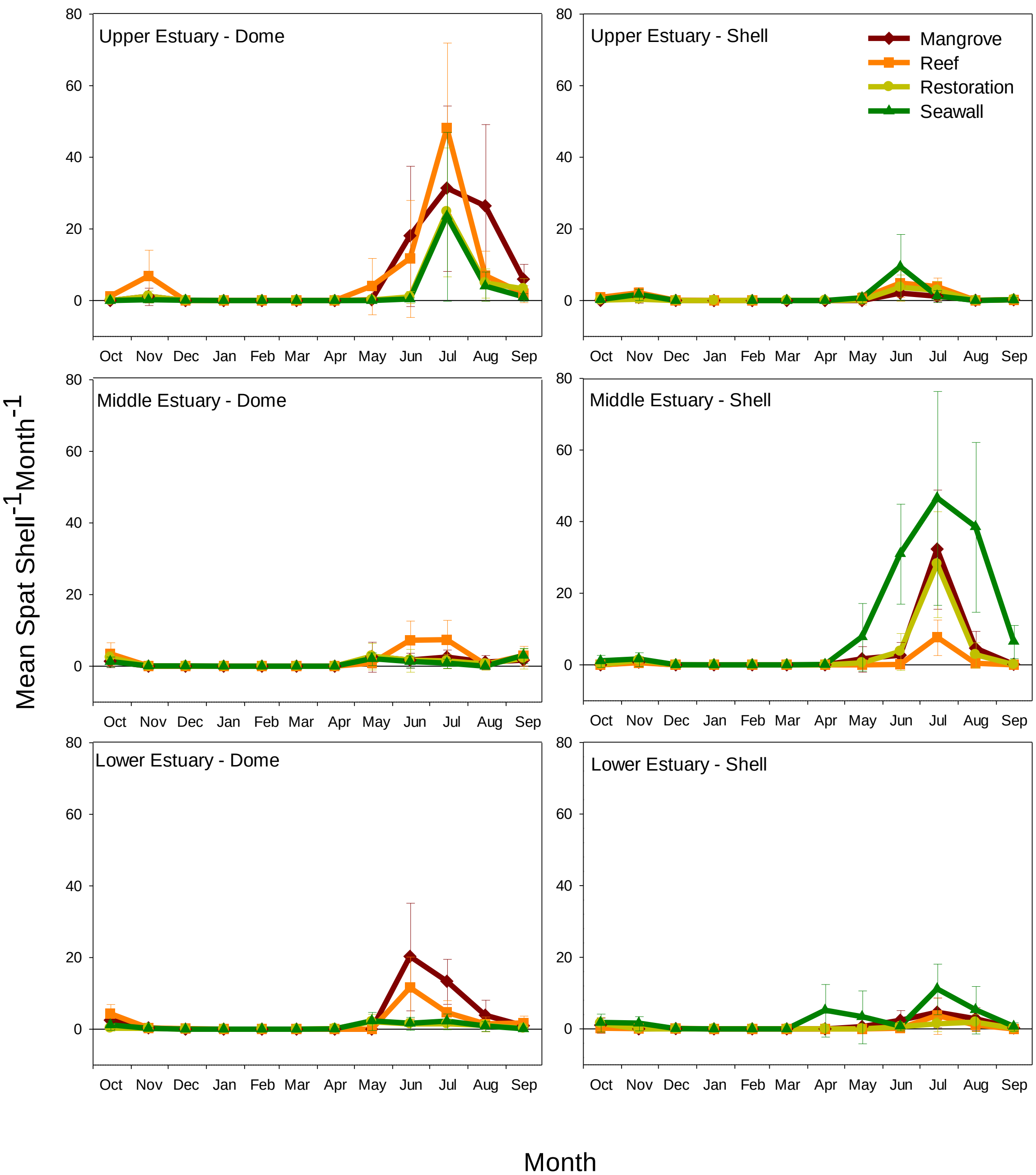

Figure 15. Oyster recruitment, measured as mean spat per shell (± SD) collected over approximately 4 week intervals, from spat arrays placed in each habitat/station over a 12-month period from October 2008 to September 2009.

Single Event Parameters

Size, Density, and Biomass

Oyster density varied significantly by habitat, site, and the interaction of the two factors ($P<0.0001$; Table 10). Although plots of the raw data show seawall and restoration habitats as having the highest mean oyster densities (Figure 16a), mangroves actually had significantly higher mean and median densities ($P<0.001$; Table 10). This is likely due to lower variability in samples collected from mangrove stations (1,780 ± 836 oysters m^{-2}; median=1620 oysters m^{-2}), i.e., those samples are consistently higher than those from seawall (2,410 ± 3477 oysters m^{-2}; median = 1118 oysters m^{-2}) and restoration (1,878 ± 2,526 oysters m^{-2}; median = 1140 oysters m^{-2}) substrates. Also, there were a few restoration and seawall samples from ME-S site that were an order of magnitude higher in density and these likely skewed the raw means higher for those two habitats. Reefs unequivocally had the lowest oyster densities across the entire bay (1,068 ± 744 oysters m^{-2} median = 914 oysters m^{-2}). Mangrove stations had a mean oyster density that ranged from 1,197 oysters m^{-2} at the LE-S site to 2,394 oysters m^{-2} at the UE-D site. Oyster reef stations had a minimum of 558 (LE-D) and a maximum of 1,554 (UE-D) oysters m^{-2}. Dome restoration sites ranged from 752 (LE-D) to 1,560 (UE-D) oysters m^{-2}, and shelled sites ranged from 664 (LE-S) to 4,570 (ME-S) oysters m^{-2}. Oyster density on seawalls ranged from 509 (UE-S) to 9,312 (ME-S) oysters m^{-2}. In general, all of the habitats in upper and mid estuary sites had significantly higher densities than those in the lower estuary (Figure 17). Only one lower estuary station, MG-LE-D, had a mean density greater than 2,000 oysters m^{-2}. The restoration and seawall stations within the ME-S site had notably higher densities than any of the other stations with individual quadrat measurements as high as 20,244 and 18,236 oysters m^{-2} respectively. No clear pattern between the significance of the habitat and site interaction term was observed.

Table 10. Tests of fixed effects of oyster density measured as the number of oysters m^{-2}. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	Num DF	Den DF	F Value	Pr > F
Habitat	3	330	22.9	<0.0001
Site	5	330	40.62	<0.0001
Site*Habitat	15	330	17.11	<0.0001

Shell height varied significantly between habitat, site, and the interaction of the two terms (Table 11). Oyster reefs (37.9 ± 14.6) and restoration substrates had significantly higher mean shell heights (37.7 ± 15.1) than mangrove (32.1 ± 13.8) and seawall stations (33.4 ± 14.9) across the entire bay (Figure 16b). Mean shell heights at the LE-D and LE-S sites were significantly higher than those at the ME-D site, which were significantly higher than the remaining mid- and upper-estuary study sites (Figure 18). The relationship between individual dry tissue weight (DW) and shell height (SH) is described by the equation $DW = 0.0003 \times SH^{1.9072}$.

Table 11. Tests of fixed effects of oyster shell height. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	Num DF	Den DF	F Value	Pr > F
Habitat	3	3515	41.54	<0.0001
Site	5	3515	45.09	<0.0001
Site*Habitat	15	3515	3.23	<0.0001

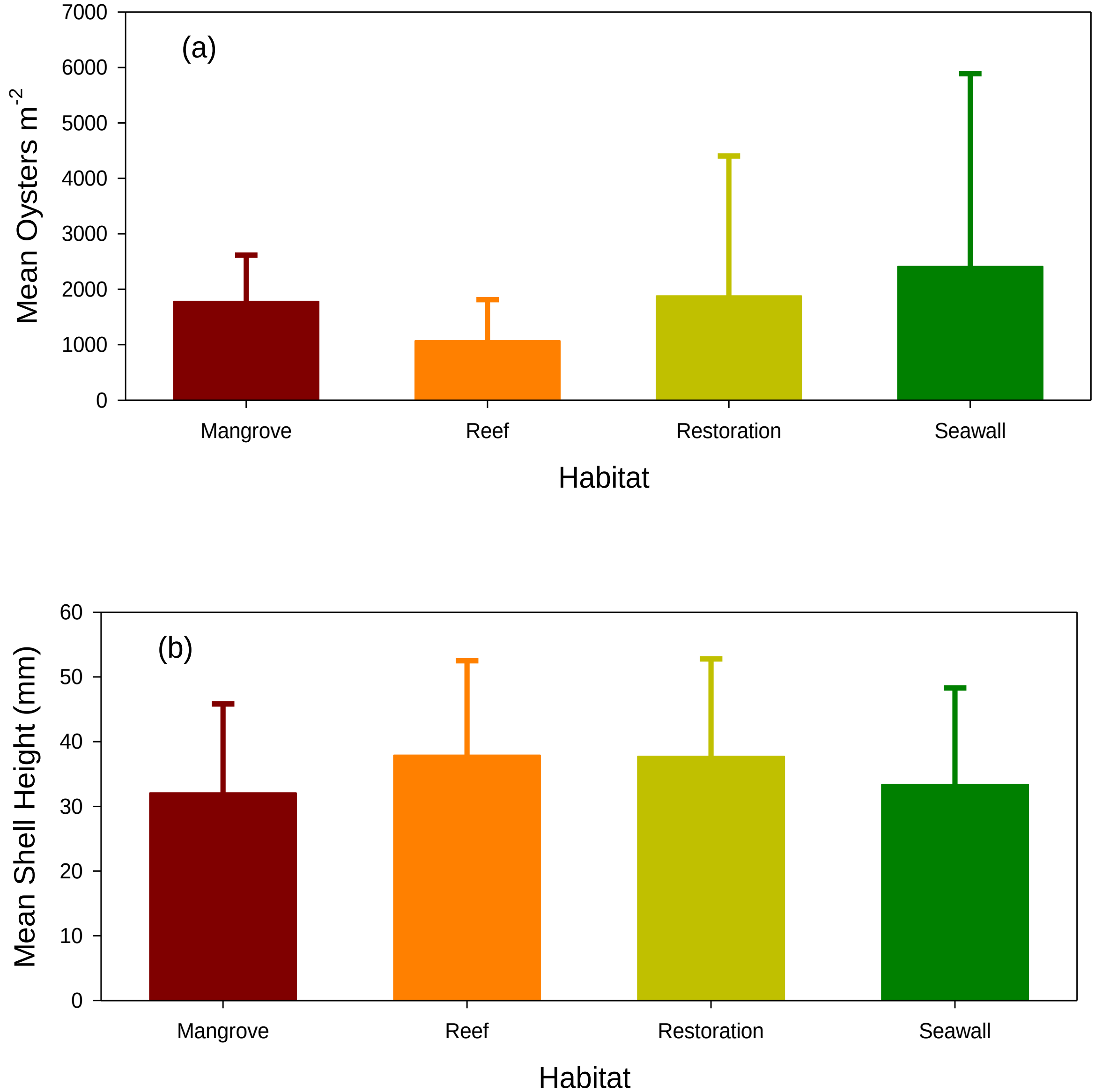

Figure 16. Mean oyster density per square meter (± SD) (a) and live oyster shell height (± SD) (b) in mangrove, reef, restoration, and seawall habitats during March 2009.

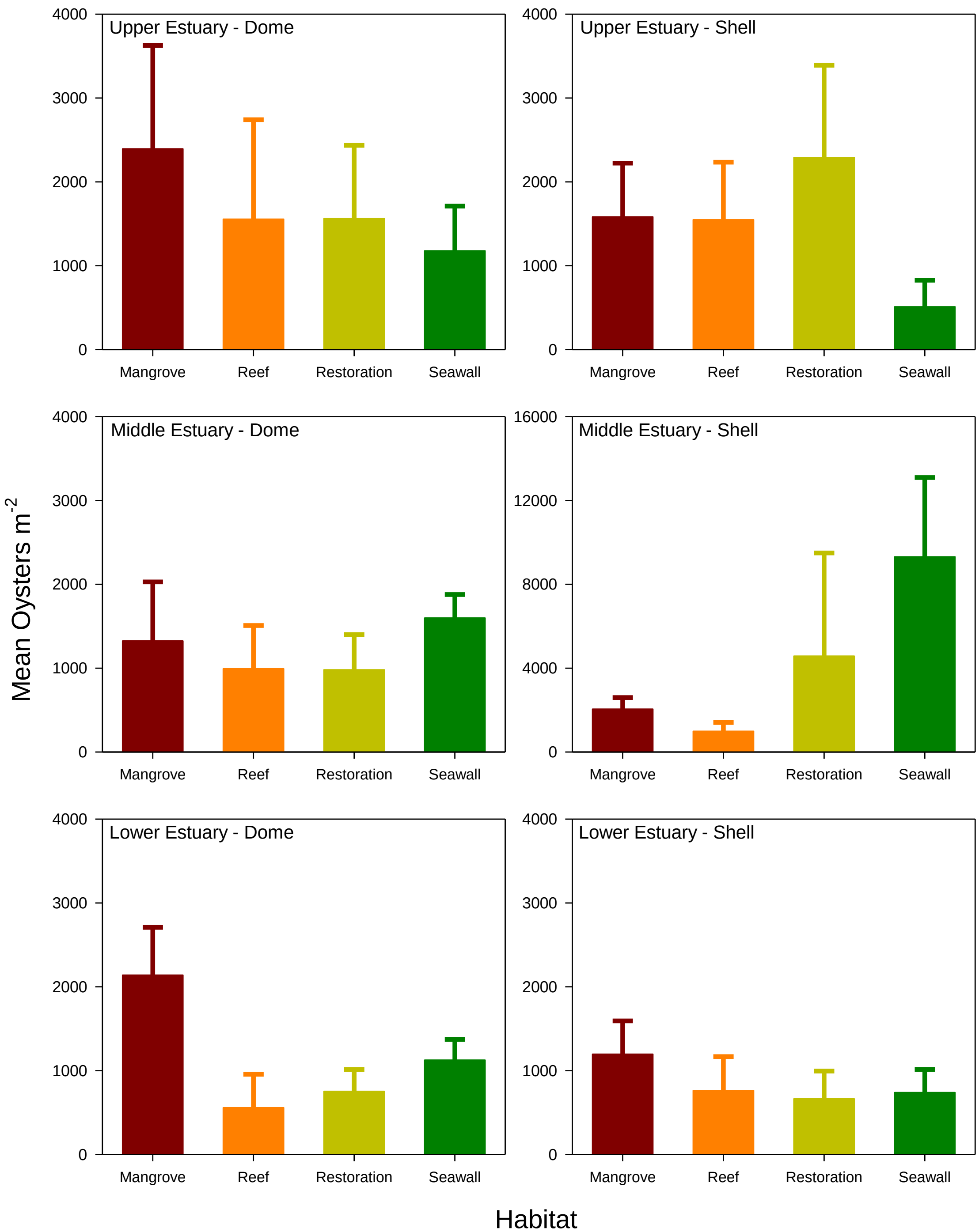

Figure 17. Mean oyster density (± SD) from each habitat/station in March 2009.

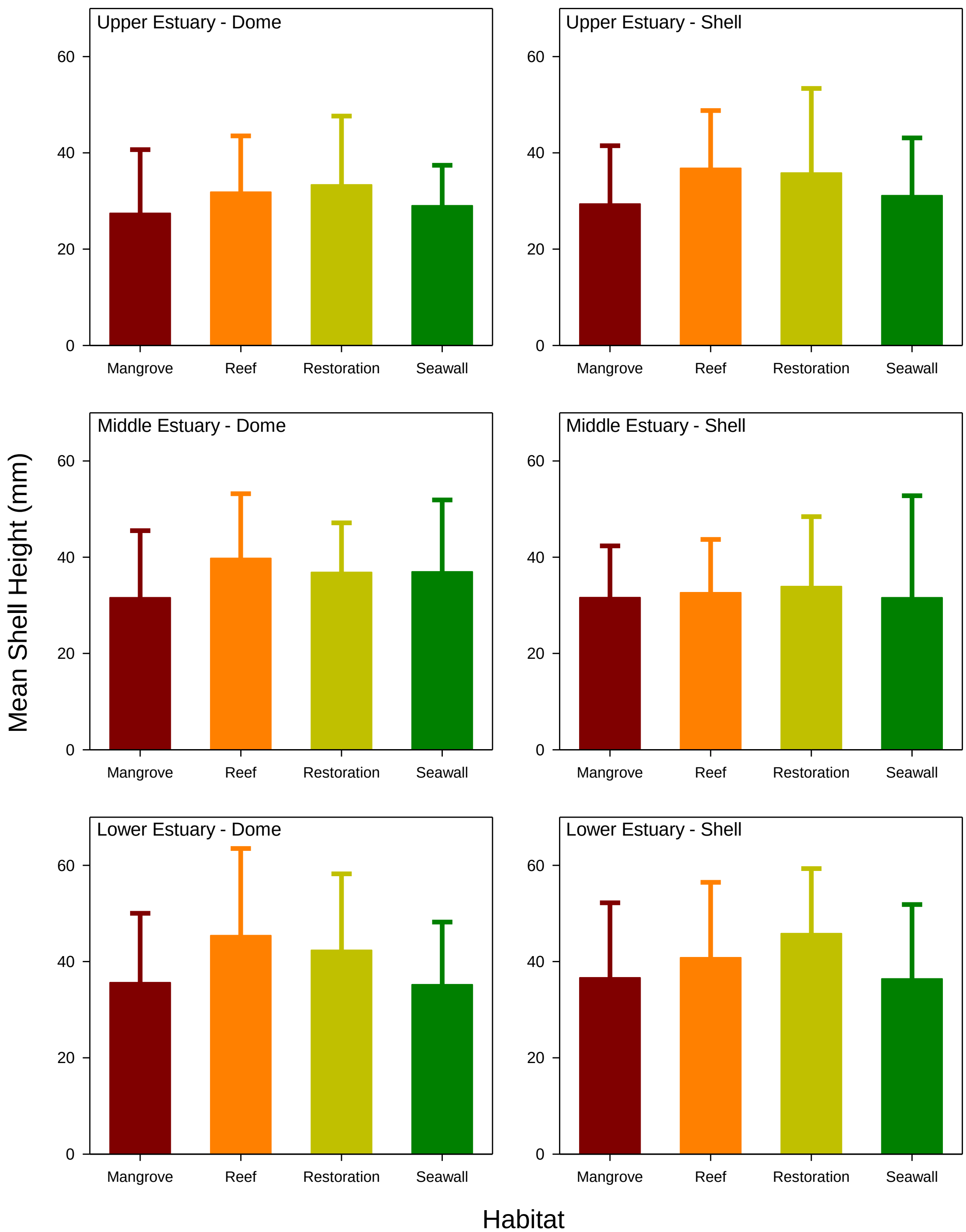

Figure 18. Mean live oyster shell height (± SD) from each habitat/station in March 2009.

Community Composition

Approximately 150 taxa representing 10 different phyla were collected from sampled locations in Tampa Bay. On average, 32 taxa were found at any individual station. Although the catch was diverse, only a few species accounted for the majority of species identified. Overall, the southern ribbed mussel, *Geukensia granosissima*, was the most abundant organism, contributing nearly 21% of the total, followed by *Crassostrea virginica* and the barnacle species complex, which each contributed approximately 15%. Other abundant taxa included the polychaetes *Polydora websteri* (7%) and members of the family Syllidae (4%), as well as taxa from the tanaid family, Leptocheliidae (4%). Not surprisingly, molluscs were the largest contributing phylum, supplying 43% of the total, with 40% contributed by bivalve molluscs alone (Figure 19). Other abundant phyla included arthropods (33%) and annelids (19%). Comparisons of phyla contributions by habitat for each site are presented in Figure 20.

The bivalves were dominated by *C. virginica*, *G. granosissima*, and *B. exustus*. The contribution of *C. virginica* to the bivalve group was fairly consistent at 20 to 40 percent and was not the most abundant bivalve overall. Oyster reef stations had the lowest density of bivalves. Seawall sites had the highest density of bivalves with a maximum of 1.19×10^5 individuals m^{-2} of seawall. *Crepidula spp*. were the most abundant gastropods with a maximum density of 7.05×10^3 individuals m^{-2}. *Boonea impressa*, an ectoparasite of *C. virginica* (White et al., 1988) was also found in densities as high as 1.49×10^3 individuals m^{-2}. The major contributor among the polychaetes was the *Polydora* complex, with a mean maximum abundance of 1.19×10^4 individuals m^{-2}.

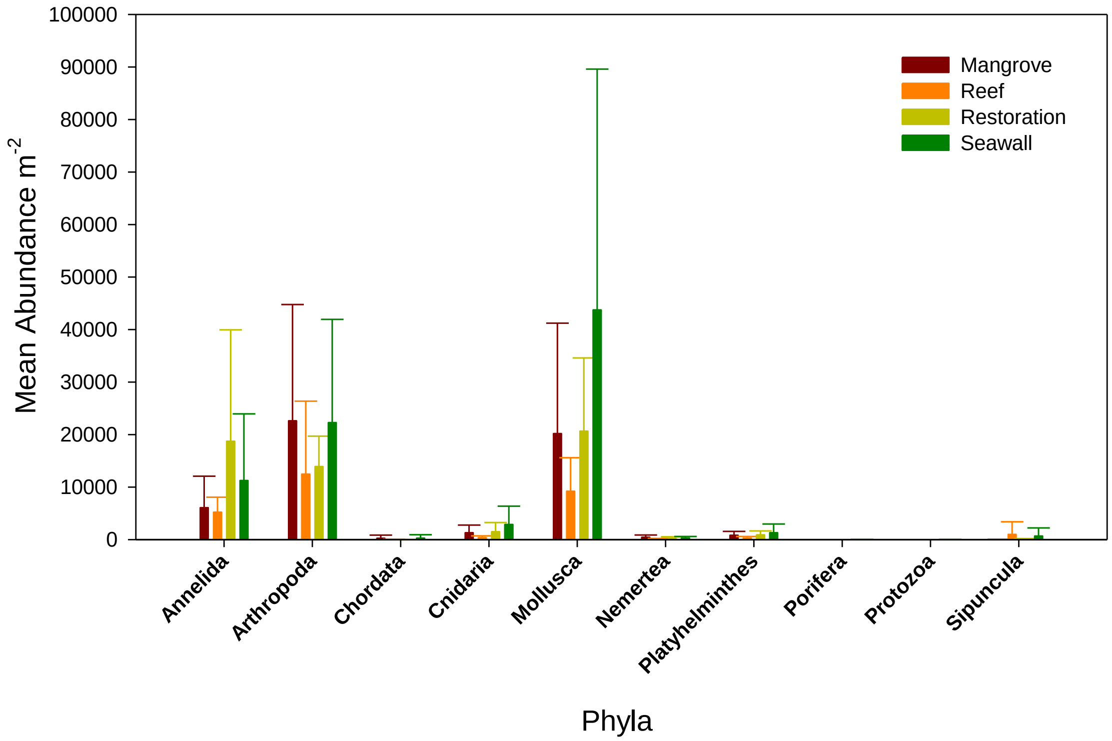

Figure 19. Mean abundance (±SD) of phyla in mangrove, reef, restoration, and seawall habitats.

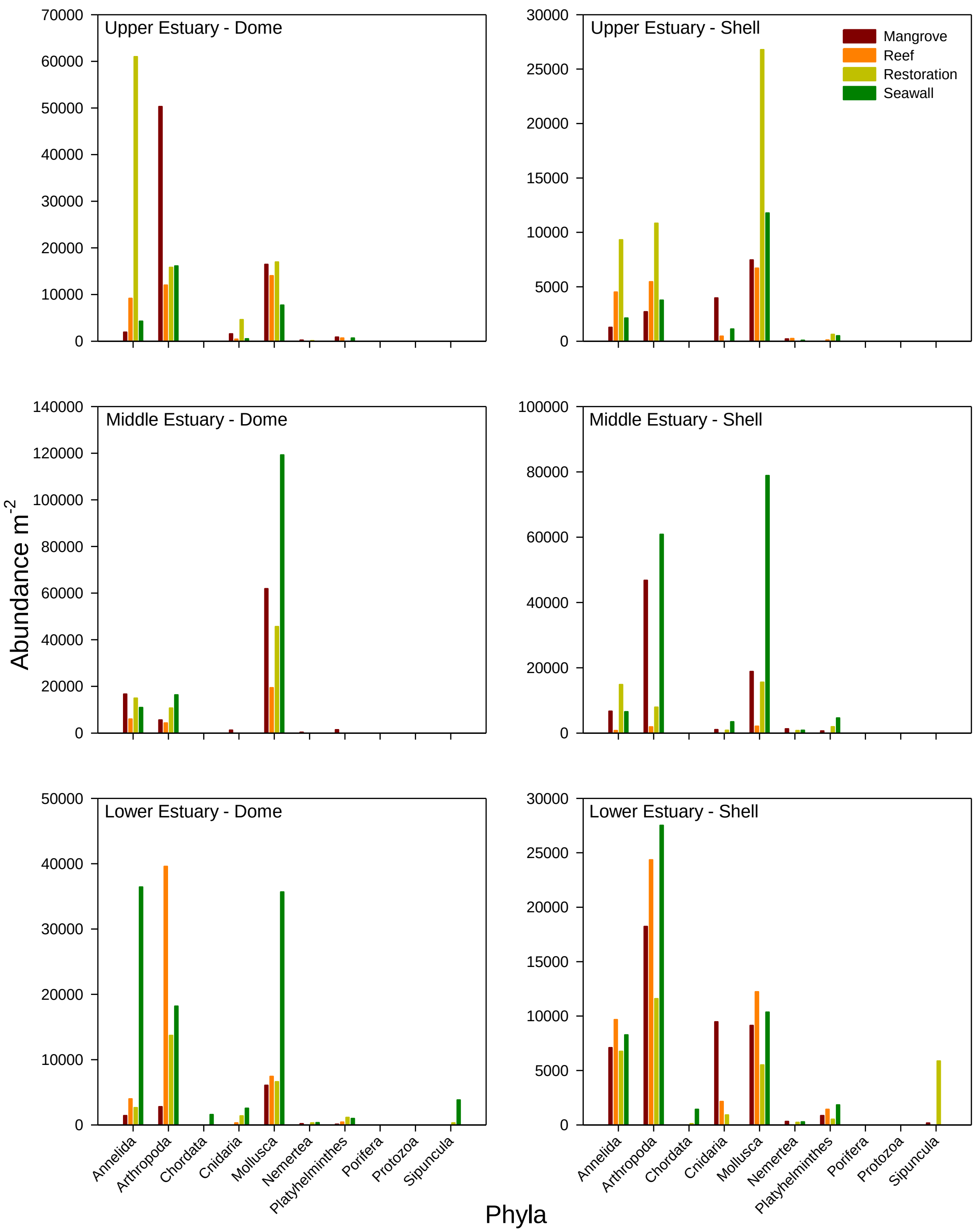

Figure 20. Abundance of phyla from each habitat/station. Note differences in scale.

Stations in the lower estuary contained markedly fewer individuals from the *Polydora* complex compared to the mid- and upper-estuary study sites. Other abundant polychaetes included *Syllidae* spp., Spirorbidae spp., *Serpula vermicularis,* and *Neanthes succinea*. The group of tanaids was dominated by species from the Leptocheliidae family, with a maximum density of 2.07×10^4 individuals m^{-2}. The two most abundant amphipods throughout every station were *Laticorophium baconi* and *Parhyale hawaiensis*, with 2.04×10^4 and 5.28×10^3 individuals m^{-2} respectively. Xanthid and porcelain crabs comprised the majority of the decapods and were found in maximum densities of 5.95×10^3 and 2.21×10^3 individuals m^{-2} respectively. Isopods consisted mainly of the species *Sphaeroma quadridentata* and were found at a maximum density of 2.76×10^4 individuals m^{-2}.

When comparing overall abundances among habitats, seawalls had the highest densities, with a mean of greater than 8.00×10^4 individuals m^{-2}, followed by restoration and mangrove habitats, which had intermediate densities of approximately 5.00×10^4 individuals m^{-2}. Reef densities were the lowest with a mean density of approximately 2.90×10^4 individuals m^{-2}. Both *C. virginica* and *G. granosissima* were dominant species within each of the four habitats, although not usually the most abundant (Appendix 2). In the mangrove and seawall habitats, barnacles also contributed substantially to overall densities. The isopod *Sphaeroma quadridentata* was the most abundant species in reef habitat, while *P. websteri* dominated in restoration habitat.

Among the different study sites, the middle estuary sites had the greatest mean densities (dome $>8.30 \times 10^4$ individuals m^{-2} and shell $>6.90 \times 10^4$ individuals m^{-2}). Within both sites, the highest abundances were again found in the seawall habitat, which were an order of magnitude greater than abundances found in the other three habitats. In both middle estuary sites, reef abundances were the lowest with approximately 3.00 x 10^4 individuals m^{-2} at the dome site and only 4.78 x 10^3 individuals m^{-2} at the shell site. The upper estuary-shell site had the lowest overall densities with approximately 2.50 x 10^4 individuals m^{-2}. The other four study sites were intermediate with densities ranging from approximately 4.40 x 10^4 to 6.90 x 10^4 individuals m^{-2}.

Dominant species in each study site differed substantially, but *C. virginica* was always within the top five contributors and in fact was the top contributor in the upper estuary-shell site, supplying 39% of the overall sample (Appendices 3-8). In the middle estuary-dome site, *G. granosissima* contributed 66% of the total sample. Within most sites, two or three taxa dominated and contributed more than 70% of the entire sample. However, in both lower estuary sites the dominant taxa contributed a smaller percentage, suggesting that there was more even representation among taxa in those samples.

Biodiversity, calculated by Shannon's diversity index (Shannon and Weaver, 1949), was found to be similar among all four habitats (P=0.609) but significantly different among sites (P=0.025; Table 12). Samples from the lower estuary-shell site had the greatest mean diversity (2.45 ± 0.14) and mean total taxa count (96), while those from the middle estuary-dome site had the lowest diversity (1.47 ± 0.33) and an intermediate taxa count (57). The lowest taxa number occurred in the middle estuary-shell site (46) which along with the remaining three sites all had intermediate mean diversities, ranging from 1.84 ± 0.32 to 2.27 ± 0.52.

Table 12. Tests of fixed effects of Shannon's Diversity Index. Results of each type of fixed effect (Effect), numerator degrees of freedom (Num DF), denominator degrees of freedom (Den DF), F value (F Value), and corresponding probability (Pr > F) are displayed

Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Habitat	3	15	0.63	0.609
Site	5	15	3.59	0.025

Cluster analysis of mean organism abundance at each station did not reveal any distinct groupings among habitat types (Figure 22). Instead, study site and strata were more similar to one another regardless of habitat type. Four statistically distinct clusters (A, B, C, D) of the 24 stations were found. Of those 24 stations, 8 were determined to be outliers, and the remaining 16 fell into one of the four clusters. Cluster A was comprised of five stations, all of which were from the two lower estuary sites. Cluster B included the four stations found within the ME-D study site. Cluster C contained three stations, two of which were from the UE-S site, as well as the ME-MG-D station. Likewise, Cluster D contained three stations from the UE-D study site and the ME-MG-S station. Major contributors to the similarity within groups and the dissimilarity between groups were driven by the abundance of of barnacles, *Polydora* spp., *C. virginica, and Leptochilidae* spp.

DISCUSSION

Oysters are most commonly associated with reef complexes located just offshore at depths ranging from intertidal to several meters, though most oysters in Florida are found at depths from 0-2 meters (MacKenzie et al., 1997). One of the most common other natural habitats where oysters are also found are among the prop roots of mangroves (common in Tampa Bay) and in salt marshes (relatively uncommon in Tampa Bay). Data from oysters in these alternate natural habitats in Florida were previously lacking. The assumption for this study was that ecosystem contributions of oysters in non-reef habitats (mangrove, reef, and restoration substrates) were comparable to reef-dwelling oysters. As a first step in the analyses, the data were examined for each metric to see if a detectable difference could be observed among the four habitats (with consideration for season where appropriate), and then further if any patterns existed among habitats within each of the six sites.

The oysters monitored in Tampa Bay from October 2008 to September 2009 exhibited similar values for biological metrics (condition index, disease load, reproductive stage, oocyte production, recruitment, density, and shell height) to oysters monitored in previous studies (Arnold et al., 2008). The predominant source of variability was a seasonal signal, with smaller contributions from both site location and habitat. The values of biological metrics from oysters dwelling on non-reef habitats were generally determined to be similar to those in reef habitat.

The community composition of fauna dwelling on differing oyster habitats varied across sites but no differences were detected in biodiversity among habitats. The relative contributions of oysters dwelling on each habitat to the ecology of the total oyster population within Tampa Bay is more dependent on the spatial extent of each habitat and the density at which oysters occur on that habitat than on the actual type of habitat they occupy.

Monthly Parameters

The observed physical environmental parameters (salinity and temperature) were comparable to recent oyster studies, but did not exhibit the full range of estuarine conditions anticipated in the study design. In Florida estuaries, oysters are typically distributed over a large range of salinities, as low as low teens (Tolley et al., 2005) and even zero (Wilson et al., 2005; Arnold et al., 2008) to near normal marine seawater. During this study, temperatures followed a typical seasonal pattern for a subtropical estuary but salinities remained near or above optimal for oyster growth. Previous observations on lower Tampa Bay oyster reefs documented salinities of around 30 ppt for the duration of a three-year study (Arnold et al., 2008), much like those observed in this study. Measurements from upper Tampa Bay were expected to reach 10 ppt or lower as described in previous studies (McBride et al., 2001; Sheng and Yassuda, 1995) but remained above 20ppt. There was a summer decline in salinities in upper estuary sites, and an even more pronounced decline at middle estuary sites, which were closer to freshwater sources despite being geographically closer to the mouth of the bay.

Measures of condition in oysters can be highly variable, even within single studies covering multiple years. Arnold et al. (2008) describe three patterns of condition in Tampa Bay oysters in three years of observation: a winter peak with a gradual decline through summer, a bimodal trend with late spring and early fall peaks, and a single mid-summer peak. Similarly, oysters in the St. Lucie estuary can have winter, summer and bimodal peaks in condition (Wilson et al., 2005). As described in the results, as a general pattern, oyster condition observed in the present study peaked in late winter, then declined through summer, with modest rises again in late summer. This pattern was most pronounced in oysters collected from the ME-D site, but was also observed at LE-D and LE-S sites. There was almost no discernable pattern at the middle estuary and upper estuary shell sites and there was a more pronounced summer peak at the upper estuary dome site.

Of the two main diseases that have impacted oysters in the eastern United States, dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*), only dermo causes significant mortality in the Gulf of Mexico (Ford and Tripp, 1996). In this study, oysters from natural reefs had the highest dermo infection prevalence and intensity and oysters from all other habitats had lower rates, with restoration sites being the lowest.

As expected, prevalence and intensity were highest during late summer and early fall. In most estuaries, the fresher areas of the oyster range offer a refuge from dermo infection. However in this study, the highest rates of infection and highest intensity occurred in upper and then mid estuary sites, with lower estuary sites actually having lowest infection rates in most months. Thus, the disease impact appears to be heaviest near areas with optimal physical conditions for oysters, and less so in the higher salinities believed to be unfavorable to oysters. Sites with optimal conditions for oyster growth are likely to sustain older individuals over time. Paynter et al. (2010) noted a marked increase in dermo intensity and prevalence in oysters over six years of age. Oyster populations less than six years of age experienced 40% prevalence, while those older than six years experienced up to 90% prevalence. Because oyster reefs have greater longevity relative to mangrove prop roots and newly planted restoration substrates, oyster reefs may support an older population of oysters. The increased presence of dermo at sites favorable to oysters may ultimately be a function of the age and survival of oysters at any given site or habitat.

Despite the significant differences detected between habitats and sites in Tampa Bay, the means of infection intensity were low relative to lethal infection levels. While lethal levels are difficult to precisely define, biological functions appear to be impacted when infection intensity reaches three (moderate) and decline dramatically at levels four and five (Ford and Tripp, 1996). No mean monthly values for any individual station for any month exceeded a mean intensity of stage two. Therefore, it is unlikely that dermo serves as a significant impediment to the physiological function of oysters from any habitat found within Tampa Bay. However, the potential for rapid mortality of infected oysters at the high temperatures and salinities seen in Tampa Bay may be biasing this conclusion; i.e., the odds of finding high infection intensities are reduced because those oysters die quickly and are unlikely to be sampled, leaving relatively more healthy oysters (Wilson et al., 2005; Ford and Tripp, 1996).

Most studies on *C. virginica* examining reproductive activity utilize the scheme of reproductive stages first characterized by Kennedy and Battle (1964), then standardized on a scale of 1-10 by Fisher et al. (1996). This scale can actually be interpreted as a cyclic scale in places where oysters live longer than one year. The two ends of the scale, 0 and 10, represent conditions furthest from reproduction: 0 or neuter gonads where no gametogenesis has begun, and 10 where cytolysis of decaying gametes is nearly complete. The middle of the 10-point scale, 5, indicates that the animal is ripe and ready to spawn. In some analyses, authors "fold" the scale – such that the lower the score, the farther the oyster is from spawning (Volety et al, 2009). This method was utilized in this study. Most of the variability in reproductive stage observed was due to seasonal fluctuation, with minor variability due to site. Reproductive stage did not differ among habitats. In all habitats there was a rapid increase in reproductive stage from March to April, corresponding to rising temperatures in spring, although some sites experienced a slow increase in February. Mean reproductive stage fell furthest and increases were most pronounced in the upper estuary, where temperatures were coldest in the winter and climbed most rapidly in spring. Changes in mean reproductive stages were least pronounced in the lower estuary, where temperatures were likely modified by tidal exchanges with the Gulf of Mexico.

Fecundity in bivalves can be estimated by several different methods. Early studies simply counted the number of eggs released when the females spawned (Galtsoff, 1964). Those data suggest 10-20 million eggs could be produced by a female in a single spawn. Another study, which accounted for size of the oyster, produced more variable estimates ranging from 10,000 to 66.4 million per spawn (Davis and Chanley, 1956), but also allowed each oyster to spawn over a two-month period. This method relied on relatively ripe females, which can be induced to spawn by manipulation of some environmental factor such as temperature, salinity, or light cycle. Unfortunately, this process can be very time consuming and only allows for fecundity estimates in very ripe animals. Barber et al. (1988) used histological methods to determine fecundity, which is usually costly and labor intensive and comes with many caveats, but does provide fecundity estimates regardless of developmental stage. The method adopted for this study involves the maceration of the gonadal tissue (Cox and Mann, 1992) and is cruder than other techniques, but has the advantages of ease of use and the ability to estimate fecundity of female oysters regardless of reproductive stage. The apparent fecundity observed in this study was much lower than that observed by Cox and Mann (1992), with a maximum of less than 1,000,000 eggs. However, when adjusted for size, these estimates of fecundity may not be exceptionally low (Thompson et al., 1996). More important to the present study are the relative values observed, since most of the observed variability was related to the seasonal cycle of reproductive development, with some variation related to site differences. Fecundity was generally lowest in winter, when temperature and reproductive stages were also low. Fecundity rose rapidly in spring, when temperatures and reproductive stage also were rising, and dipped in mid-summer followed by a minor resurgence in late summer. As with reproductive stage, habitat had little influence on fecundity, and the majority of oysters within a site basically followed a similar pattern.

Arnold et al. (2008) found that in Tampa Bay most oyster recruitment was limited to three or four months of any given year, and that the peak month varied from June to October. Similar observations have been made in other Florida estuaries. Wilson et al. (2005) showed that the duration and timing of settlement in the St. Lucie estuary and neighboring Indian River Lagoon could vary not only year-to-year, but also between stations within a year. Similar station-to-station variability in recruitment of oysters in the Caloosahatchee River has been observed (Volety et al., 2009) and is presumably the result of less than ideal conditions for either larvae, juveniles or both. In Tampa Bay, in 2009, the highest peak in recruitment occurred in all stations during either June or July. Some stations had other, minor peaks in recruitment. This pattern was played out in all habitats at all sites. The variation between habitats (slightly lower recruitment rates on restoration habitats) was both statistically and biologically insignificant; especially considering the pattern was not consistent from site to site.

To summarize the monthly parameters observed, oysters collected from Tampa Bay sites were concluding their spawning season at the onset of the study in fall 2008. Measures of reproduction were declining concurrent with temperature. Oysters enter a resting stage during the winter, where no reproductive activity occurs and oyster store energy, as evidenced by rising condition indices. Reproductive measures increase in the spring with rising temperatures, followed by spawning in the warm summer months as evidenced by declining condition and peaks in reproductive indices and recruitment. Those seasonal changes predominated over habitat and site-to-site variability. Oysters from alternate habitats recruited juvenile oysters, produced mature individuals, and contributed viable gametes at the same magnitude as oyster reefs and with similar seasonality. As a result, the contributions of oysters from non-reef habitats must be considered in any population-level study of oysters in which alternate habitats occur. The relative contributions of each respective habitat to the overall gametic output and recruitment of the entire oyster population in Tampa Bay will be a function of the density at which they occur on a given habitat, and the extent of that habitat throughout the ecosystem.

Single-Event Parameters

Oyster density, standardized to a square meter of surface area, was found to vary among habitats. On average, mangroves and seawalls had higher densities of oysters than oyster reefs, although the former oysters were found to be smaller than those on oyster reefs. However, this difference among habitats was not consistent among sites. The overall pattern was driven by the very high densities observed on seawalls in the middle estuary and by relatively high densities of oysters in mangrove habitat at dome sites. The abundances of oysters on reefs were lowest at the middle estuary-shell and lower estuary-dome sites. While the differences were quite large, there was no consistent, discernable pattern.

The density of oyster reefs measured in this study, mean value of 1,068 oysters m^{-2}, was higher than those previously measured in Tampa Bay (Arnold et al., 2008) when the highest mean density of oysters measured was only 110 oysters m^{-2}. Those oyster monitoring sites were situated in the lower portion of the estuary, two of which were located closer to the estuary mouth than either of the lower estuary sites monitored in this study. One very likely reason is that oysters in lower Tampa Bay had been recently impacted by a severe red tide event during the 2005-2007 study (Landsberg et al., 2009). Densities were also higher than those observed by Tolley et al. (2005) in south Florida or Arnold et al. (2008) in Florida east coast estuaries and are nearer the targeted living density for the Comprehensive Everglades Restoration Program goals (Volety et al., 2009).

Significant differences were detected in the mean shell heights of oysters collected from mangroves, reef, restoration, and seawall habitats but those differences were quantitatively small, ranging from 32.1 to 37.9 mm. Largest mean oyster shell heights were found in reef and restoration habitats. The differences in shell height also varied between sites. The general pattern was for oysters in mangrove and seawall habitats to be slightly smaller than reef and restoration sites. There was a consistent trend of increasing size from upper to middle and finally lower estuary, which consistently had the largest oysters.

Oyster reefs were consistently found to have the lowest densities within a given site when compared to mangrove, restoration, and seawall habitats. However, oyster reefs were also found to have a significantly higher mean shell height than mangrove and seawall sites. To some extent there is an inverse relationship between the density of oysters and shell height of oysters at a given location, because there is a limit to the available settlement substrate. One factor contributing to this relationship may be the physical orientation of the substrate. Many smaller oysters were found living inside the interstitial spaces in mangrove and seawall substrates similar to those described at the ME-RS-S site. These oysters appear to be size-limited by the space in which they settled. Unlike oyster reefs, mangrove and seawall substrates do not subside with time. Repeated cohort settlement of oysters to the interior portion of mangrove and seawall habitats will only increase the number of these size-limited oysters, decreasing the mean shell height. Alternately, oysters settling on the interior portion of oyster reefs will subside with time with the reef. Furthermore, oysters dwelling on vertically oriented substrates, such as mangrove and seawalls, may be limited in terms of the horizontal distance in which to expand. At some maximum load, the weight of oyster growth will force some portion of that population to break away from a seawall, or break the actual prop root they reside on. The combination of these factors may explain the differences in size and density of oysters between habitat types.

The main ecosystem benefit provided by oysters is their ability to improve water quality by removing particles from the water column, allowing increased light penetration and decreased eutrophication. While differences were detected in the size and density of oysters from different habitats, the rate at which those populations filter water will ultimately depend on the density of their biomass, and not individual density or size. Using the power equation derived to predict individual tissue weight from shell height, the biomass of oyster soft tissues can be determined from each habitat, and are displayed in Table 13.

Table 13. Oyster biomass density of mangrove, reef, restoration, and seawall habitats sampled from Tampa Bay, USA. Dry weight (DW) was calculated from the power function developed in this study comparing shell height (SH) to dry meat weight and is equal to $DW = 0.0003 \times SH^{1.9072.}$ Biomass density was estimated from the mean number of individuals*m^{-2} on each type of habitat multiplied by the corresponding dry weight (DW) of the individual mean shell height

Habitat	SH (mm)	DW (g)	Density (Oysters*m^{-2})	Biomass (g*m^{-2})
Mangrove	32.06	0.224	1780	398
Reef	37.88	0.307	1068	328
Restoration	37.72	0.305	1878	572
Seawall	33.38	0.241	2410	582

These findings suggest that reef and restoration habitats throughout Tampa Bay have fewer, but larger oysters per square meter while mangrove and seawall habitats have more dense, but smaller oysters per square meter. Despite this inverse relationship, estimates of biomass do not indicate a standard carrying capacity in terms of biomass density across each type of habitat. It is worth nothing that estimates of biomass density are based on an individual mean shell height from each type of habitat, and may be explored further.

The total number of taxa (>150) found in this study was much greater than the 42 taxa found on the reef community in Georgia (Bahr and Lanier, 1981), and less than the 248 species identified by Gorzelany (1986) from five rivers along the Gulf coast of Florida. However, Gorzelany identified the majority of organisms to the species level, and further identification of the taxa in this study would likely increase the total species number. Many similar species were abundant in all three studies. Those species included the southern ribbed mussel, *Geukensia granosissima*, and the eastern oyster *Crassostrea virginica*. Other common taxa included the polychaetes of the family Syllidae, blister worms of the *Polydora* species complex, Xanthid crabs, and several amphipods. Those taxa could be considered cosmopolitan in terms of oyster reefs in the southeast, and were found in the three alternate oyster habitats as well. Reef habitat observed in this study had a total mean abundance of 2.87×10^4 individuals m^{-2} which is similar to results from the Georgia study (3.80×10^4 individuals m^{-2}; Bahr and Lanier, 1981) and somewhat greater than the 1.81×10^4 individuals m^{-2} found in soft sediments from Tampa Bay (Grabe, 1998). The dominant taxa found in oysters from this study varied markedly from those found in soft sediments in the same region, providing further evidence for their role as essential fish habitat. The percent contribution of major taxonomic groups from reef habitat also closely resembled that measured by Gorzelany in the rivers north of Tampa Bay (Figure 21). Biodiversity was not found to vary significantly between habitats, suggesting that similar communities exist with oysters regardless of where those oysters reside.

Bahr and Lanier (1981) provided the most comprehensive study of oyster-associated fauna standardized by surface area in the southeastern USA. Densities of *C. virginica* in Tampa Bay were found to be largely similar to the 14.7×10^4 individuals m^{-2} in Bahr and Lanier (1981), ranging between 4.10×10^3 and 1.25×10^4 individuals m^{-2} between all four habitats. Other taxa found to be in agreement include *Neanthes succinea, Streblospio benedicti, Parhyale hawaiensis,* xanthid crabs, and most amphipods. However, the densities of some taxa were found to be an order of magnitude higher in this study relative to those reported in Georgia by Bahr and Lanier (1981). For example, the mean number of barnacles in this study ranged between 1.53×10^3 individuals m^{-2} on oyster reefs to 1.47×10^4 individuals m^{-2} on mangroves compared to 1.25×10^3 individuals m^{-2} found in Georgia oyster reefs. Other taxa found to be an order of magnitude greater included *Polydora websteri*, *Marphysa sanguinea,* and Syllidae spp. Pea crabs (*Zaops ostreum*) were only found in reef-dwelling oysters and were less abundant on reefs from Tampa Bay (3 individuals * m^{-2}) than found by Bahr and Lanier (3 and 24.5 individuals * m^{-2}).

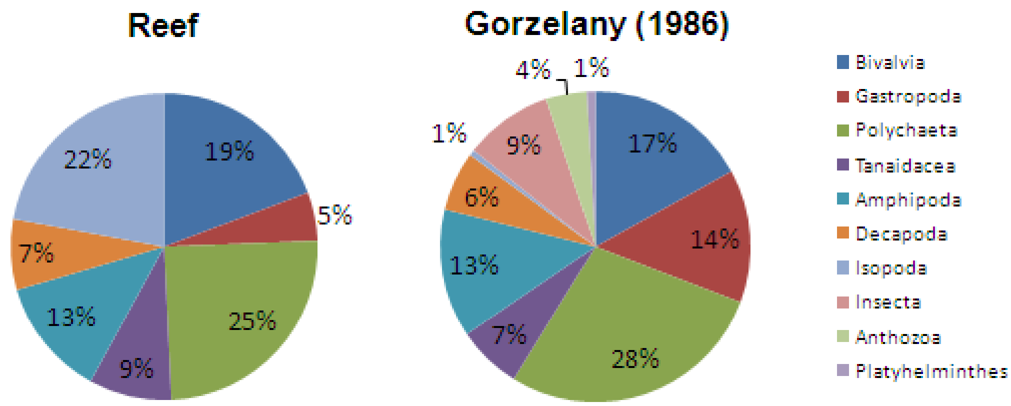

Figure 21. Percent composition of major taxonomic groups collected from reef habitat in the current study and from 5 major rivers on the Gulf Coast of Florida (adapted from Gorzelany, 1986).

No distinct differences in the faunal community between habitats were detected in either biodiversity or multivariate analysis of organism abundance. Significant differences were detected between station and strata. This suggests oyster habitat supports largely similar communities regardless of which habitat they reside on, and those communities will vary by location. Despite these differences, the major contributors to these differences were more dependent on the abundance of several dominant species, and not the presence or absence of particular species.

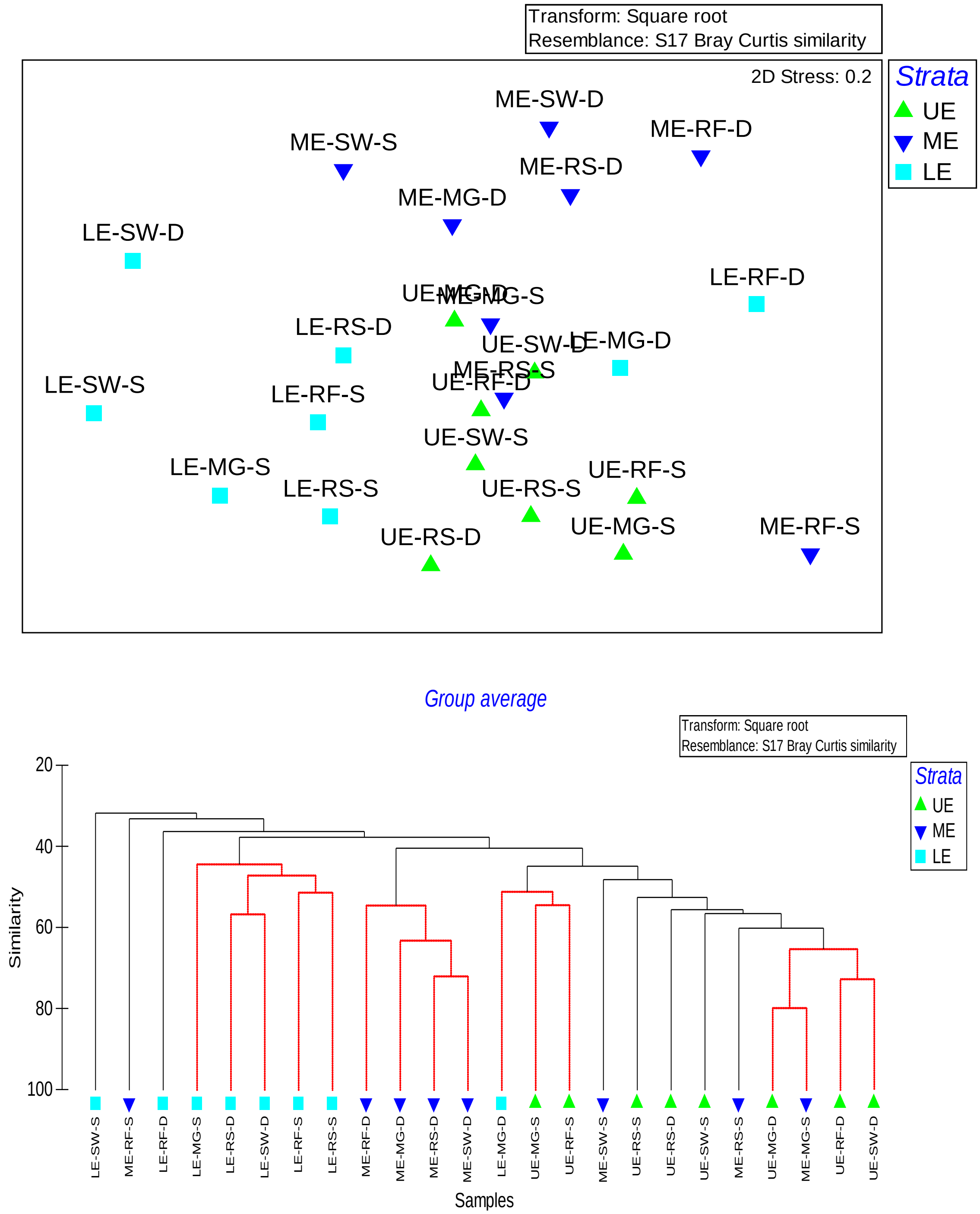

Figure 22. MDS ordination plot (top) and corresponding percent similarity cluster dendrogram (bottom) of the mean organism abundance from each site (UE-D, UE-S, ME-D, ME-S, LE-D, LE-S)* habitat (MG, RF, RS, SW) combination labeled by strata.

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CONCLUSIONS

Oysters serve a valuable function within estuarine ecosystems (Bahr and Lanier, 1981) and one objective of this study was to determine the role that each of four habitats; mangrove, reef, restoration, and seawall; play in the Tampa Bay ecosystem. During this study it was observed that for every linear meter of mangrove periphery, there was approximately 2 m^2 of oyster-habitable area within the mangrove structure. It was also observed during areal-abundance surveys that the mean intertidal range (width) of oyster growth on vertical structures, i.e., mangroves and seawalls, was 0.35m (Table 3); less than the previously estimated 0.5m. Using the oyster densities per habitat from this study and the GIS-calculated habitat areas, i.e., the 550 linear kilometers of seawall, etc., a total number of oysters and a percent contribution per habitat are presented in Table 16. The total surface area coverage for restoration sites throughout Tampa Bay is difficult to estimate. Those substrates add additional surface area and oysters to the total, although those contribution are likely to be small relative to mangrove and reef substrates.

Using these calculated values the mangrove habitat encompasses the majority (69%) of the total potential oyster population in Tampa Bay. Mangroves offer highly complex structures, and the vertical and horizontal arrangement of prop roots could easily double the area available for colonization by oysters. These data also assume that mangroves

Table 14. Estimated areas of suitable oyster substrate, mean oyster density, the calculated number of oysters, and percent contribution of oysters in Tampa Bay by habitat type: mangrove, reef, and seawall. Restoration substrate has been omitted due to the difficulty in estimating total areal coverage

Habitat	Estimated Area (m^2)	Oyster Density (m^{-2})	Potential Number of Oysters	Percent Contribution
Mangrove	7.92×10^5	1780	1.41×10^9	69%
Reef	1.60×10^5	1068	1.71×10^8	8%
Seawall	1.94×10^5	2410	4.68×10^8	23%
Total	1.15×10^6	5258	1.41×10^9	100%

are essentially linear shorelines, but in many areas this is not the case. In addition, there are no estimates for the spatial extent of oysters underneath the mangrove canopy on the sediment surface. The addition of this information would increase the resolution of data on total oyster coverage in Tampa Bay.

Results of this study suggest oysters recruit juveniles, produce mature individuals, and contribute viable gametes regardless of the substrate on which they settle. As a result, future population-scale studies of oysters should consider these alternate substrates. In Tampa Bay, alternate substrates contributed a far greater proportion of individuals than did oyster reefs. Further measurement of the proportion of each habitat containing oysters would provide a more accurate estimate of the total number of oysters found throughout the bay. This would allow for more precise estimates of important parameters associated with ecosystem function such as filtration rates and clearance times, biomass production of oysters and associated fauna, fish prey availability, and pollution uptake.

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APPENDICIES

Appendix A:

Station Coordinates

Table A1. Station coordinates for each sampling location in Tampa Bay.

Site	Habitat	Station	Latitude			Longitude		
LE-D	MG	MG-LE-D	27°	44.3	N	82°	41.6	W
LE-D	RF	RF-LE-D	27°	44.2	N	82°	41.6	W
LE-D	SW	SW-LE-D	27°	43.4	N	82°	44.3	W
LE-D	SW	SW-LE-D	27°	43.4	N	82°	44.3	W
LE-S	MG	MG-LE-S	27°	41.1	N	82°	43.0	W
LE-S	RF	RF-LE-S	27°	41.1	N	82°	43.0	W
LE-S	SW	SW-LE-S	27°	41.2	N	82°	43.1	W
LE-S	SW	SW-LE-S	27°	41.1	N	82°	43.0	W
ME-D	MG	MG-ME-D	27°	47.7	N	82°	37.9	W
ME-D	RF	RF-ME-D	27°	47.8	N	82°	37.9	W
ME-D	SW	SW-ME-D	27°	48.0	N	82°	38.0	W
ME-D	SW	SW-ME-D	27°	48.0	N	82°	38.0	W
ME-S	MG	MG-ME-S	27°	49.0	N	82°	23.9	W
ME-S	RF	RF-ME-S	27°	49.0	N	82°	23.9	W
ME-S	SW	SW-ME-S	27°	48.4	N	82°	24.7	W
ME-S	SW	SW-ME-S	27°	48.9	N	82°	24.1	W
UE-D	MG	MG-UE-D	27°	53.8	N	82°	26.1	W
UE-D	RF	RF-UE-D	27°	53.8	N	82°	26.1	W
UE-D	SW	SW-UE-D	27°	53.7	N	82°	29.2	W
UE-D	SW	SW-UE-D	27°	53.7	N	82°	29.2	W
UE-S	MG	MG-UE-S	27°	53.6	N	82°	32.5	W
UE-S	RF	RF-UE-S	27°	53.6	N	82°	32.5	W
UE-S	SW	SW-UE-S	27°	53.6	N	82°	32.5	W
UE-S	SW	SW-UE-S	27°	53.6	N	82°	32.5	W

Appendix B:

Habitat Specific Community Composition

Table B1. Mean abundance (# individuals m^{-2}) of taxa collected from mangrove, reef, restoration, and seawall habitats in Tampa Bay.

		Mangrove		Reef		Restoration		Seawall	
Taxonomic Group	**Taxa**	**# m^{-2}**	**SD**	**# m^{-2}**	**SD**	**# m^{-2}**	**SD**	**# m^{-2}**	**SD**
Annelida	Leech	13.3	32.7	0.0	0.0	0.0	0.0	0.0	0.0
	Annelid A	1.7	4.1	0.0	0.0	22.1	35.3	0.0	0.0
	Annelid B	0.0	0.0	0.0	0.0	254.4	623.1	0.0	0.0
	Annelid C	0.0	0.0	0.0	0.0	8.8	21.5	0.0	0.0
	Annelid D	0.0	0.0	6.7	16.3	0.0	0.0	0.0	0.0
	Annelid E	6.7	16.3	0.0	0.0	146.7	359.3	0.0	0.0
	Annelid F	77.4	158.8	80.6	135.1	26.7	65.3	17.5	43.0
	Annelid G	10.6	23.7	0.0	0.0	0.0	0.0	0.0	0.0
	Annelid H	0.0	0.0	26.7	65.3	0.0	0.0	0.0	0.0
	Annelid I	0.0	0.0	6.7	16.3	0.0	0.0	0.0	0.0
	Annelid J	0.0	0.0	0.0	0.0	3.3	8.2	389.3	610.3
	Annelid K	0.0	0.0	0.0	0.0	40.0	98.0	0.0	0.0
	Annelid L	6.7	16.3	62.6	96.9	62.1	128.1	8.8	21.5
	Annelid M	0.0	0.0	0.0	0.0	47.2	106.1	0.0	0.0
	Annelid N	0.0	0.0	0.0	0.0	0.0	0.0	4.9	12.0
	Annelid O	46.1	94.8	1389.5	1166.6	348.6	590.2	173.0	398.5
	Annelid P	0.8	2.0	0.0	0.0	0.0	0.0	0.0	0.0
	Amphicteis floridus	0.0	0.0	0.0	0.0	13.3	32.7	0.0	0.0
Polychaeta	*Capitella capitata*	267.9	276.7	98.9	206.1	552.9	817.8	238.6	379.7
	Chone sp.	0.0	0.0	0.0	0.0	10.4	21.1	0.0	0.0
	Dorvilleidae sp.	0.0	0.0	0.0	0.0	40.0	98.0	14.7	36.0
	Eucinidae spp.	0.0	0.0	0.0	0.0	1.7	4.1	0.0	0.0
	Eunicidae sp.	0.0	0.0	6.6	16.1	0.0	0.0	0.0	0.0
	Feather Duster	0.0	0.0	0.0	0.0	13.3	32.7	0.0	0.0
	Nereiphylla fragilis	219.9	244.2	62.7	99.6	597.9	811.4	66.0	63.3
	Hydroides dianthus	32.9	52.4	6.7	16.3	51.7	78.1	106.7	261.3
	Manayukia sp.	20.0	49.0	13.3	32.7	3.3	8.2	0.0	0.0
	Marphysa sanguinea	152.0	372.2	9.8	24.0	6.7	16.3	2.5	6.0
	Neanthes succinea	393.3	170.4	532.8	502.2	1502.3	2946.6	204.4	190.6
	Neridiidae	0.0	0.0	4.4	10.7	0.0	0.0	3.3	8.2
	Orbiniidae A	0.0	0.0	13.3	32.7	96.7	208.8	0.0	0.0
	Orbiniidae B	240.0	587.9	15.0	32.1	360.0	881.8	0.0	0.0
	Polydora websteri	1036.2	1788.6	1816.2	2396.9	12444.3	19889.1	1057.2	1512.1
	Sabillidae A	0.0	0.0	0.0	0.0	0.0	0.0	2.5	6.0
	Sabillidae B	0.8	2.0	8.8	21.5	0.0	0.0	0.0	0.0
	Sabillidae C	0.0	0.0	0.0	0.0	26.7	65.3	0.0	0.0
	Sabillidae D	0.0	0.0	0.0	0.0	16.7	32.0	0.0	0.0
	Sapella sp.	66.7	163.3	273.3	669.5	0.0	0.0	46.7	114.3
	Serpula vermicularis	1677.3	4106.1	17.2	42.0	181.4	444.3	352.9	864.5
	Spirorbidae spp.	286.7	702.2	33.3	81.6	86.7	212.3	3046.7	7462.8
	Sthenelais boa	0.0	0.0	4.9	12.0	0.0	0.0	0.0	0.0
	Streblospio spp.	4.2	8.0	4.9	12.0	0.0	0.0	0.0	0.0
	Syllidae spp.	1231.4	1093.6	638.0	680.9	1679.5	873.2	5490.7	6032.7
	Terebellidae A	6.7	16.3	0.0	0.0	8.8	21.5	10.0	24.5
	Terebellidae B	260.0	636.9	80.0	196.0	86.7	212.3	2.2	5.4
	Terebellidae C	0.0	0.0	0.0	0.0	0.0	0.0	2.2	5.4
Arthropoda	*Acari sp.*	10.0	16.7	8.3	16.0	326.7	800.2	183.3	439.3

Taxonomic Group	Taxa	Mangrove # m^{-2}	Mangrove SD	Reef # m^{-2}	Reef SD	Restoration # m^{-2}	Restoration SD	Seawall # m^{-2}	Seawall SD
Arachnida	Trombidiidae	0.0	0.0	15.6	29.5	3.3	8.2	40.0	98.0
Entognatha	*Anurida maritima*	45.0	56.1	136.0	192.3	142.1	323.0	1162.9	2341.8
	Isotominae sp.	4.9	12.0	3.3	8.2	10.0	16.7	52.5	111.8
Insecta	Chironominae	0.0	0.0	46.7	114.3	2.5	6.0	32.1	47.7
	Coleoptera sp.	0.0	0.0	0.0	0.0	1.7	4.1	0.0	0.0
	Amphipod A	0.0	0.0	0.0	0.0	6.7	16.3	0.0	0.0
Malacostraca	Amphipod B	0.0	0.0	3.3	8.2	0.0	0.0	0.0	0.0
Amphipoda	Amphipod C	3.3	8.2	5.0	12.2	30.0	64.2	46.1	112.8
	Amphipod D	0.0	0.0	0.0	0.0	0.0	0.0	2.2	5.4
	Amphipod E	2.2	5.4	0.0	0.0	0.0	0.0	56.7	138.8
	Elasmopus pectenicrus	16.5	26.2	0.0	0.0	291.6	407.2	0.0	0.0
	Laticorophium baconi	3542.6	8262.9	28.3	47.5	706.4	1538.7	2948.7	4986.4
	Melita longisetosa	858.6	980.7	294.2	253.2	353.2	190.6	262.6	336.3
	Melita sp.	0.0	0.0	0.0	0.0	124.9	252.7	0.0	0.0
	Microprotopus raneyi	0.0	0.0	0.0	0.0	0.0	0.0	13.3	32.7
	Paracaprella sp.	33.3	81.6	0.0	0.0	20.0	33.5	26.7	56.1
	Parhyale hawaiensis	1414.2	1773.1	2279.9	4188.9	841.1	804.2	1133.3	2044.9
	Podocerus brasiliensis	0.0	0.0	0.0	0.0	0.0	0.0	30.0	73.5
	Stenothoidae sp.	0.0	0.0	6.7	16.3	0.0	0.0	16.7	40.8
Decapoda	*Alpheidae sp.*	0.0	0.0	0.0	0.0	8.8	21.5	0.0	0.0
	Brachyura sp.	0.0	0.0	4.4	10.7	0.0	0.0	0.0	0.0
	Penaid	6.7	16.3	0.0	0.0	0.0	0.0	0.0	0.0
	Petrolisthes armatus	335.5	379.2	358.2	762.6	672.6	858.2	714.3	928.4
	Sesarma cinereum	0.8	2.0	51.5	126.1	0.0	0.0	10.4	21.1
	Xanthidae spp.	205.3	126.8	1145.6	1175.2	2149.9	2160.3	521.9	459.1
	Zaops ostreum	0.0	0.0	3.3	8.2	0.0	0.0	0.0	0.0
Isopoda	*Cyathura polita*	0.0	0.0	20.0	33.5	0.0	0.0	0.0	0.0
	Ligia exotica	0.0	0.0	0.0	0.0	0.0	0.0	83.4	157.0
	Paradella spp.	31.8	50.0	0.0	0.0	6.7	16.3	256.5	345.6
	Sphaeroma quadridentata	60.2	107.9	4606.7	11284.0	17.5	43.0	19.6	48.0
Tanaidacea	*Halmyrapseudes bahamensis*	0.0	0.0	2.2	5.4	0.0	0.0	0.0	0.0
	Leptocheliidae spp.	1112.9	1052.7	1821.0	3124.1	4976.0	7936.3	1840.1	3326.8
	Sinelobus stanfordi	0.0	0.0	0.0	0.0	0.0	0.0	30.0	73.5
	Teleotanais gerlachi	61.5	107.7	0.0	0.0	0.0	0.0	0.0	0.0
Maxillopoda	Barnacle spp.	14717.9	21982.3	1532.3	1925.8	3083.4	4164.8	12574.6	23705.7
Ostracoda	Ostracod	0.0	0.0	39.5	96.7	82.6	166.5	9.8	24.0
Pycnogonida	Tanystylidae A	151.1	357.3	68.9	162.3	43.3	106.1	124.2	256.2
	Tanystylidae B	3.3	8.2	0.0	0.0	0.0	0.0	73.3	179.6
Chordata	*Clavelina oblonga*	0.0	0.0	6.7	16.3	0.0	0.0	0.0	0.0
Ascidiacea	Tunicate	242.2	586.8	15.0	32.1	10.0	16.7	266.7	653.2
Osteichthyes	Fish	0.0	0.0	0.0	0.0	0.0	0.0	2.2	5.4
Cnidaria	Anemone	620.8	706.4	285.7	359.4	1505.4	1742.1	1900.4	1698.5
	Hydroid	693.0	1608.9	78.4	187.2	0.0	0.0	963.2	2080.5
Mollusca	*Anadara transversa*	0.0	0.0	0.0	0.0	1.7	4.1	0.0	0.0
Bivalvia	*Corbula contracta*	0.0	0.0	6.7	16.3	0.0	0.0	0.0	0.0
	Martesia sp.	15.0	32.1	0.0	0.0	0.0	0.0	0.0	0.0
	Sphenia antillensis	476.5	678.5	166.4	257.1	278.5	361.5	768.0	1034.0
	Amygdalum papyrium	0.8	2.0	0.0	0.0	0.0	0.0	17.5	43.0
	Brachidontes exustus	114.4	219.5	66.7	115.0	469.6	629.4	595.6	763.5
	Geukensia granosissima	9160.5	18223.0	3763.9	7185.4	7799.9	16992.9	25032.3	45887.1
	Ischadium recurvum	4.2	10.2	0.0	0.0	0.0	0.0	0.0	0.0
	Lithophaga bisulcata	0.0	0.0	6.7	16.3	0.0	0.0	13.3	32.7
	Perna viridis	36.1	49.4	0.0	0.0	0.0	0.0	393.7	646.5

Taxonomic Group	Taxa	Mangrove # m^{-2}	Mangrove SD	Reef # m^{-2}	Reef SD	Restoration # m^{-2}	Restoration SD	Seawall # m^{-2}	Seawall SD
	Anomia simplex	100.0	244.9	0.0	0.0	0.0	0.0	0.0	0.0
	Crassostrea virginica	8928.2	3823.1	4099.5	3990.0	8870.0	6011.0	12458.1	15921.2
	Ostreola equestris	160.0	391.9	0.0	0.0	121.7	199.6	313.3	767.5
	Isognomon radiatus	0.0	0.0	6.7	16.3	0.0	0.0	0.0	0.0
	Lasaea adansoni	0.0	0.0	1.7	4.1	37.5	46.1	2592.2	6333.3
	Mytilopsis leucophaeata	26.5	34.8	8.3	16.0	52.7	82.5	44.5	69.5
	Parastarte triquetra	0.0	0.0	4.9	12.0	8.8	21.5	0.0	0.0
	Tricolia affinis	7.7	12.1	0.0	0.0	0.0	0.0	3.3	8.2
Gastropoda	*Pedipes mirabilis*	0.0	0.0	0.0	0.0	0.0	0.0	175.4	279.8
	Cerithidae costata	3.3	8.2	0.0	0.0	0.0	0.0	0.0	0.0
	Cerithidae sp.	0.0	0.0	173.3	424.6	0.0	0.0	0.0	0.0
	Siphonaria pectinata	0.0	0.0	0.0	0.0	0.0	0.0	16.7	26.6
	Boonea impressa	71.1	100.4	249.5	606.2	140.0	92.2	48.2	118.2
	Odostomia sp.	2.2	5.4	0.0	0.0	0.0	0.0	0.0	0.0
	Astyris lunata	103.4	245.9	0.0	0.0	0.0	0.0	0.0	0.0
	Melongena corona	0.0	0.0	9.3	14.4	14.6	20.6	7.4	18.0
	Nassarius sp.	7.4	10.6	0.0	0.0	22.5	48.1	0.0	0.0
	Nassarius vibex	0.0	0.0	8.8	21.5	0.0	0.0	3.3	8.2
	Urosalpinx perrugata	6.7	16.3	0.0	0.0	0.0	0.0	0.0	0.0
	Urosalpinx tampaensis	0.0	0.0	0.0	0.0	2.5	6.0	19.6	48.0
	Assiminea succinea	4.2	8.0	0.0	0.0	13.7	22.4	2.5	6.0
	Bittiolum varium	46.1	112.8	56.7	129.3	301.8	505.8	30.7	75.2
	Cerith sp.	0.0	0.0	0.0	0.0	13.3	32.7	0.0	0.0
	Cerithium muscarum	0.0	0.0	54.2	96.2	35.1	85.9	0.0	0.0
	Crepidula aculeata	0.0	0.0	0.0	0.0	0.0	0.0	2.2	5.4
	Crepidula spp.	909.0	2149.2	479.4	713.3	2384.3	2915.1	237.3	489.8
	Littorina angulifera	4.4	10.7	0.0	0.0	0.0	0.0	5.0	12.2
	Vitrinellidae	0.0	0.0	0.0	0.0	17.5	43.0	0.0	0.0
	Caecum sp. A	0.0	0.0	13.3	32.7	0.0	0.0	0.0	0.0
	Caecum sp. B	0.0	0.0	2.2	5.4	26.7	65.3	0.0	0.0
	Rissoidae A	0.0	0.0	0.0	0.0	1.7	4.1	0.0	0.0
	Rissoidae B	0.0	0.0	9.8	24.0	4.9	12.0	78.4	192.1
	Olividae	0.0	0.0	4.4	10.7	0.0	0.0	0.0	0.0
	Onchidella spp.	0.0	0.0	0.0	0.0	0.0	0.0	820.0	2008.6
	Gastropod A	0.0	0.0	0.0	0.0	13.3	32.7	0.0	0.0
	Gastropod B	0.0	0.0	13.3	32.7	7.4	18.0	3.3	8.2
	Gastropod C	4.9	12.0	0.0	0.0	0.0	0.0	8.8	21.5
	Joculator fusiformis	0.0	0.0	0.0	0.0	8.8	21.5	0.0	0.0
	Juvenile Snails	0.0	0.0	0.0	0.0	0.0	0.0	40.0	98.0
	Pollia tincus	0.0	0.0	0.0	0.0	0.0	0.0	6.6	16.1
Polyplacophora	*Chiton squamosus*	0.0	0.0	6.7	16.3	0.0	0.0	0.0	0.0
Nermertea	*Micrura leidyi*	4.9	12.0	0.0	0.0	0.0	0.0	0.0	0.0
	Nemertean A	49.3	84.7	32.9	45.9	0.0	0.0	3.3	8.2
	Nemertean B	355.7	471.7	49.9	98.8	160.7	312.6	207.9	311.5
	Nemertean C	25.0	35.6	33.3	81.6	50.0	122.5	86.7	139.5
	Nemertean D	0.0	0.0	0.0	0.0	0.0	0.0	3.3	8.2
Platyhelminthes	Flatworm	825.7	723.9	310.0	272.7	907.6	735.9	1285.9	1672.3
Porifera	*Cliona sp.*	0.0	0.0	0.0	0.0	0.0	0.0	2.5	6.0
Protozoa	Foraminifera	0.0	0.0	0.0	0.0	0.0	0.0	2.5	6.0
Sipuncula	*Themiste sp.*	6.7	16.3	980.0	2400.5	53.3	130.6	670.0	1554.6
	Mean Total	**51692.7**		**28698.0**		**55976.7**		**82637.5**	

Appendix C:

Site Specific Community Composition

Table C1. Abundance (# individuals m^{-2}) of taxa collected from each habitat (mangrove (MG), reef (RF), restoration (RS), and seawall (SW)) within the Upper Estuary-Dome study site in Tampa Bay.

Upper Estuary - Dome (UE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Annelida	Leech	0	0	0	0	0.0	0.0
	Annelid A	10	0	0	0	2.5	5.0
	Annelid B	0	0	0	0	0.0	0.0
	Annelid C	0	0	0	0	0.0	0.0
	Annelid D	0	0	0	0	0.0	0.0
	Annelid E	0	0	0	0	0.0	0.0
	Annelid F	35	0	0	0	8.8	17.5
	Annelid G	5	0	0	0	1.3	2.5
	Annelid H	0	0	0	0	0.0	0.0
	Annelid I	0	0	0	0	0.0	0.0
	Annelid J	0	0	0	0	0.0	0.0
	Annelid K	0	0	0	0	0.0	0.0
	Annelid L	0	0	0	0	0.0	0.0
	Annelid M	0	0	0	0	0.0	0.0
	Annelid N	0	0	0	0	0.0	0.0
	Annelid O	0	180	0	0	45.0	90.0
	Annelid P	5	0	0	0	1.3	2.5
	Amphicteis floridus	0	0	0	0	0.0	0.0
Polychaeta	*Capitella capitata*	75	0	0	0	18.8	37.5
	Chone sp.	0	0	10	0	2.5	5.0
	Dorvilleidae sp.	0	0	0	0	0.0	0.0
	Eucinidae spp.	0	0	10	0	2.5	5.0
	Eunicidae sp.	0	0	0	0	0.0	0.0
	Feather Duster	0	0	0	0	0.0	0.0
	Nereiphylla fragilis	130	100	820	170	305.0	344.5
	Hydroides dianthus	0	0	70	0	17.5	35.0
	Manayukia sp.	0	0	0	0	0.0	0.0
	Marphysa sanguinea	0	0	40	0	10.0	20.0
	Neanthes succinea	290	1440	7480	480	2422.5	3409.0
	Nerididae	0	0	0	0	0.0	0.0
	Orbiniidae A	0	0	60	0	15.0	30.0
	Orbiniidae B	0	10	0	0	2.5	5.0
	Polydora websteri	670	6390	52020	2910	15497.5	24461.8

Upper Estuary - Dome (UE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Sabillidae A	0	0	0	0	0.0	0.0
	Sabillidae B	5	0	0	0	1.3	2.5
	Sabillidae C	0	0	0	0	0.0	0.0
	Sabillidae D	0	0	20	0	5.0	10.0
	Sapella sp.	0	0	0	0	0.0	0.0
	Serpula vermicularis	5	0	0	0	1.3	2.5
	Spirorbidae spp.	0	0	0	0	0.0	0.0
	Sthenelais boa	0	0	0	0	0.0	0.0
	Streblospio spp.	5	0	0	0	1.3	2.5
	Syllidae spp.	705	1080	460	730	743.8	255.1
	Terebellidae A	0	0	0	0	0.0	0.0
	Terebellidae B	0	0	0	0	0.0	0.0
	Terebellidae C	0	0	0	0	0.0	0.0
Arthropoda	*Acari sp.*	0	10	0	0	2.5	5.0
Arachnida	Trombidiidae	0	20	0	0	5.0	10.0
Entognatha	*Anurida maritima*	50	510	0	0	140.0	247.8
	Isotominae sp.	0	20	0	0	5.0	10.0
Insecta	Chironominae	0	280	0	20	75.0	137.0
	Coleoptera sp.	0	0	10	0	2.5	5.0
	Amphipod A	0	0	0	0	0.0	0.0
Malacostraca	Amphipod B	0	20	0	0	5.0	10.0
Amphipoda	Amphipod C	0	30	160	0	47.5	76.3
	Amphipod D	0	0	0	0	0.0	0.0
	Amphipod E	0	0	0	0	0.0	0.0
	Elasmopus pectenicrus	0	0	100	0	25.0	50.0
	Laticorophium baconi	10	10	100	0	30.0	46.9
	Melita longisetosa	1755	280	340	210	646.3	741.1
	Melita sp.	0	0	0	0	0.0	0.0
	Microprotopus raneyi	0	0	0	0	0.0	0.0
	Paracaprella sp.	0	0	40	20	15.0	19.1
	Parhyale hawaiensis	3225	1060	230	720	1308.8	1322.1
	Podocerus brasiliensis	0	0	0	0	0.0	0.0
	Stenothoidae sp.	0	40	0	0	10.0	20.0
Decapoda	*Alpheidae sp.*	0	0	0	0	0.0	0.0
	Brachyura sp.	0	0	0	0	0.0	0.0
	Penaid	0	0	0	0	0.0	0.0
	Petrolisthes armatus	425	1910	760	440	883.8	701.4
	Sesarma cinereum	5	0	0	10	3.8	4.8
	Xanthidae spp.	180	2520	2600	1230	1632.5	1154.0
	Zaops ostreum	0	20	0	0	5.0	10.0
Isopoda	*Cyathura polita*	0	0	0	0	0.0	0.0

Upper Estuary - Dome (UE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Ligia exotica	0	0	0	0	0.0	0.0
	Paradella spp.	125	0	0	0	31.3	62.5
	Sphaeroma quadrident	275	0	0	0	68.8	137.5
Tanaidacea	*Halmyrapseudes bahai*	0	0	0	0	0.0	0.0
	Leptocheliidae spp.	35	80	70	0	46.3	36.4
	Sinelobus stanfordi	0	0	0	0	0.0	0.0
	Teleotanais gerlachi	0	0	0	0	0.0	0.0
Maxillopoda	Barnacle spp.	44210	5210	11400	13500	18580.0	17445.3
Ostracoda	Ostracod	0	0	20	0	5.0	10.0
Pycnogonida	Tanystylidae A	0	0	0	0	0.0	0.0
	Tanystylidae B	0	0	0	0	0.0	0.0
Chordata	*Clavelina oblonga*	0	0	0	0	0.0	0.0
Ascidiacea	Tunicate	0	10	40	0	12.5	18.9
Osteichthyes	Fish	0	0	0	0	0.0	0.0
Cnidaria	Anemone	1575	430	4630	520	1788.8	1964.2
	Hydroid	0	10	0	0	2.5	5.0
Mollusca	*Anadara transversa*	0	0	10	0	2.5	5.0
Bivalvia	*Corbula contracta*	0	0	0	0	0.0	0.0
	Martesia sp.	10	0	0	0	2.5	5.0
	Sphenia antillensis	1745	680	990	480	973.8	555.3
	Amygdalum papyrium	5	0	0	0	1.3	2.5
	Brachidontes exustus	40	120	240	120	130.0	82.5
	Geukensia granosissim	3030	790	210	2630	1665.0	1375.6
	Ischadium recurvum	25	0	0	0	6.3	12.5
	Lithophaga bisulcata	0	0	0	0	0.0	0.0
	Perna viridis	70	0	0	0	17.5	35.0
	Anomia simplex	0	0	0	0	0.0	0.0
	Crassostrea virginica	11440	11890	9980	4170	9370.0	3561.2
	Ostreola equestris	0	0	10	0	2.5	5.0
	Isognomon radiatus	0	0	0	0	0.0	0.0
	Lasaea adansoni	0	10	0	0	2.5	5.0
	Mytilopsis leucophaea	80	10	140	120	87.5	57.4
	Parastarte triquetra	0	0	0	0	0.0	0.0
	Tricolia affinis	20	0	0	0	5.0	10.0
Gastropoda	*Pedipes mirabilis*	0	0	0	0	0.0	0.0
	Cerithidae costata	0	0	0	0	0.0	0.0
	Cerithidae sp.	0	0	0	0	0.0	0.0
	Siphonaria pectinata	0	0	0	0	0.0	0.0
	Boonea impressa	0	10	100	0	27.5	48.6
	Odostomia sp.	0	0	0	0	0.0	0.0
	Astyris lunata	15	0	0	0	3.8	7.5

Upper Estuary - Dome (UE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Melongena corona	0	0	20	0	5.0	10.0
	Nassarius sp.	5	0	0	0	1.3	2.5
	Nassarius vibex	0	0	0	0	0.0	0.0
	Urosalpinx perrugata	0	0	0	0	0.0	0.0
	Urosalpinx tampaensis	0	0	0	0	0.0	0.0
	Assiminea succinea	5	0	0	0	1.3	2.5
	Bittiolum varium	0	20	600	0	155.0	296.8
	Cerith sp.	0	0	0	0	0.0	0.0
	Cerithium muscarum	0	0	0	0	0.0	0.0
	Crepidula aculeata	0	0	0	0	0.0	0.0
	Crepidula spp.	0	510	4660	200	1342.5	2221.6
	Littorina angulifera	0	0	0	30	7.5	15.0
	Vitrinellidae	0	0	0	0	0.0	0.0
	Caecum sp. A	0	0	0	0	0.0	0.0
	Caecum sp. B	0	0	0	0	0.0	0.0
	Rissoidae A	0	0	10	0	2.5	5.0
	Rissoidae B	0	0	0	0	0.0	0.0
	Olividae	0	0	0	0	0.0	0.0
	Onchidella spp.	0	0	0	0	0.0	0.0
	Gastropod A	0	0	0	0	0.0	0.0
	Gastropod B	0	0	0	0	0.0	0.0
	Gastropod C	0	0	0	0	0.0	0.0
	Joculator fusiformis	0	0	0	0	0.0	0.0
	Juvenile Snails	0	0	0	0	0.0	0.0
	Pollia tincus	0	0	0	0	0.0	0.0
Polyplacophora	*Chiton squamosus*	0	0	0	0	0.0	0.0
Nermertea	*Micrura leidyi*	0	0	0	0	0.0	0.0
	Nemertean A	90	0	0	0	22.5	45.0
	Nemertean B	150	20	140	90	100.0	59.4
	Nemertean C	10	0	0	0	2.5	5.0
	Nemertean D	0	0	0	0	0.0	0.0
Platyhelminthes	Flatworm	895	680	90	680	586.3	346.0
Porifera	*Cliona sp.*	0	0	0	0	0.0	0.0
Protozoa	Foraminifera	0	0	0	0	0.0	0.0
Sipuncula	*Themiste sp.*	0	0	0	0	0.0	0.0
	Total/*Mean Total*	**71445**	**36410**	**98690**	**29480**	***59006.3***	

APPENDIX C (continued):

Site Specific Community Composition

Table C2. Abundance (# individuals m^{-2}) of taxa collected from each habitat (mangrove (MG), reef (RF), restoration (RS), and seawall (SW)) within the Upper Estuary-Shell study site in Tampa Bay.

Upper Estuary - Shell (UE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Annelida	Leech	0	0	0	0	0.0	0.0
	Annelid A	0	0	0	0	0.0	0.0
	Annelid B	0	0	1526	0	381.6	763.2
	Annelid C	0	0	53	0	13.2	26.3
	Annelid D	0	0	0	0	0.0	0.0
	Annelid E	0	0	0	0	0.0	0.0
	Annelid F	0	0	0	0	0.0	0.0
	Annelid G	0	0	0	0	0.0	0.0
	Annelid H	0	0	0	0	0.0	0.0
	Annelid I	0	0	0	0	0.0	0.0
	Annelid J	0	0	0	0	0.0	0.0
	Annelid K	0	0	0	0	0.0	0.0
	Annelid L	0	184	53	0	59.2	86.9
	Annelid M	0	0	0	0	0.0	0.0
	Annelid N	0	0	0	0	0.0	0.0
	Annelid O	237	2066	316	0	654.6	950.3
	Annelid P	0	0	0	0	0.0	0.0
	Amphicteis floridus	0	0	0	0	0.0	0.0
Polychaeta	*Capitella capitata*	276	79	2000	579	733.6	869.0
	Chone sp.	0	0	0	0	0.0	0.0
	Dorvilleidae sp.	0	0	0	0	0.0	0.0
	Eucinidae spp.	0	0	0	0	0.0	0.0
	Eunicidae sp.	0	0	0	0	0.0	0.0
	Feather Duster	0	0	0	0	0.0	0.0
	Nereiphylla fragilis	13	250	211	66	134.9	113.4
	Hydroides dianthus	0	0	0	0	0.0	0.0
	Manayukia sp.	0	0	0	0	0.0	0.0
	Marphysa sanguinea	0	0	0	0	0.0	0.0
	Neanthes succinea	184	276	316	250	256.6	55.3
	Nerididae	0	26	0	0	6.6	13.2
	Orbiniidae A	0	0	0	0	0.0	0.0
	Orbiniidae B	0	0	0	0	0.0	0.0

Upper Estuary - Shell (UE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Polydora websteri	39	1289	3053	158	1134.9	1397.2
	Sabillidae A	0	0	0	0	0.0	0.0
	Sabillidae B	0	53	0	0	13.2	26.3
	Sabillidae C	0	0	0	0	0.0	0.0
	Sabillidae D	0	0	0	0	0.0	0.0
	Sapella sp.	0	0	0	0	0.0	0.0
	Serpula vermicularis	0	0	0	0	0.0	0.0
	Spirorbidae spp.	0	0	0	0	0.0	0.0
	Sthenelais boa	0	0	0	0	0.0	0.0
	Streblospio spp.	0	0	0	0	0.0	0.0
	Syllidae spp.	526	289	1737	1053	901.3	641.9
	Terebellidae A	0	0	53	0	13.2	26.3
	Terebellidae B	0	0	0	13	3.3	6.6
	Terebellidae C	0	0	0	13	3.3	6.6
Arthropoda	*Acari sp.*	0	0	0	0	0.0	0.0
Arachnida	Trombidiidae	0	0	0	0	0.0	0.0
Entognatha	*Anurida maritima*	13	39	53	158	65.8	63.6
	Isotominae sp.	0	0	0	0	0.0	0.0
Insecta	Chironominae	0	0	0	53	13.2	26.3
	Coleoptera sp.	0	0	0	0	0.0	0.0
	Amphipod A	0	0	0	0	0.0	0.0
Malacostraca	Amphipod B	0	0	0	0	0.0	0.0
Amphipoda	Amphipod C	0	0	0	276	69.1	138.2
	Amphipod D	0	0	0	13	3.3	6.6
	Amphipod E	13	0	0	0	3.3	6.6
	Elasmopus pectenicrus	0	0	789	0	197.4	394.7
	Laticorophium baconi	0	0	0	26	6.6	13.2
	Melita longisetosa	66	66	316	645	273.0	274.4
	Melita sp.	0	0	632	0	157.9	315.8
	Microprotopus raneyi	0	0	0	0	0.0	0.0
	Paracaprella sp.	0	0	0	0	0.0	0.0
	Parhyale hawaiensis	408	13	1789	263	618.4	797.5
	Podocerus brasiliensis	0	0	0	0	0.0	0.0
	Stenothoidae sp.	0	0	0	0	0.0	0.0
Decapoda	*Alpheidae sp.*	0	0	53	0	13.2	26.3
	Brachyura sp.	0	26	0	0	6.6	13.2
	Penaid	0	0	0	0	0.0	0.0
	Petrolisthes armatus	26	53	105	697	220.4	319.7
	Sesarma cinereum	0	0	0	53	13.2	26.3
	Xanthidae spp.	342	2684	5947	908	2470.4	2523.6
	Zaops ostreum	0	0	0	0	0.0	0.0

Upper Estuary - Shell (UE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Isopoda	*Cyathura polita*	0	0	0	0	0.0	0.0
	Ligia exotica	0	0	0	66	16.4	32.9
	Paradella spp.	13	0	0	39	13.2	18.6
	Sphaeroma quadrident	0	0	105	0	26.3	52.6
Tanaidacea	*Halmyrapseudes bahai*	0	0	0	0	0.0	0.0
	Leptocheliidae spp.	474	342	105	145	266.4	172.7
	Sinelobus stanfordi	0	0	0	0	0.0	0.0
	Teleotanais gerlachi	276	0	0	0	69.1	138.2
Maxillopoda	Barnacle spp.	1053	1987	947	329	1078.9	684.3
Ostracoda	Ostracod	0	237	0	0	59.2	118.4
Pycnogonida	Tanystylidae A	26	13	0	105	36.2	47.3
	Tanystylidae B	0	0	0	0	0.0	0.0
Chordata	*Clavelina oblonga*	0	0	0	0	0.0	0.0
Ascidiacea	Tunicate	13	0	0	0	3.3	6.6
Osteichthyes	Fish	0	0	0	13	3.3	6.6
Cnidaria	Anemone	0	0	0	803	200.7	401.3
	Hydroid	3974	461	0	316	1187.5	1867.4
Mollusca	*Anadara transversa*	0	0	0	0	0.0	0.0
Bivalvia	*Corbula contracta*	0	0	0	0	0.0	0.0
	Martesia sp.	0	0	0	0	0.0	0.0
	Sphenia antillensis	53	53	211	224	134.9	95.1
	Amygdalum papyrium	0	0	0	0	0.0	0.0
	Brachidontes exustus	0	0	53	105	39.5	50.4
	Geukensia granosissim	53	0	0	316	92.1	151.2
	Ischadium recurvum	0	0	0	0	0.0	0.0
	Lithophaga bisulcata	0	0	0	0	0.0	0.0
	Perna viridis	0	0	0	0	0.0	0.0
	Anomia simplex	0	0	0	0	0.0	0.0
	Crassostrea virginica	6408	4289	19158	8947	9700.7	6586.1
	Ostreola equestris	0	0	0	0	0.0	0.0
	Isognomon radiatus	0	0	0	0	0.0	0.0
	Lasaea adansoni	0	0	0	13	3.3	6.6
	Mytilopsis leucophaea	0	0	0	0	0.0	0.0
	Parastarte triquetra	0	0	0	0	0.0	0.0
	Tricolia affinis	26	0	0	0	6.6	13.2
Gastropoda	*Pedipes mirabilis*	0	0	0	421	105.3	210.5
	Cerithidae costata	0	0	0	0	0.0	0.0
	Cerithidae sp.	0	0	0	0	0.0	0.0
	Siphonaria pectinata	0	0	0	0	0.0	0.0
	Boonea impressa	26	1487	211	289	503.3	664.9
	Odostomia sp.	13	0	0	0	3.3	6.6

Upper Estuary - Shell (UE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Astyris lunata	605	0	0	0	151.3	302.6
	Melongena corona	0	26	0	0	6.6	13.2
	Nassarius sp.	13	0	0	0	3.3	6.6
	Nassarius vibex	0	53	0	0	13.2	26.3
	Urosalpinx perrugata	0	0	0	0	0.0	0.0
	Urosalpinx tampaensis	0	0	0	0	0.0	0.0
	Assiminea succinea	0	0	53	0	13.2	26.3
	Bittiolum varium	276	0	0	184	115.1	138.2
	Cerith sp.	0	0	0	0	0.0	0.0
	Cerithium muscarum	0	237	0	0	59.2	118.4
	Crepidula aculeata	0	0	0	13	3.3	6.6
	Crepidula spp.	0	526	7053	1224	2200.7	3273.2
	Littorina angulifera	0	0	0	0	0.0	0.0
	Vitrinellidae	0	0	0	0	0.0	0.0
	Caecum sp. A	0	0	0	0	0.0	0.0
	Caecum sp. B	0	13	0	0	3.3	6.6
	Rissoidae A	0	0	0	0	0.0	0.0
	Rissoidae B	0	0	0	0	0.0	0.0
	Olividae	0	26	0	0	6.6	13.2
	Onchidella spp.	0	0	0	0	0.0	0.0
	Gastropod A	0	0	0	0	0.0	0.0
	Gastropod B	0	0	0	0	0.0	0.0
	Gastropod C	0	0	0	0	0.0	0.0
	Joculator fusiformis	0	0	53	0	13.2	26.3
	Juvenile Snails	0	0	0	0	0.0	0.0
	Pollia tincus	0	0	0	39	9.9	19.7
Polyplacophora	*Chiton squamosus*	0	0	0	0	0.0	0.0
Nermertea	*Micrura leidyi*	0	0	0	0	0.0	0.0
	Nemertean A	0	0	0	0	0.0	0.0
	Nemertean B	211	250	0	92	138.2	114.0
	Nemertean C	0	0	0	0	0.0	0.0
	Nemertean D	0	0	0	0	0.0	0.0
Platyhelminthes	Flatworm	0	118	632	500	312.5	301.3
Porifera	*Cliona sp.*	0	0	0	0	0.0	0.0
Protozoa	Foraminifera	0	0	0	0	0.0	0.0
Sipuncula	*Themiste sp.*	0	0	0	0	0.0	0.0
	Total/*Mean Total*	**15658**	**17513**	**47579**	**19408**	***25039.5***	

APPENDIX C (continued):

Site Specific Community Composition

Table C3. Abundance (# individuals m^{-2}) of taxa collected from each habitat (mangrove (MG), reef (RF), restoration (RS), and seawall (SW)) within the Middle Estuary-Dome study site in Tampa Bay.

Middle Estuary - Dome (ME-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Annelida	Leech	0	0	0	0	0.0	0.0
	Annelid A	0	0	0	0	0.0	0.0
	Annelid B	0	0	0	0	0.0	0.0
	Annelid C	0	0	0	0	0.0	0.0
	Annelid D	0	0	0	0	0.0	0.0
	Annelid E	0	0	0	0	0.0	0.0
	Annelid F	29	324	0	0	88.2	157.5
	Annelid G	59	0	0	0	14.7	29.4
	Annelid H	0	0	0	0	0.0	0.0
	Annelid I	0	0	0	0	0.0	0.0
	Annelid J	0	0	0	0	0.0	0.0
	Annelid K	0	0	0	0	0.0	0.0
	Annelid L	0	191	0	0	47.8	95.6
	Annelid M	0	0	0	0	0.0	0.0
	Annelid N	0	0	0	29	7.4	14.7
	Annelid O	0	1691	29	985	676.5	816.8
	Annelid P	0	0	0	0	0.0	0.0
	Amphicteis floridus	0	0	0	0	0.0	0.0
Polychaeta	*Capitella capitata*	765	515	265	853	599.3	265.1
	Chone sp.	0	0	0	0	0.0	0.0
	Dorvilleidae sp.	0	0	0	88	22.1	44.1
	Eucinidae spp.	0	0	0	0	0.0	0.0
	Eunicidae sp.	0	0	0	0	0.0	0.0
	Feather Duster	0	0	0	0	0.0	0.0
	Nereiphylla fragilis	147	0	59	15	55.1	66.2
	Hydroides dianthus	118	0	0	0	29.4	58.8
	Manayukia sp.	0	0	0	0	0.0	0.0
	Marphysa sanguinea	912	59	0	15	246.3	444.3
	Neanthes succinea	353	662	324	338	419.1	162.2
	Nerididae	0	0	0	0	0.0	0.0
	Orbiniidae A	0	0	0	0	0.0	0.0
	Orbiniidae B	0	0	0	0	0.0	0.0

Middle Estuary - Dome (ME-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Polydora websteri	882	2353	11868	3103	4551.5	4963.9
	Sabillidae A	0	0	0	15	3.7	7.4
	Sabillidae B	0	0	0	0	0.0	0.0
	Sabillidae C	0	0	0	0	0.0	0.0
	Sabillidae D	0	0	0	0	0.0	0.0
	Sapella sp.	0	0	0	0	0.0	0.0
	Serpula vermicularis	10059	103	1088	2118	3341.9	4552.9
	Spirorbidae spp.	0	0	0	0	0.0	0.0
	Sthenelais boa	0	29	0	0	7.4	14.7
	Streblospio spp.	0	29	0	0	7.4	14.7
	Syllidae spp.	3412	59	1324	3397	2047.8	1649.4
	Terebellidae A	0	0	0	0	0.0	0.0
	Terebellidae B	0	0	0	0	0.0	0.0
	Terebellidae C	0	0	0	0	0.0	0.0
Arthropoda	*Acari sp.*	0	0	0	0	0.0	0.0
Arachnida	Trombidiidae	0	74	0	0	18.4	36.8
Entognatha	*Anurida maritima*	147	15	0	279	110.3	130.7
	Isotominae sp.	29	0	0	15	11.0	14.1
Insecta	Chironominae	0	0	15	0	3.7	7.4
	Coleoptera sp.	0	0	0	0	0.0	0.0
	Amphipod A	0	0	0	0	0.0	0.0
Malacostraca	Amphipod B	0	0	0	0	0.0	0.0
Amphipoda	Amphipod C	0	0	0	0	0.0	0.0
	Amphipod D	0	0	0	0	0.0	0.0
	Amphipod E	0	0	0	0	0.0	0.0
	Elasmopus pectenicrus	59	0	0	0	14.7	29.4
	Laticorophium baconi	706	0	3838	5206	2437.5	2487.7
	Melita longisetosa	971	676	515	721	720.6	188.7
	Melita sp.	0	0	118	0	29.4	58.8
	Microprotopus raneyi	0	0	0	0	0.0	0.0
	Paracaprella sp.	0	0	0	0	0.0	0.0
	Parhyale hawaiensis	147	0	88	221	114.0	93.3
	Podocerus brasiliensis	0	0	0	0	0.0	0.0
	Stenothoidae sp.	0	0	0	0	0.0	0.0
Decapoda	*Alpheidae sp.*	0	0	0	0	0.0	0.0
	Brachyura sp.	0	0	0	0	0.0	0.0
	Penaid	0	0	0	0	0.0	0.0
	Petrolisthes armatus	324	0	0	15	84.6	159.5
	Sesarma cinereum	0	309	0	0	77.2	154.4
	Xanthidae spp.	265	15	250	103	158.1	120.3
	Zaops ostreum	0	0	0	0	0.0	0.0

Middle Estuary - Dome (ME-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Isopoda	*Cyathura polita*	0	0	0	0	0.0	0.0
	Ligia exotica	0	0	0	15	3.7	7.4
	Paradella spp.	0	0	0	279	69.9	139.7
	Sphaeroma quadrident	0	0	0	118	29.4	58.8
Tanaidacea	*Halmyrapseudes bahai*	0	0	0	0	0.0	0.0
	Leptocheliidae spp.	2853	2544	4118	8324	4459.6	2664.4
	Sinelobus stanfordi	0	0	0	0	0.0	0.0
	Teleotanais gerlachi	0	0	0	0	0.0	0.0
Maxillopoda	Barnacle spp.	118	691	1750	1029	897.1	681.9
Ostracoda	Ostracod	0	0	15	59	18.4	27.8
Pycnogonida	Tanystylidae A	0	0	0	0	0.0	0.0
	Tanystylidae B	0	0	0	0	0.0	0.0
Chordata	*Clavelina oblonga*	0	0	0	0	0.0	0.0
Ascidiacea	Tunicate	0	0	0	0	0.0	0.0
Osteichthyes	Fish	0	0	0	0	0.0	0.0
Cnidaria	Anemone	1235	44	0	29	327.2	605.7
	Hydroid	0	0	0	0	0.0	0.0
Mollusca	*Anadara transversa*	0	0	0	0	0.0	0.0
Bivalvia	*Corbula contracta*	0	0	0	0	0.0	0.0
	Martesia sp.	0	0	0	0	0.0	0.0
	Sphenia antillensis	265	0	0	15	69.9	130.1
	Amygdalum papyrium	0	0	0	0	0.0	0.0
	Brachidontes exustus	0	0	0	0	0.0	0.0
	Geukensia granosissim	46235	18265	42441	115794	55683.8	41944.7
	Ischadium recurvum	0	0	0	0	0.0	0.0
	Lithophaga bisulcata	0	0	0	0	0.0	0.0
	Perna viridis	0	0	0	0	0.0	0.0
	Anomia simplex	0	0	0	0	0.0	0.0
	Crassostrea virginica	10000	1000	2515	2632	4036.8	4044.4
	Ostreola equestris	0	0	0	0	0.0	0.0
	Isognomon radiatus	0	0	0	0	0.0	0.0
	Lasaea adansoni	0	0	0	0	0.0	0.0
	Mytilopsis leucophaeat	59	0	176	147	95.6	81.0
	Parastarte triquetra	0	29	0	0	7.4	14.7
	Tricolia affinis	0	0	0	0	0.0	0.0
Gastropoda	*Pedipes mirabilis*	0	0	0	0	0.0	0.0
	Cerithidae costata	0	0	0	0	0.0	0.0
	Cerithidae sp.	0	0	0	0	0.0	0.0
	Siphonaria pectinata	0	0	0	0	0.0	0.0
	Boonea impressa	0	0	59	0	14.7	29.4
	Odostomia sp.	0	0	0	0	0.0	0.0

Middle Estuary - Dome (ME-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Astyris lunata	0	0	0	0	0.0	0.0
	Melongena corona	0	29	15	44	22.1	19.0
	Nassarius sp.	0	0	15	0	3.7	7.4
	Nassarius vibex	0	0	0	0	0.0	0.0
	Urosalpinx perrugata	0	0	0	0	0.0	0.0
	Urosalpinx tampaensis	0	0	15	118	33.1	56.8
	Assiminea succinea	0	0	29	15	11.0	14.1
	Bittiolum varium	0	0	0	0	0.0	0.0
	Cerith sp.	0	0	0	0	0.0	0.0
	Cerithium muscarum	0	88	0	0	22.1	44.1
	Crepidula aculeata	0	0	0	0	0.0	0.0
	Crepidula spp.	5294	0	353	0	1411.8	2593.6
	Littorina angulifera	0	0	0	0	0.0	0.0
	Vitrinellidae	0	0	0	0	0.0	0.0
	Caecum sp. A	0	0	0	0	0.0	0.0
	Caecum sp. B	0	0	0	0	0.0	0.0
	Rissoidae A	0	0	0	0	0.0	0.0
	Rissoidae B	0	59	29	471	139.7	221.9
	Olividae	0	0	0	0	0.0	0.0
	Onchidella spp.	0	0	0	0	0.0	0.0
	Gastropod A	0	0	0	0	0.0	0.0
	Gastropod B	0	0	44	0	11.0	22.1
	Gastropod C	29	0	0	0	7.4	14.7
	Joculator fusiformis	0	0	0	0	0.0	0.0
	Juvenile Snails	0	0	0	0	0.0	0.0
	Pollia tincus	0	0	0	0	0.0	0.0
Polyplacophora	*Chiton squamosus*	0	0	0	0	0.0	0.0
Nermertea	*Micrura leidyi*	29	0	0	0	7.4	14.7
	Nemertean A	206	118	0	0	80.9	100.1
	Nemertean B	118	29	15	103	66.2	51.6
	Nemertean C	0	0	0	0	0.0	0.0
	Nemertean D	0	0	0	0	0.0	0.0
Platyhelminthes	Flatworm	1441	88	176	44	437.5	671.4
Porifera	*Cliona sp.*	0	0	0	15	3.7	7.4
Protozoa	Foraminifera	0	0	0	15	3.7	7.4
Sipuncula	*Themiste sp.*	0	0	0	0	0.0	0.0
	Total/*Mean Total*	**87265**	**30088**	**71544**	**146779**	***83919.1***	

APPENDIX C (continued):

Site Specific Community Composition

Table C4. Abundance (# individuals m^{-2}) of taxa collected from each habitat (mangrove (MG), reef (RF), restoration (RS), and seawall (SW)) within the Middle Estuary-Shell study site in Tampa Bay.

Middle Estuary - Shell (ME-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Annelida	Leech	0	0	0	0	0.0	0.0
	Annelid A	0	0	53	0	13.2	26.3
	Annelid B	0	0	0	0	0.0	0.0
	Annelid C	0	0	0	0	0.0	0.0
	Annelid D	0	0	0	0	0.0	0.0
	Annelid E	0	0	0	0	0.0	0.0
	Annelid F	0	0	0	105	26.3	52.6
	Annelid G	0	0	0	0	0.0	0.0
	Annelid H	0	0	0	0	0.0	0.0
	Annelid I	0	0	0	0	0.0	0.0
	Annelid J	0	0	0	1316	328.9	657.9
	Annelid K	0	0	0	0	0.0	0.0
	Annelid L	0	0	0	53	13.2	26.3
	Annelid M	0	0	263	0	65.8	131.6
	Annelid N	0	0	0	0	0.0	0.0
	Annelid O	0	0	1526	53	394.7	754.8
	Annelid P	0	0	0	0	0.0	0.0
	Amphicteis floridus	0	0	0	0	0.0	0.0
Polychaeta	*Capitella capitata*	132	0	1053	0	296.1	508.2
	Chone sp.	0	0	53	0	13.2	26.3
	Dorvilleidae sp.	0	0	0	0	0.0	0.0
	Eucinidae spp.	0	0	0	0	0.0	0.0
	Eunicidae sp.	0	39	0	0	9.9	19.7
	Feather Duster	0	0	0	0	0.0	0.0
	Nereiphylla fragilis	289	26	2158	105	644.7	1014.8
	Hydroides dianthus	0	0	0	0	0.0	0.0
	Manayukia sp.	0	0	0	0	0.0	0.0
	Marphysa sanguinea	0	0	0	0	0.0	0.0
	Neanthes succinea	553	579	895	158	546.1	301.9
	Nerididae	0	0	0	0	0.0	0.0
	Orbiniidae A	0	0	0	0	0.0	0.0
	Orbiniidae B	0	0	0	0	0.0	0.0

Middle Estuary - Shell (ME-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Polydora websteri	4605	145	7105	53	2977.0	3476.9
	Sabillidae A	0	0	0	0	0.0	0.0
	Sabillidae B	0	0	0	0	0.0	0.0
	Sabillidae C	0	0	0	0	0.0	0.0
	Sabillidae D	0	0	0	0	0.0	0.0
	Sapella sp.	0	0	0	0	0.0	0.0
	Serpula vermicularis	0	0	0	0	0.0	0.0
	Spirorbidae spp.	0	0	0	0	0.0	0.0
	Sthenelais boa	0	0	0	0	0.0	0.0
	Streblospio spp.	0	0	0	0	0.0	0.0
	Syllidae spp.	1105	0	1737	4684	1881.6	2001.6
	Terebellidae A	0	0	0	0	0.0	0.0
	Terebellidae B	0	0	0	0	0.0	0.0
	Terebellidae C	0	0	0	0	0.0	0.0
Arthropoda	*Acari sp.*	0	0	0	0	0.0	0.0
Arachnida	Trombidiidae	0	0	0	0	0.0	0.0
Entognatha	*Anurida maritima*	0	92	0	0	23.0	46.1
	Isotominae sp.	0	0	0	0	0.0	0.0
Insecta	Chironominae	0	0	0	0	0.0	0.0
	Coleoptera sp.	0	0	0	0	0.0	0.0
	Amphipod A	0	0	0	0	0.0	0.0
Malacostraca	Amphipod B	0	0	0	0	0.0	0.0
Amphipoda	Amphipod C	0	0	0	0	0.0	0.0
	Amphipod D	0	0	0	0	0.0	0.0
	Amphipod E	0	0	0	0	0.0	0.0
	Elasmopus pectenicrus	0	0	0	0	0.0	0.0
	Laticorophium baconi	0	0	0	0	0.0	0.0
	Melita longisetosa	0	263	368	0	157.9	187.3
	Melita sp.	0	0	0	0	0.0	0.0
	Microprotopus raneyi	0	0	0	0	0.0	0.0
	Paracaprella sp.	0	0	0	0	0.0	0.0
	Parhyale hawaiensis	4105	526	579	316	1381.6	1819.3
	Podocerus brasiliensis	0	0	0	0	0.0	0.0
	Stenothoidae sp.	0	0	0	0	0.0	0.0
Decapoda	*Alpheidae sp.*	0	0	0	0	0.0	0.0
	Brachyura sp.	0	0	0	0	0.0	0.0
	Penaid	0	0	0	0	0.0	0.0
	Petrolisthes armatus	158	26	2211	474	717.1	1013.2
	Sesarma cinereum	0	0	0	0	0.0	0.0
	Xanthidae spp.	105	895	2842	211	1013.2	1268.5
	Zaops ostreum	0	0	0	0	0.0	0.0

Middle Estuary - Shell (ME-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Isopoda	*Cyathura polita*	0	0	0	0	0.0	0.0
	Ligia exotica	0	0	0	0	0.0	0.0
	Paradella spp.	53	0	0	0	13.2	26.3
	Sphaeroma quadrident	26	0	0	0	6.6	13.2
Tanaidacea	*Halmyrapseudes bahai*	0	13	0	0	3.3	6.6
	Leptocheliidae spp.	316	0	263	53	157.9	154.9
	Sinelobus stanfordi	0	0	0	0	0.0	0.0
	Teleotanais gerlachi	53	0	0	0	13.2	26.3
Maxillopoda	Barnacle spp.	41947	66	1263	59789	25766.4	29890.5
Ostracoda	Ostracod	0	0	421	0	105.3	210.5
Pycnogonida	Tanystylidae A	0	0	0	0	0.0	0.0
	Tanystylidae B	0	0	0	0	0.0	0.0
Chordata	*Clavelina oblonga*	0	0	0	0	0.0	0.0
Ascidiacea	Tunicate	0	0	0	0	0.0	0.0
Osteichthyes	Fish	0	0	0	0	0.0	0.0
Cnidaria	Anemone	895	0	842	3211	1236.8	1378.2
	Hydroid	184	0	0	263	111.8	133.1
Mollusca	*Anadara transversa*	0	0	0	0	0.0	0.0
Bivalvia	*Corbula contracta*	0	0	0	0	0.0	0.0
	Martesia sp.	0	0	0	0	0.0	0.0
	Sphenia antillensis	737	66	211	2789	950.7	1259.3
	Amygdalum papyrium	0	0	0	105	26.3	52.6
	Brachidontes exustus	26	0	105	368	125.0	168.3
	Geukensia granosissim	3605	329	2368	29474	8944.1	13752.9
	Ischadium recurvum	0	0	0	0	0.0	0.0
	Lithophaga bisulcata	0	0	0	0	0.0	0.0
	Perna viridis	26	0	0	842	217.1	416.9
	Anomia simplex	0	0	0	0	0.0	0.0
	Crassostrea virginica	14421	1697	10947	44579	17911.2	18571.8
	Ostreola equestris	0	0	0	0	0.0	0.0
	Isognomon radiatus	0	0	0	0	0.0	0.0
	Lasaea adansoni	0	0	105	0	26.3	52.6
	Mytilopsis leucophaeat	0	0	0	0	0.0	0.0
	Parastarte triquetra	0	0	53	0	13.2	26.3
	Tricolia affinis	0	0	0	0	0.0	0.0
Gastropoda	*Pedipes mirabilis*	0	0	0	632	157.9	315.8
	Cerithidae costata	0	0	0	0	0.0	0.0
	Cerithidae sp.	0	0	0	0	0.0	0.0
	Siphonaria pectinata	0	0	0	0	0.0	0.0
	Boonea impressa	0	0	211	0	52.6	105.3
	Odostomia sp.	0	0	0	0	0.0	0.0

Middle Estuary - Shell (ME-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Astyris lunata	0	0	0	0	0.0	0.0
	Melongena corona	0	0	53	0	13.2	26.3
	Nassarius sp.	26	0	0	0	6.6	13.2
	Nassarius vibex	0	0	0	0	0.0	0.0
	Urosalpinx perrugata	0	0	0	0	0.0	0.0
	Urosalpinx tampaensis	0	0	0	0	0.0	0.0
	Assiminea succinea	0	0	0	0	0.0	0.0
	Bittiolum varium	0	0	1211	0	302.6	605.3
	Cerith sp.	0	0	0	0	0.0	0.0
	Cerithium muscarum	0	0	211	0	52.6	105.3
	Crepidula aculeata	0	0	0	0	0.0	0.0
	Crepidula spp.	0	0	0	0	0.0	0.0
	Littorina angulifera	26	0	0	0	6.6	13.2
	Vitrinellidae	0	0	105	0	26.3	52.6
	Caecum sp. A	0	0	0	0	0.0	0.0
	Caecum sp. B	0	0	0	0	0.0	0.0
	Rissoidae A	0	0	0	0	0.0	0.0
	Rissoidae B	0	0	0	0	0.0	0.0
	Olividae	0	0	0	0	0.0	0.0
	Onchidella spp.	0	0	0	0	0.0	0.0
	Gastropod A	0	0	0	0	0.0	0.0
	Gastropod B	0	0	0	0	0.0	0.0
	Gastropod C	0	0	0	53	13.2	26.3
	Joculator fusiformis	0	0	0	0	0.0	0.0
	Juvenile Snails	0	0	0	0	0.0	0.0
	Pollia tincus	0	0	0	0	0.0	0.0
Polyplacophora	*Chiton squamosus*	0	0	0	0	0.0	0.0
Nermertea	*Micrura leidyi*	0	0	0	0	0.0	0.0
	Nemertean A	0	0	0	0	0.0	0.0
	Nemertean B	1316	0	789	842	736.8	545.3
	Nemertean C	0	0	0	0	0.0	0.0
	Nemertean D	0	0	0	0	0.0	0.0
Platyhelminthes	Flatworm	658	13	1947	4632	1812.5	2044.2
Porifera	*Cliona sp.*	0	0	0	0	0.0	0.0
Protozoa	Foraminifera	0	0	0	0	0.0	0.0
Sipuncula	*Themiste sp.*	0	0	0	0	0.0	0.0
	Total/*Mean Total*	**75368**	**4776**	**41947**	**155158**	***69312.5***	

APPENDIX C (continued):

Site Specific Community Composition

Table C5. Abundance (# individuals m^{-2}) of taxa collected from each habitat (mangrove (MG), reef (RF), restoration (RS), and seawall (SW)) within the Lower Estuary-Dome study site in Tampa Bay.

Lower Estuary - Dome (LE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Annelida	Leech	0	0	0	0	0.0	0.0
	Annelid A	0	0	0	0	0.0	0.0
	Annelid B	0	0	0	0	0.0	0.0
	Annelid C	0	0	0	0	0.0	0.0
	Annelid D	0	0	0	0	0.0	0.0
	Annelid E	0	0	0	0	0.0	0.0
	Annelid F	0	0	0	0	0.0	0.0
	Annelid G	0	0	0	0	0.0	0.0
	Annelid H	0	0	0	0	0.0	0.0
	Annelid I	0	0	0	0	0.0	0.0
	Annelid J	0	0	20	0	5.0	10.0
	Annelid K	0	0	0	0	0.0	0.0
	Annelid L	40	0	0	0	10.0	20.0
	Annelid M	0	0	20	0	5.0	10.0
	Annelid N	0	0	0	0	0.0	0.0
	Annelid O	0	3080	20	0	775.0	1536.7
	Annelid P	0	0	0	0	0.0	0.0
	Amphicteis floridus	0	0	0	0	0.0	0.0
Polychaeta	*Capitella capitata*	360	0	0	0	90.0	180.0
	Chone sp.	0	0	0	0	0.0	0.0
	Dorvilleidae sp.	0	0	0	0	0.0	0.0
	Eucinidae spp.	0	0	0	0	0.0	0.0
	Eunicidae sp.	0	0	0	0	0.0	0.0
	Feather Duster	0	0	0	0	0.0	0.0
	Nereiphylla fragilis	60	0	140	40	60.0	58.9
	Hydroides dianthus	0	40	200	640	220.0	293.0
	Manayukia sp.	0	0	20	0	5.0	10.0
	Marphysa sanguinea	0	0	0	0	0.0	0.0
	Neanthes succinea	340	200	0	0	135.0	166.0
	Neridiidae	0	0	0	0	0.0	0.0
	Orbiniidae A	0	0	0	0	0.0	0.0
	Orbiniidae B	0	0	0	0	0.0	0.0

Lower Estuary - Dome (LE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Polydora websteri	20	40	60	120	60.0	43.2
	Sabillidae A	0	0	0	0	0.0	0.0
	Sabillidae B	0	0	0	0	0.0	0.0
	Sabillidae C	0	0	0	0	0.0	0.0
	Sabillidae D	0	0	0	0	0.0	0.0
	Sapella sp.	0	0	0	280	70.0	140.0
	Serpula vermicularis	0	0	0	0	0.0	0.0
	Spirorbidae spp.	0	0	520	18280	4700.0	9056.7
	Sthenelais boa	0	0	0	0	0.0	0.0
	Streblospio spp.	20	0	0	0	5.0	10.0
	Syllidae spp.	600	640	1660	17080	4995.0	8071.6
	Terebellidae A	0	0	0	0	0.0	0.0
	Terebellidae B	0	0	0	0	0.0	0.0
	Terebellidae C	0	0	0	0	0.0	0.0
Arthropoda	*Acari sp.*	20	0	1960	1080	765.0	943.0
Arachnida	Trombidiidae	0	0	20	0	5.0	10.0
Entognatha	*Anurida maritima*	60	160	800	5920	1735.0	2809.2
	Isotominae sp.	0	0	20	280	75.0	137.0
Insecta	Chironominae	0	0	0	0	0.0	0.0
	Coleoptera sp.	0	0	0	0	0.0	0.0
	Amphipod A	0	0	40	0	10.0	20.0
Malacostraca	Amphipod B	0	0	0	0	0.0	0.0
Amphipoda	Amphipod C	20	0	20	0	10.0	11.5
	Amphipod D	0	0	0	0	0.0	0.0
	Amphipod E	0	0	0	0	0.0	0.0
	Elasmopus pectenicrus	0	0	20	0	5.0	10.0
	Laticorophium baconi	140	40	300	240	180.0	114.3
	Melita longisetosa	80	480	20	0	145.0	225.9
	Melita sp.	0	0	0	0	0.0	0.0
	Microprotopus raneyi	0	0	0	80	20.0	40.0
	Paracaprella sp.	0	0	80	0	20.0	40.0
	Parhyale hawaiensis	520	10760	1920	5280	4620.0	4554.7
	Podocerus brasiliensis	0	0	0	0	0.0	0.0
	Stenothoidae sp.	0	0	0	0	0.0	0.0
Decapoda	*Alpheidae sp.*	0	0	0	0	0.0	0.0
	Brachyura sp.	0	0	0	0	0.0	0.0
	Penaid	0	0	0	0	0.0	0.0
	Petrolisthes armatus	40	0	0	120	40.0	56.6
	Sesarma cinereum	0	0	0	0	0.0	0.0
	Xanthidae spp.	20	120	660	520	330.0	308.3
	Zaops ostreum	0	0	0	0	0.0	0.0

Lower Estuary - Dome (LE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Isopoda	*Cyathura polita*	0	80	0	0	20.0	40.0
	Ligia exotica	0	0	0	400	100.0	200.0
	Paradella spp.	0	0	40	320	90.0	154.5
	Sphaeroma quadrident	60	27640	0	0	6925.0	13810.0
Tanaidacea	*Halmyrapseudes bahai*	0	0	0	0	0.0	0.0
	Leptocheliidae spp.	1560	80	4700	2520	2215.0	1937.0
	Sinelobus stanfordi	0	0	0	0	0.0	0.0
	Teleotanais gerlachi	0	0	0	0	0.0	0.0
Maxillopoda	Barnacle spp.	260	240	2860	360	930.0	1287.7
Ostracoda	Ostracod	0	0	0	0	0.0	0.0
Pycnogonida	Tanystylidae A	0	0	260	640	225.0	302.6
	Tanystylidae B	20	0	0	440	115.0	216.9
Chordata	*Clavelina oblonga*	0	0	0	0	0.0	0.0
Ascidiacea	Tunicate	0	0	20	1600	405.0	796.7
Osteichthyes	Fish	0	0	0	0	0.0	0.0
Cnidaria	Anemone	20	320	1400	2560	1075.0	1153.8
	Hydroid	0	0	0	0	0.0	0.0
Mollusca	*Anadara transversa*	0	0	0	0	0.0	0.0
Bivalvia	*Corbula contracta*	0	0	0	0	0.0	0.0
	Martesia sp.	0	0	0	0	0.0	0.0
	Sphenia antillensis	60	40	220	880	300.0	395.0
	Amygdalum papyrium	0	0	0	0	0.0	0.0
	Brachidontes exustus	60	0	820	1960	710.0	913.1
	Geukensia granosissim	2000	2960	1300	1960	2055.0	683.4
	Ischadium recurvum	0	0	0	0	0.0	0.0
	Lithophaga bisulcata	0	0	0	80	20.0	40.0
	Perna viridis	0	0	0	0	0.0	0.0
	Anomia simplex	0	0	0	0	0.0	0.0
	Crassostrea virginica	3700	3320	3980	8440	4860.0	2401.9
	Ostreola equestris	0	0	240	1880	530.0	907.1
	Isognomon radiatus	0	0	0	0	0.0	0.0
	Lasaea adansoni	0	0	40	15520	3890.0	7753.4
	Mytilopsis leucophaeai	20	0	0	0	5.0	10.0
	Parastarte triquetra	0	0	0	0	0.0	0.0
	Tricolia affinis	0	0	0	0	0.0	0.0
Gastropoda	*Pedipes mirabilis*	0	0	0	0	0.0	0.0
	Cerithidae costata	20	0	0	0	5.0	10.0
	Cerithidae sp.	0	1040	0	0	260.0	520.0
	Siphonaria pectinata	0	0	0	40	10.0	20.0
	Boonea impressa	200	0	20	0	55.0	97.1
	Odostomia sp.	0	0	0	0	0.0	0.0

Lower Estuary - Dome (LE-D)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Astyris lunata	0	0	0	0	0.0	0.0
	Melongena corona	0	0	0	0	0.0	0.0
	Nassarius sp.	0	0	0	0	0.0	0.0
	Nassarius vibex	0	0	0	0	0.0	0.0
	Urosalpinx perrugata	0	0	0	0	0.0	0.0
	Urosalpinx tampaensis	0	0	0	0	0.0	0.0
	Assiminea succinea	20	0	0	0	5.0	10.0
	Bittiolum varium	0	0	0	0	0.0	0.0
	Cerith sp.	0	0	0	0	0.0	0.0
	Cerithium muscarum	0	0	0	0	0.0	0.0
	Crepidula aculeata	0	0	0	0	0.0	0.0
	Crepidula spp.	0	0	0	0	0.0	0.0
	Littorina angulifera	0	0	0	0	0.0	0.0
	Vitrinellidae	0	0	0	0	0.0	0.0
	Caecum sp. A	0	0	0	0	0.0	0.0
	Caecum sp. B	0	0	0	0	0.0	0.0
	Rissoidae A	0	0	0	0	0.0	0.0
	Rissoidae B	0	0	0	0	0.0	0.0
	Olividae	0	0	0	0	0.0	0.0
	Onchidella spp.	0	0	0	4920	1230.0	2460.0
	Gastropod A	0	0	0	0	0.0	0.0
	Gastropod B	0	80	0	0	20.0	40.0
	Gastropod C	0	0	0	0	0.0	0.0
	Joculator fusiformis	0	0	0	0	0.0	0.0
	Juvenile Snails	0	0	0	0	0.0	0.0
	Pollia tincus	0	0	0	0	0.0	0.0
Polyplacophora	*Chiton squamosus*	0	0	0	0	0.0	0.0
Nermertea	*Micrura leidyi*	0	0	0	0	0.0	0.0
	Nemertean A	0	40	0	0	10.0	20.0
	Nemertean B	140	0	20	40	50.0	62.2
	Nemertean C	60	0	300	320	170.0	163.7
	Nemertean D	0	0	0	0	0.0	0.0
Platyhelminthes	Flatworm	120	440	1160	1000	680.0	484.4
Porifera	*Cliona sp.*	0	0	0	0	0.0	0.0
Protozoa	Foraminifera	0	0	0	0	0.0	0.0
Sipuncula	*Themiste sp.*	0	0	320	3840	1040.0	1872.8
	Total/*Mean Total*	**10660**	**51840**	**26220**	**99680**	***47100.0***	

APPENDIX C (continued):

Site Specific Community Composition

Table C6. Abundance (# individuals m^{-2}) of taxa collected from each habitat (mangrove (MG), reef (RF), restoration (RS), and seawall (SW)) within the Lower Estuary-Shell study site in Tampa Bay.

Lower Estuary - Shell (LE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Annelida	Leech	80	0	0	0	20.0	40.0
	Annelid A	0	0	80	0	20.0	40.0
	Annelid B	0	0	0	0	0.0	0.0
	Annelid C	0	0	0	0	0.0	0.0
	Annelid D	0	40	0	0	10.0	20.0
	Annelid E	40	0	880	0	230.0	433.7
	Annelid F	400	160	160	0	180.0	164.9
	Annelid G	0	0	0	0	0.0	0.0
	Annelid H	0	160	0	0	40.0	80.0
	Annelid I	0	40	0	0	10.0	20.0
	Annelid J	0	0	0	1020	255.0	510.0
	Annelid K	0	0	240	0	60.0	120.0
	Annelid L	0	0	320	0	80.0	160.0
	Annelid M	0	0	0	0	0.0	0.0
	Annelid N	0	0	0	0	0.0	0.0
	Annelid O	40	1320	200	0	390.0	626.0
	Annelid P	0	0	0	0	0.0	0.0
	Amphicteis floridus	0	0	80	0	20.0	40.0
Polychaeta	*Capitella capitata*	0	0	0	0	0.0	0.0
	Chone sp.	0	0	0	0	0.0	0.0
	Dorvilleidae sp.	0	0	240	0	60.0	120.0
	Eucinidae spp.	0	0	0	0	0.0	0.0
	Eunicidae sp.	0	0	0	0	0.0	0.0
	Feather Duster	0	0	80	0	20.0	40.0
	Nereiphylla fragilis	680	0	200	0	220.0	320.8
	Hydroides dianthus	80	0	40	0	30.0	38.3
	Manayukia sp.	120	80	0	0	50.0	60.0
	Marphysa sanguinea	0	0	0	0	0.0	0.0
	Neanthes succinea	640	40	0	0	170.0	313.9
	Nerididae	0	0	0	20	5.0	10.0
	Orbiniidae A	0	80	520	0	150.0	249.5
	Orbiniidae B	1440	80	2160	0	920.0	1058.3

Lower Estuary - Shell (LE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Polydora websteri	0	680	560	0	310.0	361.3
	Sabillidae A	0	0	0	0	0.0	0.0
	Sabillidae B	0	0	0	0	0.0	0.0
	Sabillidae C	0	0	160	0	40.0	80.0
	Sabillidae D	0	0	80	0	20.0	40.0
	Sapella sp.	400	1640	0	0	510.0	776.6
	Serpula vermicularis	0	0	0	0	0.0	0.0
	Spirorbidae spp.	1720	200	0	0	480.0	832.0
	Sthenelais boa	0	0	0	0	0.0	0.0
	Streblospio spp.	0	0	0	0	0.0	0.0
	Syllidae spp.	1040	1760	3160	6000	2990.0	2191.2
	Terebellidae A	40	0	0	60	25.0	30.0
	Terebellidae B	1560	480	520	0	640.0	657.3
	Terebellidae C	0	0	0	0	0.0	0.0
Arthropoda	*Acari sp.*	40	40	0	20	25.0	19.1
Arachnida	Trombidiidae	0	0	0	240	60.0	120.0
Entognatha	*Anurida maritima*	0	0	0	620	155.0	310.0
	Isotominae sp.	0	0	40	20	15.0	19.1
Insecta	Chironominae	0	0	0	120	30.0	60.0
	Coleoptera sp.	0	0	0	0	0.0	0.0
	Amphipod A	0	0	0	0	0.0	0.0
Malacostraca	Amphipod B	0	0	0	0	0.0	0.0
Amphipoda	Amphipod C	0	0	0	0	0.0	0.0
	Amphipod D	0	0	0	0	0.0	0.0
	Amphipod E	0	0	0	340	85.0	170.0
	Elasmopus pectenicrus	40	0	840	0	220.0	413.8
	Laticorophium baconi	20400	120	0	12220	8185.0	9958.7
	Melita longisetosa	2280	0	560	0	710.0	1079.4
	Melita sp.	0	0	0	0	0.0	0.0
	Microprotopus raneyi	0	0	0	0	0.0	0.0
	Paracaprella sp.	200	0	0	140	85.0	101.2
	Parhyale hawaiensis	80	1320	440	0	460.0	604.4
	Podocerus brasiliensis	0	0	0	180	45.0	90.0
	Stenothoidae sp.	0	0	0	100	25.0	50.0
Decapoda	*Alpheidae sp.*	0	0	0	0	0.0	0.0
	Brachyura sp.	0	0	0	0	0.0	0.0
	Penaid	40	0	0	0	10.0	20.0
	Petrolisthes armatus	1040	160	960	2540	1175.0	993.0
	Sesarma cinereum	0	0	0	0	0.0	0.0
	Xanthidae spp.	320	640	600	160	430.0	229.5
	Zaops ostreum	0	0	0	0	0.0	0.0

Lower Estuary - Shell (LE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
Isopoda	*Cyathura polita*	0	40	0	0	10.0	20.0
	Ligia exotica	0	0	0	20	5.0	10.0
	Paradella spp.	0	0	0	900	225.0	450.0
	Sphaeroma quadrident	0	0	0	0	0.0	0.0
Tanaidacea	*Halmyrapseudes bahai*	0	0	0	0	0.0	0.0
	Leptocheliidae spp.	1440	7880	20600	0	7480.0	9393.7
	Sinelobus stanfordi	0	0	0	180	45.0	90.0
	Teleotanais gerlachi	40	0	0	0	10.0	20.0
Maxillopoda	Barnacle spp.	720	1000	280	440	610.0	317.3
Ostracoda	Ostracod	0	0	40	0	10.0	20.0
Pycnogonida	Tanystylidae A	880	400	0	0	320.0	418.3
	Tanystylidae B	0	0	0	0	0.0	0.0
Chordata	*Clavelina oblonga*	0	40	0	0	10.0	20.0
Ascidiacea	Tunicate	1440	80	0	0	380.0	707.7
Osteichthyes	Fish	0	0	0	0	0.0	0.0
Cnidaria	Anemone	0	920	2160	4280	1840.0	1851.8
	Hydroid	0	0	0	5200	1300.0	2600.0
Mollusca	*Anadara transversa*	0	0	0	0	0.0	0.0
Bivalvia	*Corbula contracta*	0	40	0	0	10.0	20.0
	Martesia sp.	80	0	0	0	20.0	40.0
	Sphenia antillensis	0	160	40	220	105.0	102.5
	Amygdalum papyrium	0	0	0	0	0.0	0.0
	Brachidontes exustus	560	280	1600	1020	865.0	577.2
	Geukensia granosissim	40	240	480	20	195.0	214.4
	Ischadium recurvum	0	0	0	0	0.0	0.0
	Lithophaga bisulcata	0	40	0	0	10.0	20.0
	Perna viridis	120	0	0	1520	410.0	742.2
	Anomia simplex	600	0	0	0	150.0	300.0
	Crassostrea virginica	7600	2400	6640	5980	5655.0	2269.6
	Ostreola equestris	960	0	480	0	360.0	459.6
	Isognomon radiatus	0	40	0	0	10.0	20.0
	Lasaea adansoni	0	0	80	20	25.0	37.9
	Mytilopsis leucophaeat	0	40	0	0	10.0	20.0
	Parastarte triquetra	0	0	0	0	0.0	0.0
	Tricolia affinis	0	0	0	20	5.0	10.0
Gastropoda	*Pedipes mirabilis*	0	0	0	0	0.0	0.0
	Cerithidae costata	0	0	0	0	0.0	0.0
	Cerithidae sp.	0	0	0	0	0.0	0.0
	Siphonaria pectinata	0	0	0	60	15.0	30.0
	Boonea impressa	200	0	240	0	110.0	128.1
	Odostomia sp.	0	0	0	0	0.0	0.0

Lower Estuary - Shell (LE-S)

Taxonomic Group	Taxa	MG # m^{-2}	RF # m^{-2}	RS # m^{-2}	SW # m^{-2}	Mean # m^{-2}	SD
	Astyris lunata	0	0	0	0	0.0	0.0
	Melongena corona	0	0	0	0	0.0	0.0
	Nassarius sp.	0	0	120	0	30.0	60.0
	Nassarius vibex	0	0	0	20	5.0	10.0
	Urosalpinx perrugata	40	0	0	0	10.0	20.0
	Urosalpinx tampaensis	0	0	0	0	0.0	0.0
	Assiminea succinea	0	0	0	0	0.0	0.0
	Bittiolum varium	0	320	0	0	80.0	160.0
	Cerith sp.	0	0	80	0	20.0	40.0
	Cerithium muscarum	0	0	0	0	0.0	0.0
	Crepidula aculeata	0	0	0	0	0.0	0.0
	Crepidula spp.	160	1840	2240	0	1060.0	1145.2
	Littorina angulifera	0	0	0	0	0.0	0.0
	Vitrinellidae	0	0	0	0	0.0	0.0
	Caecum sp. A	0	80	0	0	20.0	40.0
	Caecum sp. B	0	0	160	0	40.0	80.0
	Rissoidae A	0	0	0	0	0.0	0.0
	Rissoidae B	0	0	0	0	0.0	0.0
	Olividae	0	0	0	0	0.0	0.0
	Onchidella spp.	0	0	0	0	0.0	0.0
	Gastropod A	0	0	80	0	20.0	40.0
	Gastropod B	0	0	0	20	5.0	10.0
	Gastropod C	0	0	0	0	0.0	0.0
	Joculator fusiformis	0	0	0	0	0.0	0.0
	Juvenile Snails	0	0	0	240	60.0	120.0
	Pollia tincus	0	0	0	0	0.0	0.0
Polyplacophora	*Chiton squamosus*	0	40	0	0	10.0	20.0
Nermertea	*Micrura leidyi*	0	0	0	0	0.0	0.0
	Nemertean A	0	40	0	20	15.0	19.1
	Nemertean B	200	0	0	80	70.0	94.5
	Nemertean C	80	200	0	200	120.0	98.0
	Nemertean D	0	0	0	20	5.0	10.0
Platyhelminthes	Flatworm	1840	520	1440	860	1165.0	588.9
Porifera	*Cliona sp.*	0	0	0	0	0.0	0.0
Protozoa	Foraminifera	0	0	0	0	0.0	0.0
Sipuncula	*Themiste sp.*	40	5880	0	180	1525.0	2904.4
	Total/*Mean Total*	**49760**	**31560**	**49880**	**45320**	***44130.0***	