THE 2006-2007 HILTON HEAD ISLAND RENOURISHMENT PROJECT: PHYSICAL AND BIOLOGICAL RESPONSES OF THE JOINER AND BARRETT SHOALS BORROW AREAS TO DREDGING

FINAL REPORT

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EXECUTIVE SUMMARY

Dredging of subtidal sand deposits for beach nourishment is a common strategy for countering erosion in the southeastern US, but its impacts on soft bottom habitats remain poorly understood. During 2006-2007, Hilton Head Island was nourished using sand from two borrow areas, one located in Joiner Shoals on the north end of the island and the south edge of the Port Royal Sound entrance channel, and one located in Barrett Shoals on the south end of the island near the inlet of Calibogue Sound. The South Carolina Department of Natural Resources monitored the sediment and benthic community in these borrow areas between August 2006 and March 2008 to determine the impacts associated with dredging and to determine whether the borrow areas showed evidence of recovering over a one year period following dredging.

Ten randomly selected stations were sampled by $0.043 m^2$ Young grab in each borrow area and each of two reference areas prior to dredging (August 29, 2006) and three time periods after dredging (March 14, 2007, August 29, 2007, and March 6, 2008). Each surficial (~ 10 cm deep) sediment sample was sub-sampled for analysis of sediment characteristics (percent sand, silt, clay, $CaCO_3$, organic matter content, and sand grain size distribution) and the remainder of the sample was washed through a 0.5 mm mesh sieve, preserved for identification and enumeration of benthic infauna. All data were added to a larger Microsoft Access database. Overall impacts of dredging on benthic sediment and biological responses were analyzed using analysis of variance. Multivariate ordination of benthic community data was performed using non-metric multidimensional scaling.

Sediment composition and biological community structure changed significantly in both borrow areas following dredging while the reference areas changed very little. In the Joiner Shoals borrow area, fine sediments and organic matter rapidly accumulated, and the biological community changed substantially and remained heavily altered one year later. It is likely that ebb tidal transport from Port Royal Sound acted as the source of fine sediment and organic matter to this borrow pit. Periods of strong wind and/or wave energy from the south and east may periodically deposit sand from the surrounding shoal complex into the pit, creating caps of sand over the previously deposited fine sediment. In the Barrett Shoals borrow area, sediment composition shifted away from calcium carbonate and towards fine sands, and the biological community changed modestly but retained many characteristics in common with the reference areas. The surficial sediment composition of this borrow area following dredging was very similar to the reference areas through one year post-dredging, but whether this was due to the pit refilling with sand or to the failure of the pit to refill at all is not clear.

We provide several recommendations to improve our knowledge base and the sustainability of the sand resources for future Hilton Head Island nourishment projects. Joiner Shoals is not a sustainable source for beach fill and should not be excavated using current practices in future projects. Bathymetric and sediment composition surveys of the Barrett Shoals borrow area should be performed in order to calculate its refilling rate. Excavation depths in these active inlet zones should be minimized to reduce the accumulation of fine sediment in the borrow pits, and hydrologic and sediment transport modeling studies should be conducted to improve borrow area design. Studies should be performed on the amount and vertical distribution of fines material and the thickness of any overlying beach compatible sediment layer in previous borrow pits. Pre-construction project coordination should be improved so that borrow area monitoring occurs at more than one time prior to dredging.

BACKGROUND

Nourishment is a common strategy for countering beach erosion in the eastern United States and many other parts of the world (Valverde et al. 1999; Finkle et al. 2006). In most cases, beach nourishment involves removal of sediments from a nearshore subtidal source by dredge and placing that sediment onto the shoreface to replace eroded sand. Although dredging of subtidal sand deposits, termed "borrow areas", for beach fill has a long history of use in the southeastern US, its impacts on subtidal soft bottom habitats remain poorly understood.

Sediment characteristics sometimes change dramatically in the excavated pit left by the dredging operation. In some cases, dredging uncovers shell material or carbonate rubble, and, in others, silts and clays settle into the pit over time (Van Dolah et al. 1992; Van Dolah et al. 1994; Jutte et al. 2001a; Bergquist et al. 2008, 2009). While some borrow pits refill quickly with beach-compatible material, others do not refill at all or refill with silt and clay that is then covered by sand (Van Dolah et al. 1998). Failure to refill or accumulation of fine material (silt, clay, and/or organic matter) can prevent the reuse of borrow areas as sources of beach fill. Historically in South Carolina, this has occurred in areas located in close proximity to sources of estuarine fine material such as tidal inlets and rivers and those areas dredged more than one meter below the surrounding seafloor (Van Dolah et al. 1998; Bergquist and Crowe 2009).

Invertebrates form a primary link between benthic and pelagic environments through re-working of sediments, structuring habitat, processing nutrients and materials and serving as prey for larger invertebrates and vertebrates. Dredging necessarily depopulates benthic sediments, reducing benthic invertebrate densities and diversity in the short term (Van Dolah et al. 1994; Jutte et al. 1999b). However, longer-term recolonization rates vary significantly. Recovery times (time required for the impacted area to return to background conditions) tend to be associated with borrow areas that were excavated deeper below the seafloor and those that accumulated substantial amounts of silt and clay (Jutte et al. 2002). Unfortunately, the impacts of severely altered benthic community composition on the fishery value of soft-bottom habitats and functioning of the nearshore ecosystem are practically unknown.

As part of a larger beach management program, Hilton Head Island has been nourished repeatedly to build a recreationally-compatible beach and to protect structures from erosion. The first major nourishment project was conducted in 1990 and included dredging of 2.5 million cubic yards of sand from two nearshore borrow areas (Joiner Shoals and Gaskin Bank). The Gaskin Bank borrow area, located near the middle of the island, experienced no major changes in sediment composition and rather short-lived (six months to one year) changes in benthic community characteristics (Van Dolah et al. 1992). In contrast, the Joiner Shoals borrow pit, located near the entrance of Port Royal Sound, accumulated substantial amounts of mud and showed a significantly altered benthic community one to two years later (Van Dolah et al. 1992). In a follow-up study, Van Dolah et al. (1998) found that by 1996, 83% of the material taken from the Joiner Shoals borrow area had refilled, while only 51% of the material taken from Gaskin Banks had refilled. The second major nourishment project was performed in 1997 and including the dredging of over 2.9 million cubic yards of sand from Gaskin Banks and Joiner Shoals. The Gaskin Banks borrow area had higher mud content and a significantly different benthic community composition than control areas through two years post-dredging (Jutte and Van Dolah 1999, 2000). The Joiner Shoals borrow area had higher mud content and a different biological community through one year post-dredging, but showed evidence of a return to background conditions two years post-dredging (Jutte and Van Dolah 1999, 2000). Monitoring for this project did not include pre-dredging data, so conclusions about actual changes in sediment and benthic community characteristics were not possible. These results do suggest that significant impacts are likely with continued dredging, especially at Joiner Shoals, but that the response of borrow pits in a given location are not always consistent (such as the very different responses of the two Gaskin Banks borrow pits).

The most recent large-scale renourishment of Hilton Head Island was performed between September 2006 and February 2007, during which almost 2 million cubic yards of sediment was removed from a Joiner Shoals borrow area and almost 950,000 cubic yards was removed from a Barrett Shoals borrow area (Olsen and Associates, Inc. 2008). The Joiner Shoals borrow area lies in the same area in which dredging has been shown to have significant and sometimes lasting effects in past projects. The Barrett Shoals borrow area lies at the southern, and previously unstudied, end of the island. Based on a statewide survey of borrow areas, Van Dolah et al. (1998) hypothesized that borrow areas located on the northern ends of barrier island accumulate substantial amounts of fine material transported out of estuaries while those at the southern ends rapidly refill with beach compatible sand transported off the active shoreface. The placement of borrow areas at the north and south ends of a single island during a single nourishment project provides a unique opportunity to test this hypothesis.

The purpose of this study was to determine the impact on and recovery of sediment characteristics and macroinvertebrate communities following dredging in the borrow areas used for the 2006-2007 Hilton Head Island renourishment project. The monitoring project described here utilized a Before-After Control-Impact (BACI) design in order to document the changes in two impact areas (borrow areas) relative to two non-impacted control (reference) areas. All impact and reference areas were sampled multiple times during the year following dredging in order to assess the recovery of these resources over that time frame.

MATERIALS AND METHODS

Study Site and Study Design

Hilton Head Island, located in Beaufort County, SC, is a barrier island with approximately 20.5 km of Atlantic shoreface bordered to the north by Port Royal Sound and to the south by Calibogue Sound (Fig. 1). The island supports a resident population of approximately 34,000 residents (US Bureau of the Census, 2000), and a tourist industry worth approximately one billion dollars annually. Beach access is critical for both the residents and visitors of the island, thus the Town of Hilton Head Island adopted a Beach Management Plan that includes a proactive beach stabilization and renourishment process. In response to chronic erosion along its Atlantic shoreface, Hilton Head Island has undergone three major renourishments in 1990, 1997, and 2007. The 1990 and 1997 projects used sand dredged from Joiner Shoals and Gaskin Bank (Fig. 1). The 2007 project (monitored here) dredged almost 2 mcy of sediment from Joiner Shoals and almost 1 mcy of sediment Barrett Shoals to renourish approximately 13.5 km of beach at a cost of 16.7 million dollars (Olsen Associates, Inc., 2008).

The center of Joiner Shoals borrow area was located 2.6 km from shore near the Port Royal Sound entrance channel (Table 1; Fig. 1). This borrow area was oriented on the sloped channel edge of the shoal between water depths of 2.5-6.1 m, and original plans called for dredging material to a water depth of 6.1 m (Olsen Associates, Inc.,

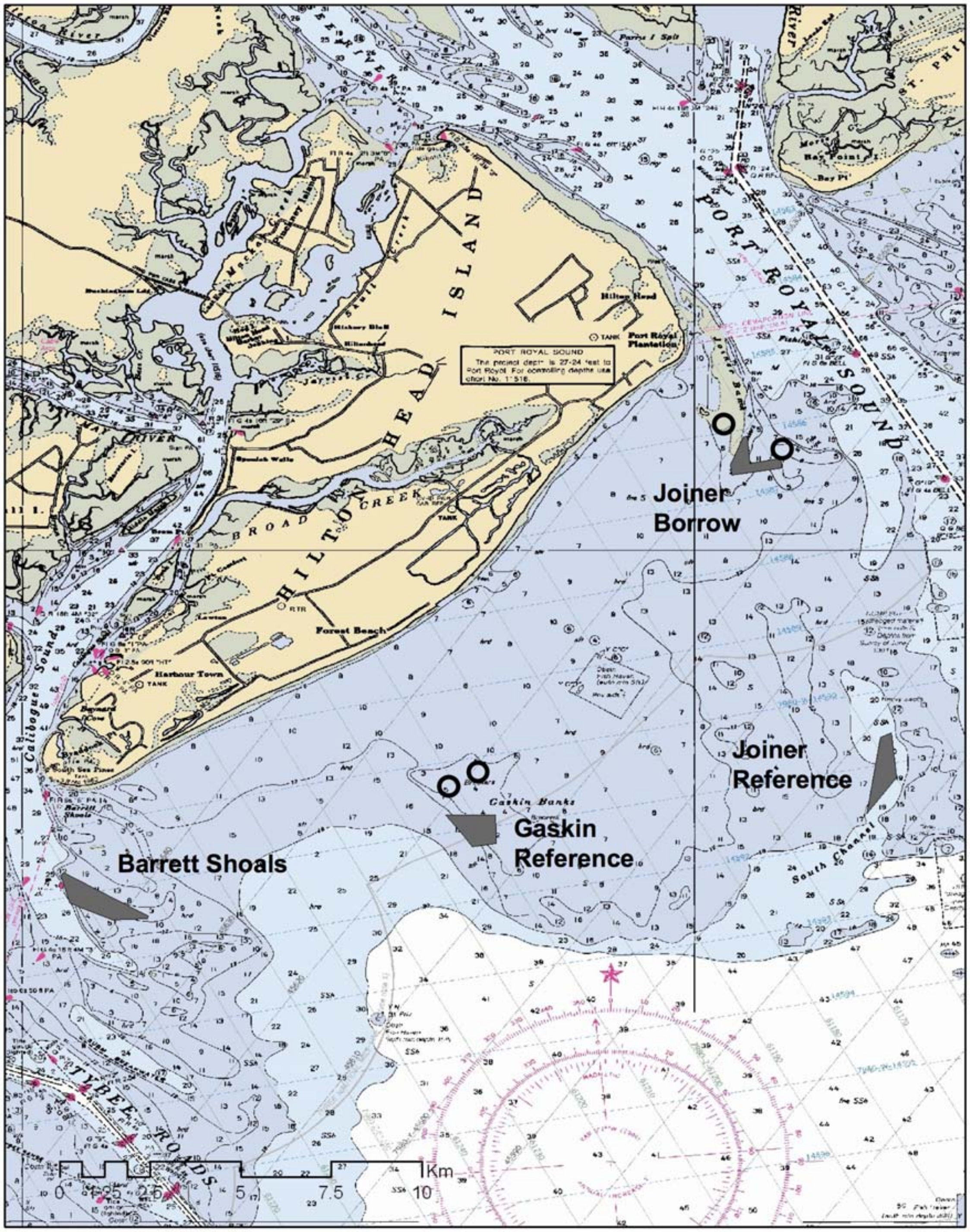

Figure 1. Map of Hilton Head Island, SC showing locations of the borrow areas (Joiner Shoals, and Barrett Shoals) and the reference areas (Joiner Reference, Barrett Reference) used in the 2006-2007 renourishment project. Approximate locations of previous borrow areas are shown as open circles.

2006). This decision to orient the borrow area on the slope edge of the shoal to create a "pocket" was based on rapid accumulation of fine sediments in previous pit-like borrow areas (Van Dolah et al., 1992, 1993; Jutte and Van Dolah, 1999, 2000). The intention of this design was to facilitate transport of fine material out of the pocket by tidal flushing through the Port Royal Sound inlet. The Barrett Shoals borrow area was located approximately 2.5 km from shore near the entrance to Calibogue Sound (Table 1; Fig. 1). This borrow area was oriented to remove a series of bathymetric high features in 2.1-6.1 m of water along the rather narrow shoal by dredging to a final water depth of 5.5-6.1 m.

The South Carolina Department of Natural Resources (SCDNR) performed an early reconnaissance and located two reference areas similar to the borrow areas based upon gross sediment characteristics and water depth. One reference area was located on Gaskin Bank in approximately 2.5 m water depth and the second was located south of the Joiner Shoals complex in 5.5 m water depth. Arc-GIS was used to randomly select ten sampling stations each borrow and each reference area prior to dredging (Appendix 1). Previous studies have indicated that ten samples per borrow area and date are sufficient to characterize the dominant benthic taxa (e.g., Van Dolah et al. 1994; Jutte et al. 1999a).

Table 1. Characteristics of the Joiner and Barrett Shoals borrow areas (summarized or calculated from figures in Olsen and Associates, Inc. (2008)).

	Joiner Shoals	**Barrett Shoals**
Permitted area size (ha)	74	132
Distance from shore (km)	2.6	2.5
Dredge type used	Hydraulic	Hydraulic
Percent of permitted area dredged	93%	30%
Amount of material removed (cy)	1,523,442	718,295
Water depth prior to dredging (m)	3.4 (2.5-6.1)	2.8 (2.1-6.1)
Water depth after dredging (m)	5.8	5.5
Change in water depth (m)	2.4	2.7

Dredging occurred within only a portion of the borrow area, so sampling locations were placed within the dredged pit for all post-dredging time frames. Random station locations were regenerated during each sampling event to provide a temporally-independent set of samples within each area. Stations within the borrow and reference areas were sampled prior to dredging (Pre), following dredging (Post), approximately six months after dredging (6-mo Post) and approximately one year after dredging (12-mo Post) corresponding to August 29, 2006, March 14, 2007, August 29, 2007, and March 6, 2008, respectively. Because dredging occurred sequentially rather than simultaneously in each borrow area, the terms Pre, Post, 6-mo Post and 12-mo Post are meant only as convenient descriptors that refer to more specific sampling time frames shown in Table 2. Because the impact to sediments and biological communities at Barrett Shoals was found to be minimal during the Post and 6-mo Post time periods (considered “recovery”; see results), per the contract between SCDNR and the Town of Hilton Head, the time-consuming processing of samples for benthic community taxonomy was not performed for the 12-mo Post time period.

Table 2. Dates and number of months pre-dredging (Pre) or post-dredging (Post, 6-mo Post, 12-mo Post) for each sampling event at each borrow area.

Event	**Joiner Shoals**		**Barrett Shoals**	
	Date	Months	Date	Months
Pre	August 29, 2006	-0.6	August 29, 2006	-4.3
Start of dredging	September 17, 2006	--	January 5, 2007	--
End of dredging	December 22, 2006	--	February 10, 2007	--
Post	March 14, 2007	2.7	March 14, 2007	1.1
6-mo Post	August 29, 2007	8.2	August 29, 2007	6.6
12-mo Post	March 6, 2008	14.4	March 6, 2008	12.8

Field and Laboratory Methods

A 0.043 m^2 Young grab was deployed from a boat and a single sample collected at each of the ten stations within each borrow and each reference area. Any sample in which the grab did not penetrate evenly to at least 8.0 cm depth (80% of the total depth of the grab) was discarded and re-collected. Each sample was sub-sampled for analysis of sediment characteristics (percent sand, silt, clay, $CaCO_3$, organic matter content, and sand grain size distribution) using a 3.5 cm diameter plastic tube inserted through the top of each grab to the bottom of the sample. The remainder of the grab sample, representing approximately 0.04 m^2 of the bottom surface area, was washed through a 0.5 mm mesh sieve. Organisms and sediment retained on the sieve were preserved in a buffered solution of 10% formalin/seawater containing rose bengal stain.

Sediment composition subsamples were analyzed for percentages (by weight) of sand, silt, clay, and calcium carbonate ($CaCO_3$) using procedures described in Folk (1980) and Pequegnat et al. (1981). Sand fractions were dry-sieved using a Ro-tap mechanical shaker, and grain size was determined by using fourteen 0.5 phi-interval screens, where phi = $-\log_2$ (grain diameter in mm) according to the Udden-Wentworth Phi classification (Brown and McLachlan 1990). Total organic matter (TOM) was determined by weighing a dried (70° C) portion of the subsample, combusting it at 550° C in a muffle furnace for two hours, and re-weighing it as described by Plumb (1981).

Benthic organisms were sorted from retained material under a magnifying lens, and each individual specimen was identified to the lowest possible taxonomic level, and enumerated by experienced taxonomists. All subsequent analyses excluded meiofaunal species (such as nematodes and copepods that are not well quantified using a 0.5 mm sieve). Organisms which could not be identified to species level due to damage were merged with those that could be identified to species to avoid overestimating the total number of species (e.g. *Prionospio* sp. included *Prionospio* that could be identified to species) unless the damaged organism(s) were clearly representing a unique taxon. A voucher collection was created for the project and maintained by the Environmental Research Section at the SCDNR Marine Resources Research Institute (Charleston, SC).

All samples processed for sediment composition, sorting and taxonomy were subjected to a rigorous quality assurance (QA) process. Samples were processed in batches of ten with every tenth sample being re-processed by a second experienced staff member. If the calculated sediment component was more than 10% different between the original and QA measurements, the batch was considered to have failed QA and the entire batch of ten was re-processed until QA was passed. For sorting and identification, the same process was followed but if less than 90% of the organisms were sorted from the sieve-retained material or more than 10% of the specimens were mis-identified, the entire batch was re-processed until QA was passed.

Data Management and Analysis

Data were added to a larger Microsoft Access database that included all available nourishment monitoring project data for South Carolina. The database included project data (such as beach and borrow area locations, time of sampling, type of sampling site (impact and reference)), sediment composition data, borrow site infaunal data and beach burrowing macrofauna data (not presented in this report).

To detect changes and recovery in borrow areas following dredging, data were transformed (and in rare cases, extreme outliers with standard deviations > 3.0 were removed) as needed to meet the assumptions of a general linear model and analyzed according to the Before-After-Control-Impact study design. For this analysis, one assumes that, if dredging had no effect, the borrow and reference areas would change in the same manner from the pre-dredging time frame to any given post-dredging time frame; however, if dredging does have an effect, the two areas would be expected to change differently. Overall impacts of dredging on benthic sediment and biological responses were analyzed using Analysis of Variance (ANOVA) following appropriate models described in Underwood (1994) (Table 2). Briefly, the full model includes two main factors: Before/After (BA) that compares pre-dredge (Before) and post-dredge (After) time periods, and Impact/Reference (IR) that compares the borrow (Impact) and non-dredged reference (Reference) areas. The factor Time (T), describing the multiple sampling times in the After period (these areas were sampled only once during the Before period), was nested within the Before vs. After factor (T(BA)). The factor Location (L), describing the multiple borrow (Joiner Shoals vs Barrett Shoals) and reference (Gaskin Reference vs Joiner Reference), was nested within the Impact vs. Reference factor (L(IR)). The interaction between the two main factors (BA x IR) describes whether the responses of the Impact and Reference areas change differently between the Before and After periods, thus providing the primary indication of a significant effect of dredging in the borrow area. The advantage of this analytical design is that takes natural spatial and temporal variation into account. The result is that the borrow and reference areas do not have to be identical prior to the impact, nor does the natural environment have to be constant through time for the analysis to detect differences in temporal change between the impact and reference sites.

A series of two-way ANOVAs with Time and Impact/Reference as factors were also performed to determine the specific time scales of disturbance and recovery at the

Table 2. Comparison between terms in the full general linear model identified by Underwood (1994) and used by the current study.

Source *sensu* Underwood (1994)	**Current study**
Before vs. After = B	Before/After = BA—tests for difference before and after dredging
Impact vs. Control = C	Impact/Reference = IR—tests for difference between dredged borrow area and non-dredged reference
B x C	Interaction = BA x IR—tests for difference in pre- to post-dredging changes between impact and reference areas
Times(Before or After) = T(B)	Nested Times = T(BA)—tests for difference among times within the before and after periods
T(B) x C	Interaction = IR x T(BA)— tests for whether differences among times within before and after periods differ between impact and reference areas
	Nested Locations = L(IR)—tests for differences between the two borrow area and between the two reference areas
	Interaction = BA X L—tests for whether the two borrow areas or the two reference areas are changing differently through time.
Residual	Residual—unexplained variability

borrow area. For these analyses, the Impact and Reference areas were compared between the pre-dredging time (Pre) and each of the other times (Post, 6 mo Post, and 12 mo Post). Similar to the analyses above, the IR x T interaction term indicates whether the Impact and Reference areas responded differently between the two Times analyzed. Comparisons of the Pre and 6 mo Pre times were performed to determine whether significant natural temporal variation was evident at the borrow area prior to dredging.

Multivariate ordination of borrow and reference area biological communities was performed by non-metric Multi-Dimensional Scaling (nMDS) using Primer v6.1.9 software (PRIMER-E ltd, 2006) to examine successional vectors in community response and recovery. Bray-Curtis similarities were calculated among all pairs of Area-Time communities following a fourth-root transformation to improve normality. The analyses were performed on individual "Station" communities (150 total: 4 areas X 3 or 4 times X 10 stations) and on "Area-Time" communities (15 total: 4 areas X 3 or 4 times). The species matrix consisted of the 50 most abundant species in the entire study (each representing >0.25% of all individuals collected); the environmental matrix consisted of the sediment characteristics (sand phi size, silt/clay content, calcium carbonate content and total organic matter).

RESULTS

Sediment Characteristics

All four sediment characteristics changed significantly at the impact (borrow) areas following dredging compared to the reference areas (IR x BA interaction in Table 3). These changes remained significant despite the variation among the post-dredging times (nested T(BA) term in Table 3) and among the various spatially-discrete locations that were monitored (nested L(IR) term in Table 3). Sediment composition changed only modestly at the reference areas over the one-year study (Fig. 2A-D), and, for the most part, both reference areas changed similarly through time. In contrast, sediment composition changed substantially in the impact areas during the same time period (Fig. 2A-D). Figure 2E-H shows the difference between each borrow pit and the two reference areas during each Time; positive values indicate higher levels at the borrow pit and negative values indicate lower levels at the borrow pit relative to the reference areas. This shows that while the broad changes in sediment composition (increasing or

Table 3. Results of analysis of variance of sediment characteristics through one-year post-dredging. BA = Before vs. After, IR = Impact vs. Reference, T = Time, L = Location. Bold italics significant at p < 0.05.

Source	**df**	**F**	**p**
Silt/Clay Content			
IR	1	82.39	**<0.001**
BA	1	29.04	**<0.001**
IR X BA	1	31.12	**<0.001**
T(BA)	2	8.26	**<0.001**
IR X T	2	12.40	**<0.001**
L(IR)	2	25.16	**<0.001**
BA X L	2	28.04	**<0.001**
Residual	148		
Sand Phi Size			
IR	1	26.36	**<0.001**
BA	1	7.25	**0.008**
IR X BA	1	17.93	**<0.001**
T(BA)	2	4.40	**0.014**
IR X T	2	1.64	0.198
L(IR)	2	36.76	**<0.001**
BA X L	2	0.26	0.770
Residual	148		
Calcium Carbonate Content			
IR	1	100.07	**<0.001**
BA	1	55.92	**<0.001**
IR X BA	1	84.49	**<0.001**
T(BA)	2	1.90	0.153
IR X T	2	2.36	0.098
L(IR)	2	41.50	**<0.001**
BA X L	2	105.36	**<0.001**
Residual	144		
Total Organic Matter Content			
IR	1	1.25	0.266
BA	1	3.34	0.070
IR X BA	1	140.55	**<0.001**
T(BA)	2	7.73	**0.001**
IR X T	2	7.52	**0.001**
L(IR)	2	40.61	**<0.001**
BA X L	2	0.47	0.627
Residual	148		

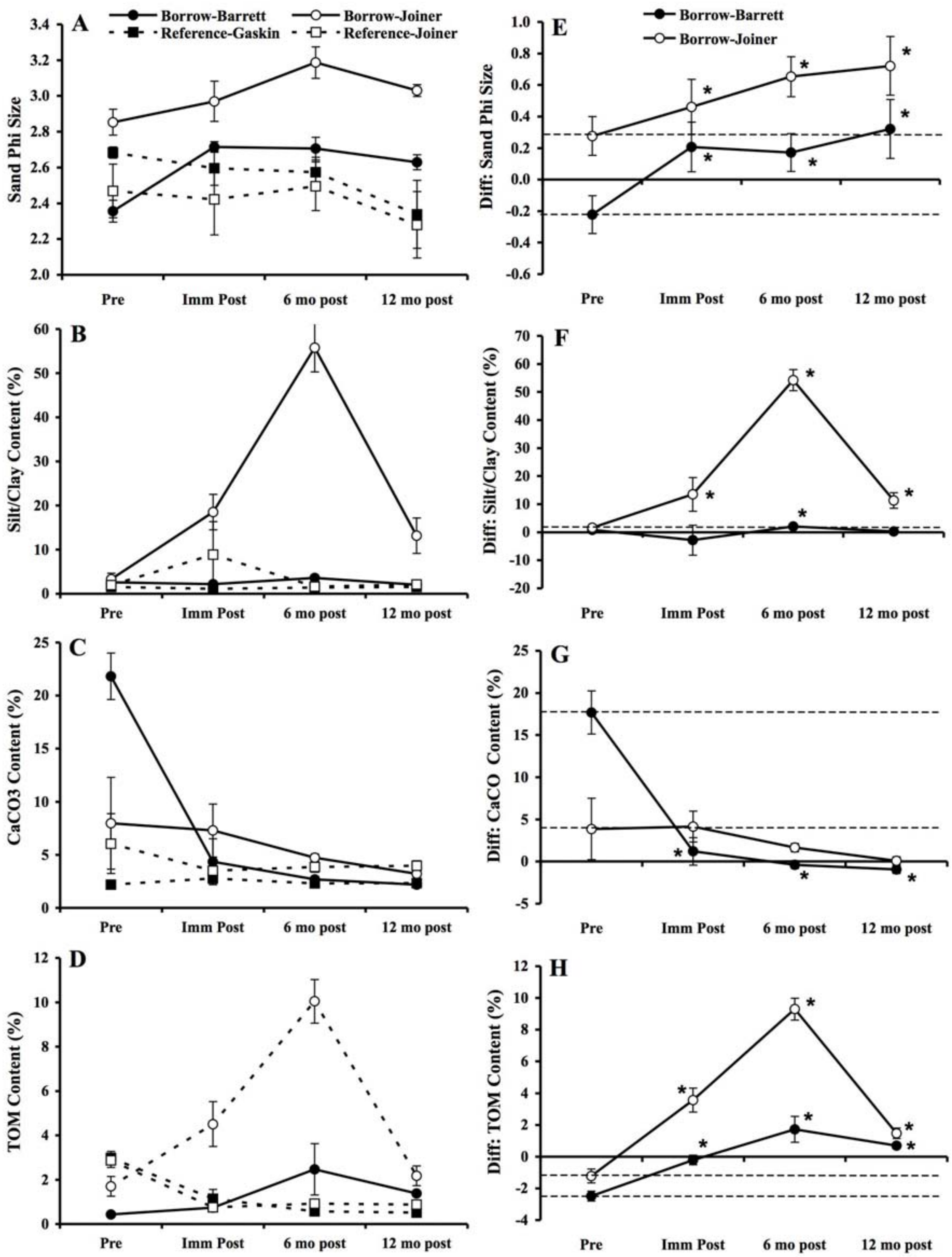

*Figure 2. Average values of sediment characteristics of the impact and reference areas (A-D) and differences in sediment characteristics between the impact and reference areas (E-H) during each time. *--interaction term significant ($p < 0.05$) in two-way ANOVA comparing sediment changes at the impact and reference areas between the Pre time and each of the post-dredging times.*

decreasing) were similar between the two borrow areas, the types and magnitudes of those changes differed substantially between them.

In the Joiner Shoals borrow pit, sand phi size, silt and clay, and organic matter increased significantly during the Post time (Fig. 2; Table 4), indicating elevated fine content of the surficial sediment layer. By the 6 mo Post time, sand phi size, silt and clay and TOM content had increased even further and remained significantly elevated (Table 4). Silt and clay content was almost 17-fold and TOM content 6-fold higher than pre-dredging levels in the borrow pit, while both sediment components decreased at the reference areas over the same time period (Fig. 2B,D,F,H). At the 12 mo Post time, silt and clay and TOM content appeared to be returning to levels similar to the immediate post-dredging time frame (Fig. 2B,D,F,H), but they remained significantly elevated relative to the Pre time (Table 4). Calcium carbonate content decreased steadily although not significantly in the borrow area, reflecting the rapid accumulation of fines (Fig. 2C,G).

In the Barrett Shoals borrow area, sand phi size and total organic matter increased and calcium carbonate decreased significantly following dredging, but silt/clay content did not change (Fig. 2; Table 4). During the 6 mo Post and 12 mo Post times, sand phi size and total organic matter remained significantly elevated and calcium carbonate significantly lower in the surficial sediments of this borrow area and showed little evidence of returning to pre-dredging conditions more than a year after dredging (Fig. 2E,G,H). When compared to the Joiner Shoals borrow area, the changes in total organic matter at the Barrett Shoals borrow area were lower in magnitude (Fig. 2H), but the change in calcium carbonate was far more severe (Fig. 2G).

Table 4. Results of ANOVAs to determine the time course of disturbance and recovery of sediment characteristics at the borrow (Impact) area. IR = Impact vs Reference, T = Time, L = reference Location. Bold italics significant at $p < 0.05$.

	Pre vs. Post			Pre vs. 6 mo Post			Pre vs. 12 mo Post		
Source	**df**	**F**	**p**	**df**	**F**	**p**	**df**	**F**	**p**
Barrett Shoals									
Silt/Clay									
IR	1	18.77	*<0.001*	1	19.63	*<0.001*	1	2.12	0.152
T	1	0.34	0.564	1	0.73	0.397	1	0.00	0.997
L(IR)	1	8.10	*0.006*	1	0.43	0.513	1	5.65	*0.021*
IR x T	1	2.50	0.120	1	5.02	***0.029***	1	0.07	0.799
Residual	52			52			52		
Phi									
IR	1	1.24	0.270	1	0.51	0.480	1	0.69	0.408
T	1	9.41	*0.003*	1	8.38	*0.005*	1	0.73	0.396
L(IR)	1	2.66	0.108	1	1.39	0.244	1	1.96	0.167
IR x T	1	12.51	***0.001***	1	13.11	***0.001***	1	12.50	***0.001***
Residual	55			55			55		
$CaCO_3$									
IR	1	97.10	*<0.001*	1	176.91	*<0.001*	1	161.70	*<0.001*
T	1	146.62	*<0.001*	1	183.01	*<0.001*	1	242.29	*<0.001*
L(IR)	1	11.55	*0.001*	1	24.38	*<0.001*	1	29.16	*<0.001*
IR x T	1	182.08	***<0.001***	1	215.29	***<0.001***	1	291.34	***<0.001***
Residual	52			54			54		
TOM									
IR	1	108.16	*<0.001*	1	82.30	*<0.001*	1	38.15	*<0.001*
T	1	17.75	*<0.001*	1	9.73	*0.003*	1	1.50	0.225
L(IR)	1	0.03	0.854	1	3.74	0.058	1	3.47	0.068
IR x T	1	116.89	***<0.001***	1	121.34	***<0.001***	1	200.61	***<0.001***
Residual	54			53			55		
Joiner Shoals									
Silt/Clay									
IR	1	50.93	*<0.001*	1	111.03	*<0.001*	1	29.40	*<0.001*
T	1	21.24	*<0.001*	1	74.16	*<0.001*	1	22.07	*<0.001*
L(IR)	1	2.48	0.121	1	3.32	0.074	1	3.99	0.051
IR x T	1	30.92	***<0.001***	1	79.19	***<0.001***	1	14.33	***<0.001***
Residual	54			55			55		
Phi									
IR	1	75.59	*<0.001*	1	63.21	*<0.001*	1	68.75	*<0.001*
T	1	15.24	*<0.001*	1	15.54	*<0.001*	1	3.77	0.058
L(IR)	1	1.89	0.175	1	0.39	0.534	1	1.36	0.250
IR x T	1	18.37	***<0.001***	1	18.73	***<0.001***	1	17.05	***<0.001***
Residual	53			55			54		
$CaCO_3$									
IR	1	10.95	*0.002*	1	14.36	*<0.001*	1	2.20	0.144
T	1	4.58	*0.037*	1	6.2	*0.016*	1	0.18	0.675
L(IR)	1	2.76	0.103	1	17.21	*<0.001*	1	17.65	*<0.001*
IR x T	1	3.35	0.073	1	2.39	0.128	1	0.53	0.471
Residual	53			53			53		
TOM									
IR	1	7.24	*0.009*	1	106.13	*<0.001*	1	2.61	0.112
T	1	1.94	0.169	1	14.98	*<0.001*	1	25.49	*<0.001*
L(IR)	1	0.19	0.661	1	4.46	*0.039*	1	2.14	0.149
IR x T	1	49.41	***<0.001***	1	385.73	***<0.001***	1	49.43	***<0.001***
Residual	55			54			55		

Biological Communities

Species richness (number of species) and diversity changed significantly at the borrow areas relative to the reference areas following dredging (IR X BA interaction in Table 5). For these same parameters, locations within the borrow and/or reference groups (L(IR) term) varied significantly and impact and reference areas differed in the way they changed among post-dredging times (IR X T in Table 5). The changes in total fauna density and species evenness (Jaccard's index) at the borrow areas were not significantly different than at the reference areas (Table 5). With the exception of total fauna density, the two reference areas changed similarly in their broad community metrics over the course of the study (Fig. 3A-D). This suggests that the differences seen among locations of a group (borrow or reference) were largely due to the two borrow areas responding differently through time.

Both the Joiner Shoals and Barrett Shoals borrow areas experienced a decrease in total fauna density relative to the reference areas immediately following dredging, but this change was only significant at Joiner Shoals (Fig. 3E; Table 6). Total fauna density returned to background levels (similar to references) by the 6 mo Post (Barrett) or 12 mo Post (Joiner) time period. The other metrics (richness, evenness, and diversity) generally increased through time at both borrow areas relative to the reference areas, but again, these changes were only significant in the Joiner Shoals borrow area (Fig 3F-H). By the 12 mo Post time period, these measures of the benthic community had not recovered to background levels at the Joiner Shoals borrow area.

Of the four higher taxonomic groups examined (amphipods, molluscs, polychaetes, and other crustaceans), only the "other crustaceans" did not change

Table 5. Results of analysis of variance of community characteristics through one-year post-dredging. BA = Before vs. After, IR = Impact vs. Reference, T = Time, L = Location. Bold italics significant at p < 0.05.

Source	**df**	**F**	**p**
Total Density			
IR	1	40.89	***<0.001***
BA	1	2.49	0.117
IR X BA	1	2.41	0.123
T(BA)	2	13.78	***<0.001***
IR X T	2	5.80	***0.004***
L(IR)	2	1.92	0.151
BA X L	2	2.29	0.105
Residual	137		
Number of Species			
IR	1	8.55	***0.004***
BA	1	12.85	***<0.001***
IR X BA	1	7.36	***0.008***
T(BA)	2	1.03	0.359
IR X T	2	9.00	***<0.001***
L(IR)	2	3.17	***0.045***
BA X L	2	1.99	0.141
Residual	138		
Evenness			
IR	1	0.37	0.543
BA	1	4.39	***0.038***
IR X BA	1	2.54	0.113
T(BA)	2	3.75	***0.026***
IR X T	2	1.32	0.271
L(IR)	2	5.66	***0.004***
BA X L	2	2.36	0.098
Residual	138		
Diversity			
IR	1	4.46	***0.037***
BA	1	12.98	***<0.001***
IR X BA	1	7.93	***0.006***
T(BA)	2	0.77	0.464
IR X T	2	3.25	***0.042***
L(IR)	2	11.58	***<0.001***
BA X L	2	0.72	0.489
Residual	138		

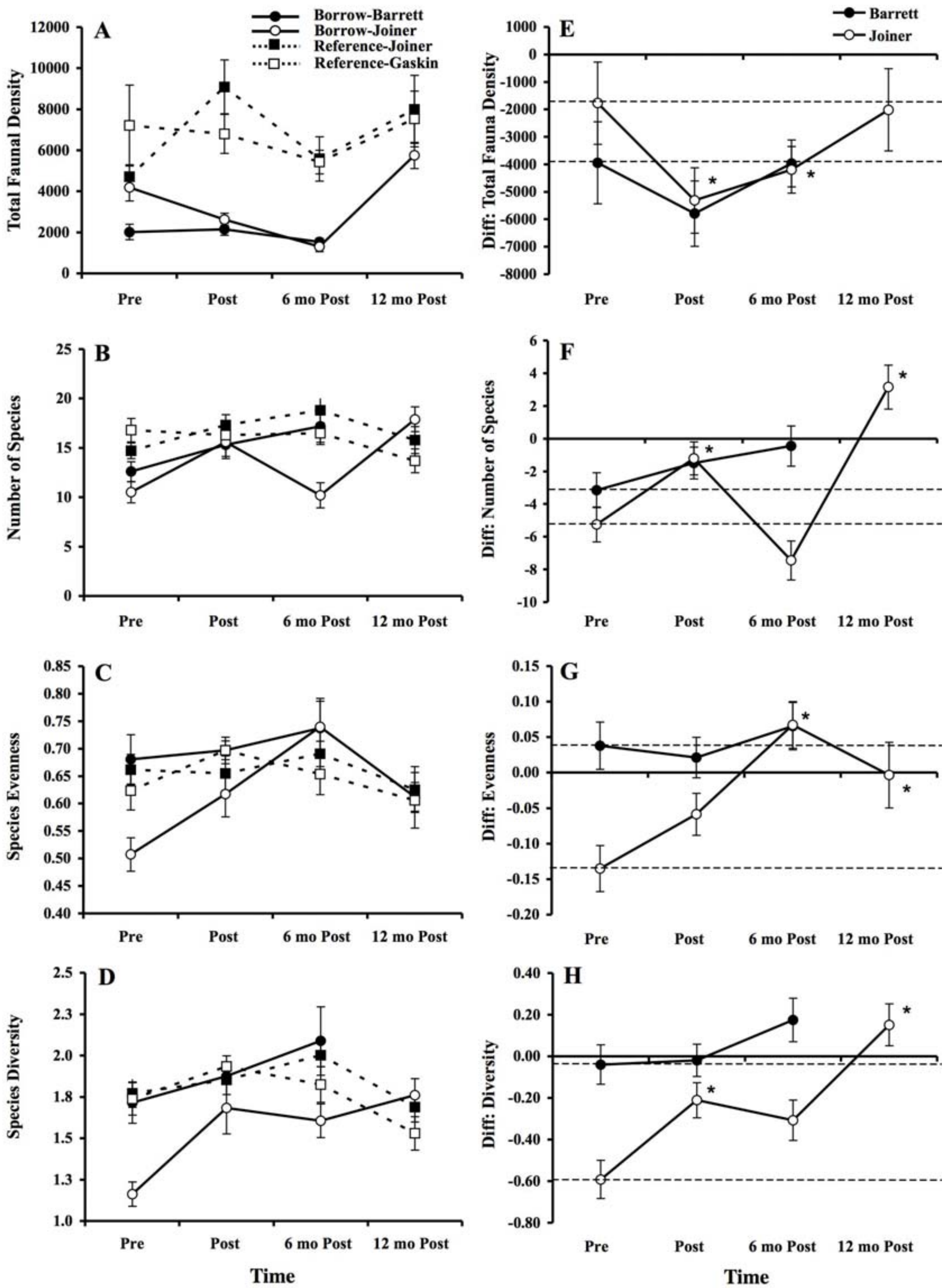

*Figure 3. Average values of benthic community characteristics in the impact and reference areas (A-D) and differences in these characteristics between the impact and reference areas (E-H) during each time. Results of the 2005 Folly Beach renourishment project are shown in E-H for comparison. *--interaction term significant ($p < 0.05$) in two-way ANOVA comparing community changes at the impact and reference areas between the Pre time and each of the other times.*

Table 6. Results of ANOVAs to determine the time course of disturbance and recovery of community characteristics at the borrow (Impact) areas. IR = Impact vs Reference, T = Time, L = reference Location. Bold and/or italics significant at $p < 0.05$.

	Pre vs. Post			Pre vs. 6 mo Post			Pre vs. 12 mo Post		
Source	**df**	**F**	**p**	**df**	**F**	**p**	**df**	**F**	**p**
Barrett Shoals									
Fauna Density									
IR	1	66.16	*<0.001*	1	67.06	*<0.001*			
T	1	2.55	0.116	1	0.60	0.440			
L(IR)	1	0.00	0.957	1	1.46	0.231			
IR x T	1	0.43	0.515	1	0.22	0.643			
Residual	55			55					
No. Species									
IR	1	7.74	*0.007*	1	2.78	0.101			
T	1	4.9	0.031	1	9.05	*0.004*			
L(IR)	1	0.29	0.591	1	0.01	0.936			
IR x T	1	1.01	0.320	1	1.56	0.217			
Residual	55			55					
Evenness									
IR	1	2.67	0.108	1	3.88	0.054			
T	1	0.00	0.997	1	2.23	0.141			
L(IR)	1	0.44	0.509	1	0.68	0.412			
IR x T	1	0.54	0.465	1	0.36	0.553			
Residual	53			55					
Diversity									
IR	1	0.09	0.767	1	1.51	0.224			
T	1	2.06	0.157	1	8.94	*0.004*			
L(IR)	1	0.09	0.768	1	0.70	0.408			
IR x T	1	0.36	0.553	1	2.05	0.158			
Residual	54			55					
Joiner Shoals									
Fauna Density									
IR	1	22.86	*0.000*	1	32.74	*<0.001*	1	0.91	0.344
T	1	0.04	0.837	1	15.66	*<0.001*	1	1.65	0.204
L(IR)	1	0.00	0.957	1	0.99	0.324	1	0.47	0.498
IR x T	1	5.92	***0.018***	1	13.70	***<0.001***	1	0.61	0.437
Residual	55			55			55		
No. Species									
IR	1	10.58	*0.002*	1	42.10	*<0.001*	1	1.06	0.308
T	1	9.62	*0.003*	1	0.67	0.417	1	9.82	*0.003*
L(IR)	1	0.23	0.633	1	0.01	0.930	1	0.00	1.000
IR x T	1	4.17	***0.046***	1	1.26	0.266	1	16.91	***<0.001***
Residual	53			55			55		
Evenness									
IR	1	11.7	*0.001*	1	1.29	0.260	1	4.84	*0.032*
T	1	6.40	*0.014*	1	19.43	*<0.001*	1	1.46	0.232
L(IR)	1	0.01	0.927	1	1.07	0.304	1	0.62	0.433
IR x T	1	1.93	0.170	1	11.65	***0.001***	1	4.49	***0.039***
Residual	55			55			55		
Diversity									
IR	1	22.26	*<0.001*	1	33.24	*<0.001*	1	7.83	*0.007*
T	1	14.96	*<0.001*	1	14.84	*<0.001*	1	8.15	*0.006*
L(IR)	1	0.05	0.816	1	1.41	0.241	1	1.14	0.291
IR x T	1	5.01	***0.029***	1	3.35	0.073	1	22.01	***<0.001***
Residual	55			55			55		

significantly at the borrow area relative to the reference area following dredging (BA x IR in Table 6). Despite their broad distribution along the Hilton Head Island nearshore zone, both borrow locations and both reference locations hosted similar proportions of the various higher taxonomic groups during the Pre time period (Fig. 4A-D). Amphipods were the dominant group and each of the other taxa comprised less than 20% of the community at all locations before dredging. At the reference locations, this distribution of fauna amongst the taxonomic groups persisted throughout the study, and both reference locations changed similarly through time (Fig. 4A-D). At the borrow locations amphipods decreased and polychaetes increased in relative abundance following dredging, although the patterns of change were much stronger in the Joiner Shoals borrow area (Fig. 4A,C). The Joiner Shoals borrow area also experienced a temporary increase in the relative abundance of “other crustaceans” and a longer-term pattern of increase in molluscs (Fig. 4B,D). In general, a pattern of significant temporal change (the T(BA) term in Table 6) was detected, largely reflecting seasonal trends of reproduction, recruitment and survivorship in benthic invertebrate communities.

At the Barrett Shoals borrow area, proportions of molluscs and polychaetes increased significantly and other crustaceans decreased significantly relative to the reference areas following dredging, but the changes were no longer significant by the 6 mo Post time period (Fig. 4F-H; IR X T term in Table 8). Although amphipods decreased in importance following dredging, this change was not significant. During the Post time period at the Joiner Shoals borrow area, the proportion of amphipods decreased significantly and other crustaceans increased significantly, while polychaetes increased (not significantly) and molluscs remained stable relative to the borrow areas (Fig. 4E-H;

Table 7. Results of analysis of variance of higher taxonomic groups through one-year post-dredging. BA = Before vs. After, IR = Impact vs. Reference, T = Time, L = Location. Bold italics significant at $p < 0.05$.

Source	**df**	**F**	**p**
% Amphipods			
IR	1	35.48	***<0.001***
BA	1	24.26	***<0.001***
IR X BA	1	5.49	***0.021***
T(BA)	2	3.42	***0.036***
IR X T	2	3.98	***0.021***
L(IR)	2	3.04	0.051
BA X L	2	4.17	***0.018***
Residual	138		
% Molluscs			
IR	1	44.37	***<0.001***
BA	1	6.91	***0.010***
IR X BA	1	6.08	***0.015***
T(BA)	2	5.39	***0.006***
IR X T	2	5.39	***0.006***
L(IR)	2	0.51	0.602
BA X L	2	0.65	0.523
Residual	138		
% Polychaetes			
IR	1	36.81	***<0.001***
BA	1	48.89	***<0.001***
IR X BA	1	14.86	***<0.001***
T(BA)	2	5.15	***0.007***
IR X T	2	0.50	0.609
L(IR)	2	0.33	0.717
BA X L	2	1.59	0.207
Residual	138		
% Other Crustaceans			
IR	1	1.20	0.276
BA	1	0.00	0.980
IR X BA	1	0.95	0.330
T(BA)	2	1.36	0.261
IR X T	2	7.40	***0.001***
L(IR)	2	0.04	0.961
BA X L	2	16.67	***<0.001***
Residual	138		

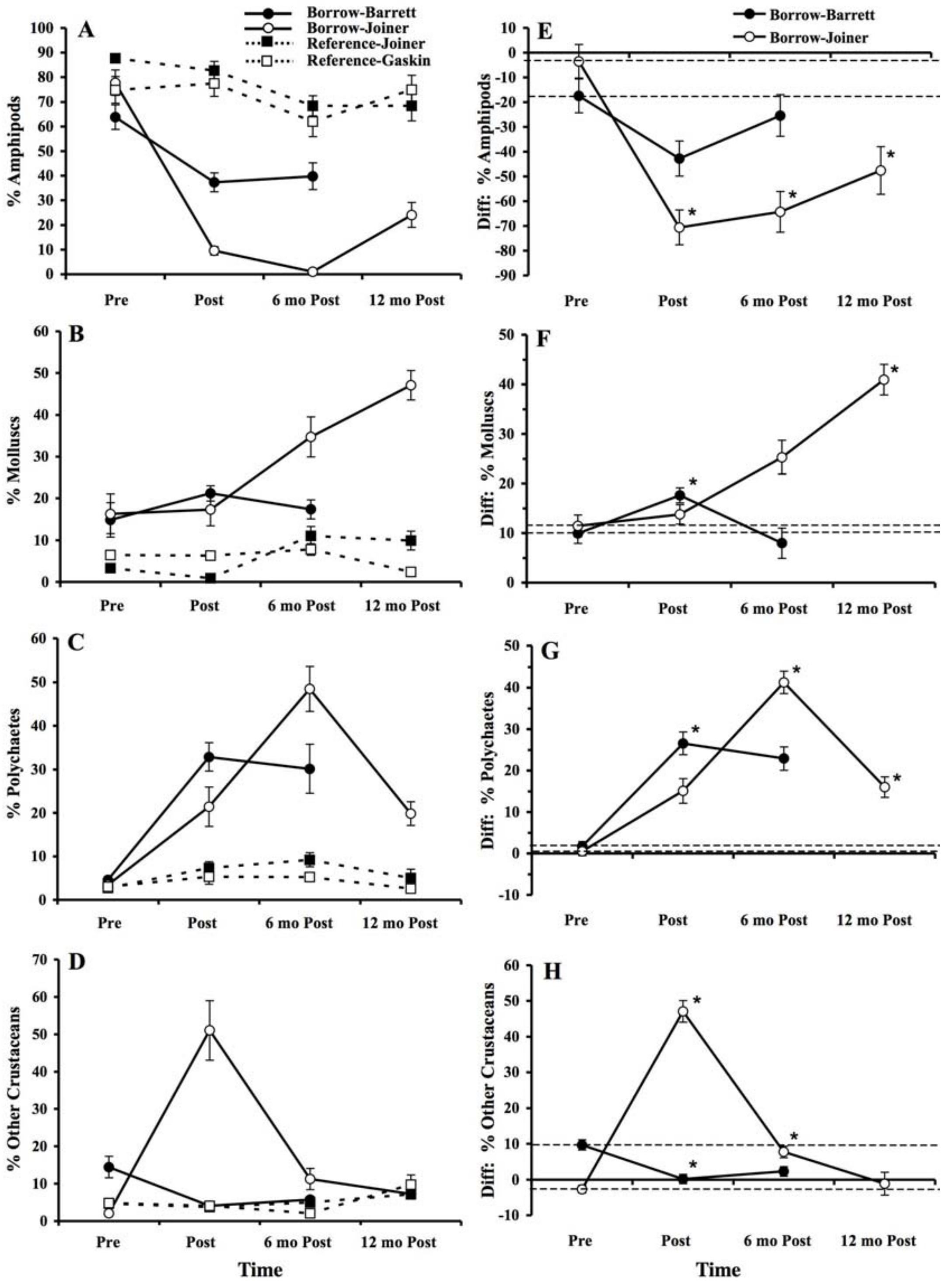

*Figure 4. Average values of higher taxonomic groups in the impact and reference areas during each time (A-D) and differences in these characteristics between the impact and reference areas during each time (E-H). *--interaction term significant (*--p < 0.05; **--p < 0.01) in two-way ANOVA comparing community composition changes at the impact and reference areas between the Pre time and each of the other times.*

Table 8. Results of ANOVAs to determine the time course of disturbance and recovery of higher taxonomic groups at the borrow (Impact) areas. IR = Impact vs Reference, T = Time, L = reference Location. Italics significant at p < 0.05. Significant IR X T p-value (bolded) indicates significant impact detected.

	Pre vs. Post			**Pre vs. 6 mo Post**			**Pre vs. 12 mo Post**		
Source	**df**	**F**	**p**	**df**	**F**	**p**	**df**	**F**	**p**
Barrett Shoals									
% Amphipods									
IR	1	32.73	*<0.001*	1	12.64	*0.001*			
T	1	2.92	0.093	1	13.13	*0.001*			
L(IR)	1	4.77	*0.033*	1	3.02	0.088			
IR x T	1	2.22	0.142	1	0.86	0.359			
Residual	55			55					
% Molluscs									
IR	1	46.31	*<0.001*	1	7.35	*0.009*			
T	1	1.78	0.187	1	3.49	0.067			
L(IR)	1	14.04	*<0.001*	1	0.24	0.623			
IR x T	1	9.09	***0.004***	1	0.06	0.804			
Residual	55			55					
% Polychaetes									
IR	1	31.52	*<0.001*	1	14.68	*<0.001*			
T	1	39.56	*<0.001*	1	29.66	*<0.001*			
L(IR)	1	0.01	0.910	1	0.03	0.859			
IR x T	1	10.27	***0.002***	1	2.51	0.119			
Residual	53			55					
% Other Crustaceans									
IR	1	1.65	0.205	1	8.84	*0.004*			
T	1	12.27	*0.001*	1	7.18	*0.010*			
L(IR)	1	0.05	0.826	1	2.04	0.159			
IR x T	1	4.28	***0.043***	1	0.21	0.648			
Residual	54			55					
Joiner Shoals									
% Amphipods									
IR	1	204.11	*<0.001*	1	215.63	*<0.001*	1	33.64	*<0.001*
T	1	188.92	*<0.001*	1	352.99	*<0.001*	1	47.15	*<0.001*
L(IR)	1	2.36	0.130	1	0.32	0.572	1	0.01	0.916
IR x T	1	204.17	***<0.001***	1	215.13	***<0.001***	1	33.31	***<0.001***
Residual	51			54			51		
% Molluscs									
IR	1	15.50	*<0.001*	1	14.41	*<0.001*	1	45.68	*<0.001*
T	1	0.48	0.489	1	7.63	*0.008*	1	9.44	*0.003*
L(IR)	1	8.92	*0.004*	1	0.21	0.646	1	0.60	0.442
IR x T	1	0.41	0.523	1	0.61	0.437	1	12.39	***0.001***
Residual	55			55			55		
% Polychaetes									
IR	1	5.61	*0.021*	1	28.58	*<0.001*	1	26.26	*<0.001*
T	1	16.88	*<0.001*	1	72.10	*<0.001*	1	12.40	*0.001*
L(IR)	1	0.01	0.923	1	0.04	0.847	1	1.61	0.209
IR x T	1	2.21	0.143	1	18.47	***<0.001***	1	16.85	***<0.001***
Residual	55			55			54		
% Other Crustaceans									
IR	1	12.93	*0.001*	1	0.34	0.562	1	3.37	0.072
T	1	28.38	*<0.001*	1	2.61	0.112	1	10.94	*0.002*
L(IR)	1	0.05	0.826	1	2.07	0.156	1	0.20	0.657
IR x T	1	45.69	***<0.001***	1	14.85	***<0.001***	1	3.06	0.086
Residual	55			55			55		

Table 8). The proportion of amphipods remained significantly lower and polychaetes significantly higher through the 12 mo Post time period (Fig. 4E,G). Molluscs began increasing in relative abundance and were significantly higher by the 12 mo Post time period (Fig. 4F). Other crustaceans decreased sharply from their Post time peak and returned to background levels by the 12 mo Post time (Fig. 4H).

Multivariate analysis of borrow and reference area communities identified strong temporal changes in community structure at the Joiner Shoals borrow area, smaller changes in the Barrett Shoals borrow area, seasonal changes at the reference areas. Individual Station communities formed several clusters: a large central cluster containing most stations prior to dredging (Pre) as well as most of the reference station regardless of sampling time, a cluster to the right comprised of 6mo Post stations at the Joiner Shoals and Barrett Shoals borrow areas, a cluster near the top comprised largely of Post stations at the Joiner Shoals borrow area, and a small cluster to the left comprised of a small number of 12 mo Post stations from the Joiner reference area (Fig. 5A). In general, the most consistent outlying communities were those from Joiner Shoals borrow area after the completion of dredging.

Simplifying the multivariate analysis to Area-Time communities reveals a similar pattern (Fig. 5B; Table 9). The reference areas show the underlying seasonal variation in the benthic communities of the area. Between the Pre (August) and Post (March) times, the communities shifted slightly up and left on the ordination plot, shifted back down toward the Pre communities 6 mo Post (August) and shifted back up and left 12 mo Post (March) (Fig. 5B). The reference area were consistently similar to each other through time (Bray Curtis similarities (S) = 68-78). While these seasonal fluctuations were apparent at the borrow areas, the borrow area communities also showed a strong shift

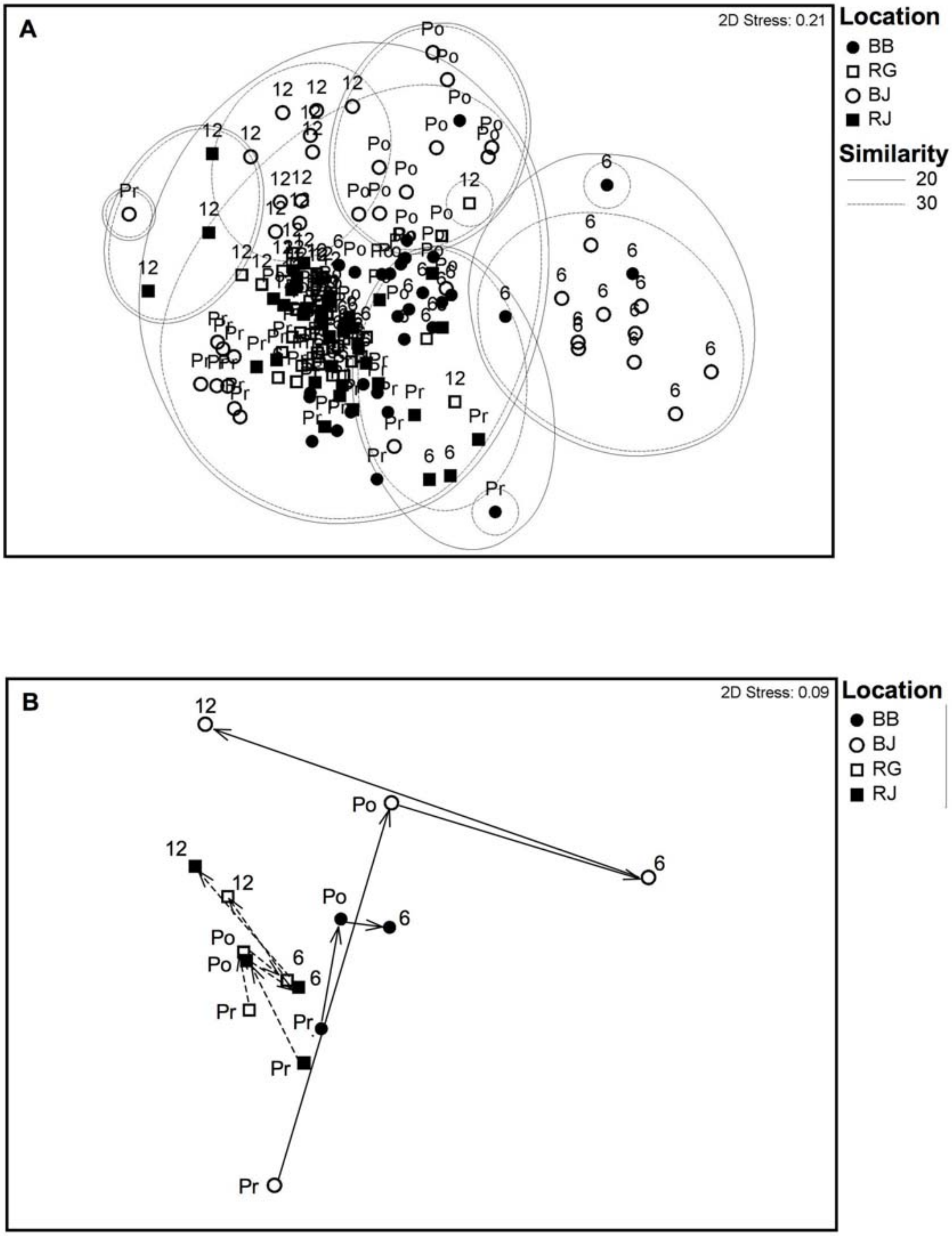

Figure 5. nMDS ordination plots for "Station" communities (A) and "Area-Time" communities (B). BB—Barrett borrow area, BJ—Joiner borrow area, RG—Gaskin reference area, RJ—Joiner reference area. Pr—pre, Po—Post, 6—6 mo Post, 12—12 mo Post. Arrows show trajectory of each area through time.

upwards and slightly right in the ordination plot immediately following dredging (Post). This upward shift was rather small at the Barrett Shoals borrow area, but was very strong at the Joiner Shoals borrow area. Between the Pre and Post time periods the Barrett Shoals communities become less similar to the reference areas (S = 71-74 Pre and 64-66 Post; Table 9). Over the same time, the overall similarity of the Joiner Shoals borrow to the reference areas did not change substantially (S = 50-52 Pre and 46-50 Post; Table 9); however, this does not reflect the very large shift that occurred in the Joiner Shoals community. The similarity between the Pre and Post Joiner Shoals borrow area communities was quite low (S = 33) while the similarities between the Pre and Post communities at the other areas were close to twice as high (S = 61-73; Table 9). Following the large post-dredging change in community structure at the Joiner Shoals borrow area, an exaggerated seasonal fluctuation began, and the communities showed little evidence of returning to pre-dredging of reference conditions. The Joiner Shoals

Table 9. Bray-Curtis similarities among all pair of Area-Time biological communities. BB—Barrett borrow area, BJ—Joiner borrow area, RG—Gaskin reference area, RJ—Joiner reference area

		Pre				**Post**				**6 mo Post**				**12 mo Post**	
		BB	**BJ**	**RG**	**RJ**	**BB**	**BJ**	**RG**	**RJ**	**BB**	**BJ**	**RG**	**RJ**	**BJ**	**RG**
Pre	**BJ**	48													
	RG	74	50												
	RJ	71	52	68											
Post	**BB**	61	36	60	51										
	BJ	41	33	39	35	49									
	RG	60	49	73	58	66	49								
	RJ	60	44	69	65	64	46	78							
6 mo Post	**BB**	61	36	58	52	63	63	57	57						
	BJ	28	15	23	30	30	40	27	27	43					
	RG	76	49	73	64	63	45	70	69	66	28				
	RJ	68	41	68	71	60	45	67	71	64	31	78			
12 mo Post	**BJ**	30	25	38	30	38	50	43	41	40	12	37	39		
	RG	55	38	59	45	53	47	76	67	51	30	65	58	48	
	RJ	49	28	60	46	47	42	64	62	51	21	60	59	62	69

borrow area was most dissimilar to the reference areas during the 6 mo Post time (S = 28-31).

The communities that diverged most strongly (Joiner Shoals post-dredging) were associated with an increased silt/clay content, elevated organic matter, somewhat elevated fine sand content and decreased $CaCO_3$ content (Fig 6A-D). The most dissimilar community (Joiner Shoals during 6 mo Post) was also associated with the highest sand phi size, silt/clay content and total organic matter measured in this study. The non-seasonal shift of the Barrett Shoals borrow area communities post-dredging were associated with decreased $CaCO_3$ content elevated fine sand content, and somewhat elevated organic matter (Fig 6A-D).

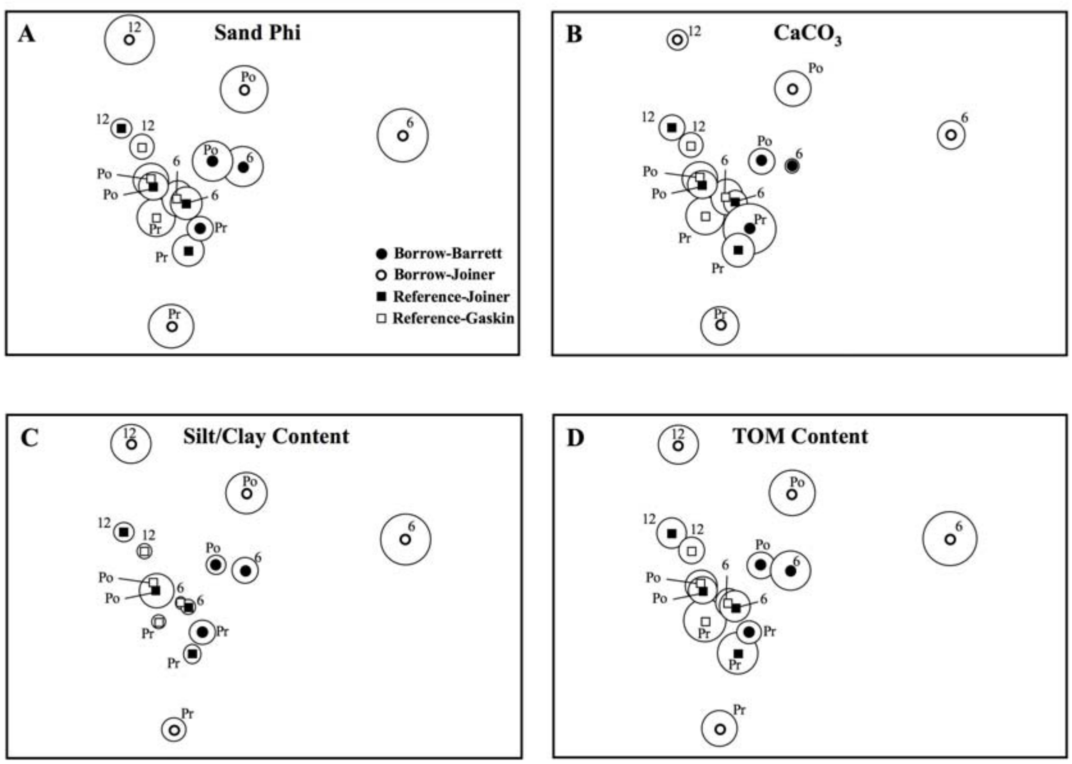

Figure 6. nMDS bubble plots showing the relationship between differences in benthic community structure and sediment composition. Size of bubble indicates relative level of sediment characteristic (larger circle = larger value of characteristic).

The ten most abundant taxa ("dominant taxa") represented 67-95% of all fauna in Area-Time communities in terms of total infaunal abundance; excluding the Barrett Shoals borrow area during the 6 mo Post time, that range jumps to 82-95% (Table 10a,b). In all areas, amphipod crustaceans, particularly *Protohaustorius deichmannae*, *Acanthohaustorius millsi*, *A. intermedius*, *A. shoemakeri*, and *Eudevenopus honduranus*, dominated the benthic communities across all areas and time periods. Further, most of the dominant taxa were present in at least half of the ten stations sampled for each Area-Time community (Table 10a,b), suggesting that these taxa were not severely patchy in their distributions within each area.

Prior to dredging, all areas shared a large number of dominant taxa, all of which were amphipods (Table 10a,b; Table 11). Considering all species, not just dominant taxa, the reference areas had approximately half of their species in common, and the Joiner Shoals and Barrett Shoals borrow areas had 45% and 77%, respectively, of their species in common with at least one of the reference areas ("Total Common" in Table 11). Following dredging of the borrow areas, the borrow areas had a much lower number of dominant species in common with the reference areas than the reference areas had in common with each other (Table 11). This was particularly notable at the Joiner Shoals borrow area where only *P. deichmannae* and *Oxyurostylis smithi* (a cumacean) occurred at both the borrow area and at least one of the reference areas, and then only during the Post and 12 mo Post times. However, when all species were considered, the borrow areas had a similar percent of their species in common with the reference areas post-dredging as the reference areas had in common with each other.

Table 10a. Ten most abundant benthic taxa (dominant taxa) collected at the borrow immediately prior to dredging (Pre) and immediately, 6 months and 12 months following the completion of dredging (Post, 6 mo Post, and 12 mo Post, respectively). Abundance values represent the total number of individuals collected in ten samples ($0.04m^2$ per sample). Higher taxa codes are P = Polychaete, A = Amphipod, M = Mollusc, and O = Other taxa.

Joiner Shoals Borrow Area				
SpeciesName	**Category**	**Total Abundance**	**Percent Abundance**	**% Stations Present**
Pre				
Protohaustorius deichmannae	A	1057	63.1	100
Acanthohaustorius millsi	A	202	12.1	70
Tellina probrina	M	108	6.5	50
Acanthohaustorius shoemakeri	A	59	3.5	60
Haustoriidae	A	43	2.6	50
Tellina sp.	M	42	2.5	50
Haustorius canadensis	A	33	2.0	10
Acanthohaustorius sp.	A	25	1.5	10
Metharpinia floridana	A	7	0.4	30
Nephtys picta	P	7	0.4	30
Total of all other species		***91***	***5.4***	
Post				
Oxyurostylis smithi	O	360	34.2	90
Tellina agilis	M	147	14.0	90
Mediomastus californiensis	P	133	12.6	30
Leucon americanus	O	55	5.2	60
Cumacea	O	51	4.8	90
Protohaustorius deichmannae	A	48	4.6	60
Leitoscoloplos fragilis	P	21	2.0	40
Cyclaspis varians	O	20	1.9	40
Edotia montosa	O	19	1.8	40
Leitoscoloplos sp.	P	18	1.7	80
Total of all other species		***180***	***17.1***	
6 mo Post				
Acteocina candei	M	196	37.5	90
Mediomastus californiensis	P	108	20.7	80
Prionospio pygmaea	P	77	14.8	90
Nemertea	O	25	4.8	60
Glycinde nordmanni	P	16	3.1	70
Decapoda	O	15	2.9	80
Pelecypoda	M	13	2.5	50
Copepoda	O	12	2.3	70
Nassarius vibex	M	12	2.3	50
Leitoscoloplos robustus	P	6	1.1	30
Total of all other species		***42***	***8.1***	
12 mo Post				
Acteocina canaliculata	M	770	33.5	100
Protohaustorius deichmannae	A	526	22.9	90
Leitoscoloplos fragilis	P	306	13.3	100
Oxyurostylis smithi	O	147	6.4	100
Tellina alternata	M	147	6.4	80
Paraprionospio pinnata	P	49	2.1	70
Tellina agilis	M	42	1.8	50
Tiron tropakis	A	41	1.8	90
Nassarius albus	M	30	1.3	70
Carinomella lactea	O	26	1.1	50
Total of all other species		***215***	***9.4***	

Barrett Shoals Borrow Area				
SpeciesName	**Category**	**Total Abundance**	**Percent Abundance**	**% Stations Present**
Pre				
Protohaustorius deichmannae	A	234	29.0	90
Parahaustorius longimerus	A	149	18.5	60
Donax variabilis	M	137	17.0	30
Acanthohaustorius millsi	A	36	4.5	40
Acanthohaustorius intermedius	A	34	4.2	60
Tanaissus psammophilus	O	26	3.2	40
Rhepoxynius hudsoni	A	18	2.2	40
Tellinidae	M	16	2.0	60
Eudevenopus honduranus	A	13	1.6	30
Haustoriidae	A	12	1.5	50
Total of all other species		***131***	***16.3***	
Post				
Protohaustorius deichmannae	A	258	30.0	90
Spiophanes bombyx	P	249	29.0	100
Tellina agilis	M	106	12.3	100
Lucinidae	M	43	5.0	90
Nemertea	O	20	2.3	80
Paraonis fulgens	P	17	2.0	60
Acanthohaustorius intermedius	A	11	1.3	70
Haustoriidae	A	11	1.3	70
Oxyurostylis smithi	O	11	1.3	50
Olivella mutica	M	10	1.2	30
Total of all other species		***124***	***14.4***	
6 mo Post				
Protohaustorius deichmannae	A	181	29.4	80
Rhepoxynius hudsoni	A	50	8.1	60
Tellina agilis	M	48	7.8	60
Prionospio sp.	P	27	4.4	10
Spiophanes bombyx	P	24	3.9	10
Nemertea	O	21	3.4	80
Eudevenopus honduranus	A	19	3.1	50
Glycinde nordmanni	P	17	2.8	50
Mediomastus californiensis	P	14	2.3	40
Pelecypoda	M	13	2.1	70
Total of all other species		***202***	***32.8***	

Table 10b. Ten most abundant benthic taxa (dominant taxa) collected at the reference immediately prior to dredging (Pre) and immediately, 6 months and 12 months following the completion of dredging (Post, 6 mo Post, and 12 mo Post, respectively). Abundance values represent the total number of individuals collected in ten samples (0.04m² per sample). Higher taxa codes are P = Polychaete, A = Amphipod, M = Mollusc, and O = Other taxa.

Joiner Shoals Reference Area					Gaskin Banks Reference Area				
SpeciesName	**Category**	**Total Abundance**	**Percent Abundance**	**% Stations Present**	**SpeciesName**	**Category**	**Total Abundance**	**Percent Abundance**	**% Stations Present**
Pre					**Pre**				
Protohaustorius deichmannae	A	894	31.0	90	*Protohaustorius deichmannae*	A	722	38.3	100
Pyura vittata	O	708	24.6	10	*Acanthohaustorius millsi*	A	456	24.2	100
Eudevenopus honduranus	A	240	8.3	100	*Acanthohaustorius intermedius*	A	184	9.8	100
Acanthohaustorius intermedius	A	218	7.6	60	*Eudevenopus honduranus*	A	98	5.2	100
Nematoda	O	86	3.0	40	Haustoriidae	A	86	4.6	80
Branchiostoma sp.	O	74	2.6	60	*Acanthohaustorius shoemakeri*	A	56	3.0	80
Metharpinia floridana	A	74	2.6	90	*Rhepoxynius hudsoni*	A	38	2.0	60
Pelecypoda	M	70	2.4	50	*Ogyrides hayi*	O	34	1.8	80
Acanthohaustorius sp.	A	48	1.7	20	*Olivella mutica*	M	20	1.1	60
Acanthohaustorius millsi	A	38	1.3	40	*Onuphis eremita*	P	16	0.8	20
Total of all other species		***432***	***15.0***		***Total of all other species***		***174***	***9.2***	
Post					**Post**				
Protohaustorius deichmannae	A	1148	42.2	100	*Protohaustorius deichmannae*	A	1118	30.7	90
Acanthohaustorius intermedius	A	352	12.9	80	*Acanthohaustorius millsi*	A	1084	29.8	100
Eudevenopus honduranus	A	252	9.3	100	*Acanthohaustorius intermedius*	A	380	10.5	100
Rhepoxynius hudsoni	A	200	7.4	80	*Bathyporeia parkeri*	A	174	4.8	90
Acanthohaustorius millsi	A	102	3.8	70	Haustoriidae	A	158	4.3	100
Bathyporeia parkeri	A	70	2.6	80	*Paraonis fulgens*	P	126	3.5	90
Oxyurostylis smithi	O	60	2.2	80	*Acanthohaustorius shoemakeri*	A	120	3.3	70
Haustoriidae	A	56	2.1	90	Nematoda	O	86	2.4	80
Acanthohaustorius shoemakeri	A	54	2.0	60	*Eudevenopus honduranus*	A	68	1.9	80
Nematoda	O	40	1.5	60	*Rhepoxynius hudsoni*	A	54	1.5	70
Total of all other species		***386***	***14.2***		***Total of all other species***		***268***	***7.4***	
6 mo Post					**6 mo Post**				
Protohaustorius deichmannae	A	750	34.5	90	*Protohaustorius deichmannae*	A	838	37.5	100
Acanthohaustorius intermedius	A	242	11.1	60	*Acanthohaustorius millsi*	A	380	17.0	90
Thyonella gemmata	O	188	8.7	20	*Eudevenopus honduranus*	A	126	5.6	80
Eudevenopus honduranus	A	174	8.0	100	*Rhepoxynius hudsoni*	A	94	4.2	80
Branchiostoma sp.	O	164	7.6	80	*Paraonis fulgens*	P	82	3.7	70
Rhepoxynius hudsoni	A	86	4.0	70	*Donax variabilis*	M	80	3.6	70
Acanthohaustorius millsi	A	54	2.5	50	Haustoriidae	A	78	3.5	70
Renilla reniformis	O	52	2.4	50	*Bathyporeia parkeri*	A	68	3.0	90
Tellina agilis	M	42	1.9	70	*Parahaustorius longimerus*	A	64	2.9	70
Bathyporeia parkeri	A	36	1.7	50	*Acanthohaustorius intermedius*	A	38	1.7	80
Total of all other species		***384***	***17.7***		***Total of all other species***		***384***	***17.2***	
12 mo Post					**12 mo Post**				
Protohaustorius deichmannae	A	1370	45.5	90	*Protohaustorius deichmannae*	A	1204	37.6	90
Acanthohaustorius intermedius	A	454	15.1	90	*Acanthohaustorius millsi*	A	800	25.0	80
Acanthohaustorius millsi	A	336	11.2	40	Nematoda	O	180	5.6	60
Nematoda	O	236	7.8	60	*Bathyporeia parkeri*	A	172	5.4	80
Bathyporeia parkeri	A	112	3.7	80	*Acanthohaustorius shoemakeri*	A	126	3.9	10
Eudevenopus honduranus	A	102	3.4	80	*Acanthohaustorius intermedius*	A	124	3.9	80
Oxyurostylis smithi	O	72	2.4	70	*Donax variabilis*	M	118	3.7	90
Rhepoxynius hudsoni	A	72	2.4	70	*Eudevenopus honduranus*	A	72	2.3	60
Campylaspis affinis	O	38	1.3	70	*Oxyurostylis smithi*	O	58	1.8	90
Glycera americana	P	28	0.9	40	*Rhepoxynius epistomus*	A	58	1.8	70
Total of all other species		***192***	***6.4***		***Total of all other species***		***286***	***8.9***	

Table 11. Dominant species in common and total number and percent (bolded italics) of species in common between each of the borrow areas and the reference areas and between the two reference areas during each time. Percent of common species was calculated based on the total number of species present at an area during the appropriate post-dredging time. Percent for the reference areas depended on the reference area used for calculation, hence a range is presented. For each post-dredging time, the number and percent of common species that were also common pre-dredging is also shown.

	Species in common between		
Area	**Joiner Borrow vs References**	**Barrett Borrow vs References**	**Reference vs. Reference**
Pre	*Protohaustorius deichmannae* *Acanthohaustorius millsi* *Acanthohaustorius shoemakeri* Haustoriidae *Acanthohaustorius* sp. *Metharpina floridana* ***Total Common: 24 (45%)***	*Protohaustorius deichmannae* *Acanthohaustorius millsi* *Acanthohaustorius intermedius* *Rhepoxynius hudsoni* *Eudevenopus honduranus* Haustoriidae ***Total Common: 41 (77%)***	*Protohaustorius deichmannae* *Eudevenopus honduranus* *Acanthohaustorius intermedius* *Acanthohaustorius millsi* ***Total Common: 31 (42-69%)***
Post	*Oxyurostylis smithi* *Protohaustorius deichmannae* ***Total Common: 25 (40%)*** ***Also Common Pre: 7 (28%)***	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* Haustoriidae *Oxyurostylis smithi* ***Total Common: 30 (56%)*** ***Also Common Pre: 16 (53%)***	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* *Eudevenopus honduranus* *Rhepoxynius hudsoni* *Acanthohaustorius millsi* *Bathyporeia parkeri* Haustoriidae *Acanthohaustorius shoemakeri* Nematoda ***Total Common: 33 (60-65%)*** ***Also Common Pre: 15 (45%)***
6 mo Post	***Total Common: 22 (63%)*** ***Also Common Pre: 3 (14%)***	*Protohaustorius deichmannae* *Rhepoxynius hudsoni* *Tellina agilisus* *Eudevenopus honduranus* ***Total Common: 47 (59%)*** ***Also Common Pre: 21 (45%)***	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* *Eudevenopus honduranus* *Rhepoxynius hudsoni* *Acanthohaustorius millsi* *Bathyporeia parkeri* ***Total Common: 33 (56%)*** ***Also Common Pre: 17 (52%)***
12 mo Post	*Protohaustorius deichmannae* *Oxyurostylis smithi* ***Total Common: 28 (53%)*** ***Also Common Pre: 4 (14%)***	Data Not Available	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* *Acanthohaustorius millsi* Nematoda *Bathyporeia parkeri* *Eudevenopus honduranus* *Oxyurostylis smithi* ***Total Common: 25 (45-58%)*** ***Also Common Pre: 12 (48%)***

We also examined the species in common between borrow areas and the reference areas during the post-dredging times that were also in common among them pre-dredging ("Also Common Pre" in Table 11). Approximately half (45-52%) of all the species that the reference areas had in common with each other during each post-dredging time were also species they had in common during the pre-dredging time. The Barrett Shoals borrow area followed a similar trend: about half of the species that it had in common with at least one reference area during the post-dredging times were also common species during the pre-dredging time. The Joiner Shoals borrow area showed a very different pattern with only 14-28% of the taxa it had in common with the reference areas post-dredging it also had in common with the reference areas pre-dredging.

When the dominant species are compared between the pre-dredging and each of the post-dredging times within each area, Joiner Shoals shows a strong pattern of dominant species turnover as compared to the other areas (Table 10a,b; Table 12). Many of the taxa that were dominant at the reference areas pre-dredging were also dominant in those areas post-dredging (Table 12). Considering all species, 37-56% of the species that

Table 12. Dominant species in common and total number and percent (bolded italics) of species in common between each post-dredging time and the pre-dredging time at each area. Percent of common species was calculated based on the total number of species present at an area during the appropriate post-dredging time.

	Species in common between Pre and		
Area	**Post**	**6 mo Post**	**12 mo Post**
Joiner Borrow	*Protohaustorius deichmannae* ***Total Common: 19 (31%)***	***Total Common: 7 (20%)***	*Protohaustorius deichmannae* ***Total Common: 10 (19%)***
Barrett Borrow	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* Haustoriidae ***Total Common: 26 (48%)***	*Protohaustorius deichmannae* *Rhepoxynius hudsoni* *Eudevenopus honduranus* ***Total Common: 32 (41%)***	Data Not Available
Joiner Reference	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* *Eudevenopus honduranus* *Acanthohaustorius millsi* Nematoda ***Total Common: 31 (56%)***	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* *Eudevenopus honduranus* *Branchiostoma* sp. *Acanthohaustorius millsi* ***Total Common: 32 (54%)***	*Protohaustorius deichmannae* *Acanthohaustorius intermedius* *Eudevenopus honduranus* *Acanthohaustorius millsi* ***Total Common: 16 (37%)***
Gaskin Reference	*Protohaustorius deichmannae* *Acanthohaustorius millsi* *Acanthohaustorius intermedius* Haustoriidae *Acanthohaustorius shoemakeri* *Eudevenopus honduranus* *Rhepoxynius hudsoni* ***Total Common: 23 (45%)***	*Protohaustorius deichmannae* *Acanthohaustorius millsi* *Eudevenopus honduranus* *Rhepoxynius hudsoni* Haustoriidae *Acanthohaustorius intermedius* ***Total Common: 27 (46%)***	*Protohaustorius deichmannae* *Acanthohaustorius millsi* *Acanthohaustorius shoemakeri* *Acanthohaustorius intermedius* *Eudevenopus honduranus* ***Total Common: 23 (42%)***

were present pre-dredging were also present during the three post-dredging times (Table 12). The Barrett Shoals borrow area showed a similar pattern, although fewer dominant species were similar between the pre-dredging and post-dredging times. Of the dominant taxa present at the Joiner Shoals borrow area pre-dredging, only *P. deichmannae* was present during any post-dredging time (Table 12). When considering all species present, only 19-31% of those present at Joiner Shoals pre-dredging were also present during any post-dredging time.

DISCUSSION

The sediment and biological characteristics of both borrow areas changed significantly following dredging, but the two areas responded very differently to the impact. The Joiner Shoals borrow area rapidly accumulated fine material (fine sand and silts and clays) as well as large amounts of organic matter. The biological community inhabiting Joiner Shoals also changed substantially following nourishment and showed little evidence of recovery one year later. The Barrett Shoals borrow area increased in finer sands and decreased in calcium carbonate (mostly shell) following dredging. The biological community here also changed following dredging, but this change was far less severe and long-lasting compared to the changes at Joiner Shoals. By contrast, very little change was documented in the sediment characteristics or biological communities of the reference areas over the entire course of this study.

Response of the Joiner Shoals Borrow Area

Sediment composition changes that occurred in the Joiner Shoals borrow area following dredging were among the most severe documented in South Carolina. Eight months after the completion of dredging (the "6 mo Post" time), the surficial sediment of this previously sand-dominated coastal shoal contained almost 60% silt/clay and 10% organic matter. This is more than twice the amount of these sediment components found in a typical shallow, estuarine tidal creek in South Carolina (Van Dolah et al. 2006) and is very atypical of nearshore environments. Nearby parts of Joiner Shoals have been mined for two earlier nourishment projects on Hilton Head Island, and both times the borrow pit showed evidence of accumulating fine material (Fig. 7A,B; Van Dolah et al 1992; Jutte

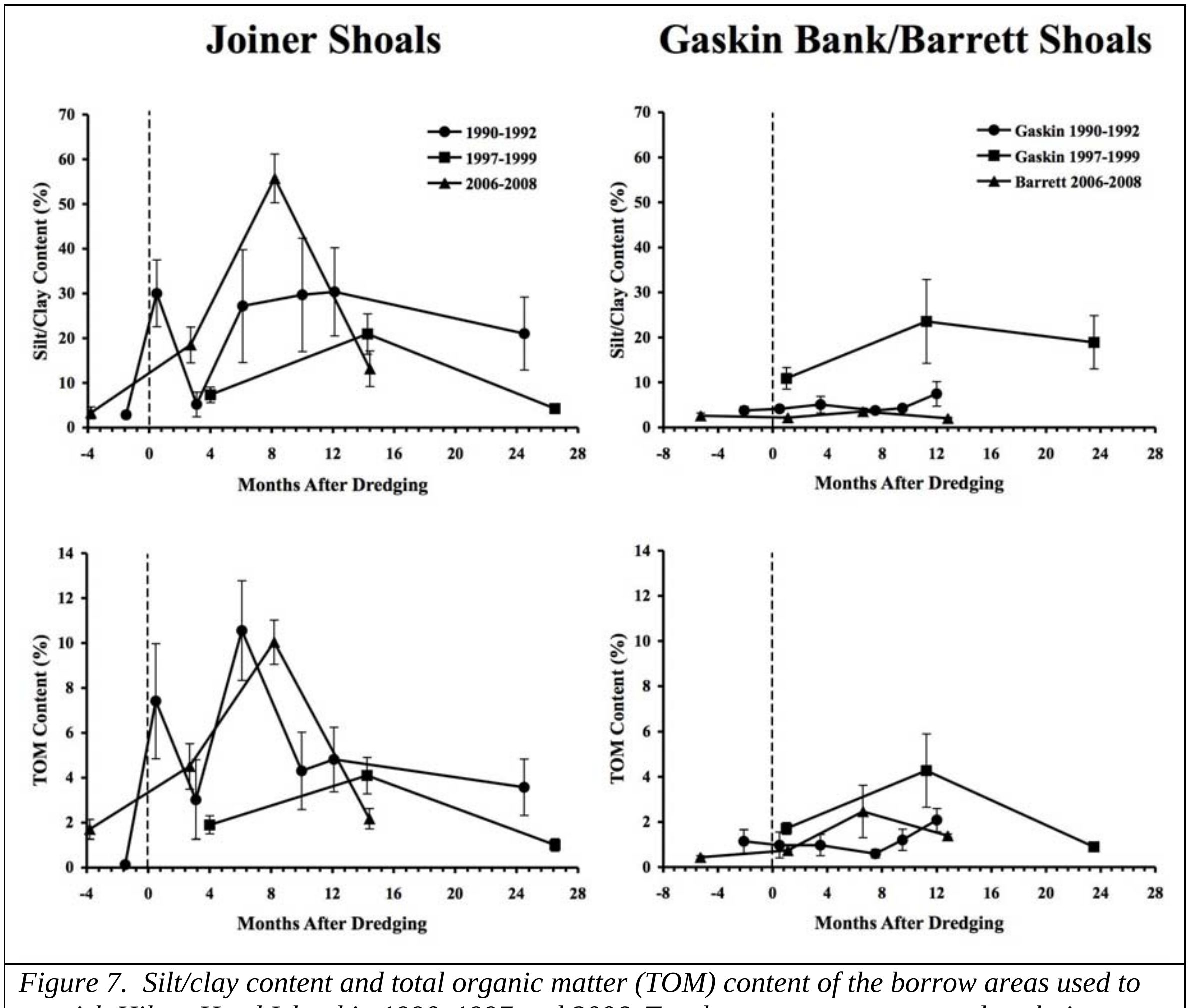

Figure 7. Silt/clay content and total organic matter (TOM) content of the borrow areas used to nourish Hilton Head Island in 1990, 1997 and 2006. Two borrow areas were used each time, one on Joiner Shoals (A,B) and one either on Gaskin Bank or Barrett Shoals (C,D). Vertical dashed line shows the point at which dredging was completed; points to left of line are pre-dredging sampling events.

and Van Dolah 2000). All three borrow pits reached peak fine and organic matter contents within a year of dredging and showed some evidence of lesser fine content two years after dredging. In this case, ebb tidal transport from Port Royal Sound appears to be acting as a source of fines and organic material to borrow areas on Joiner Shoals.

This pattern of fine material accumulation is typical, albeit more extreme, of other borrow areas located in estuarine environments or near inlets in South Carolina. For example, three borrow areas used to nourish Folly Beach have shown significant increases in fine sediments following dredging. One of these borrow areas was located in the Folly River behind Folly Island (Van Dolah et al. 1994) and the other two were located downdrift of the Charleston Harbor plume (Bergquist et al. 2008, 2009). The concern with this pattern is that areas accumulating significant fine sediments will no longer be compatible with placement on beaches, requiring future dredging further from shore at greater cost and impacting additional areas of seafloor.

The surficial sediment composition of Joiner Shoals changes severely and episodically following dredging, suggesting temporally heterogenous patterns of sediment transport in the area. Following dredging in 1990, fines increased from less than 5% to approximately 30% (Fig. 7A). Three months later, fines decreased to near 5% and then returned to 25-30%. Following dredging in 2006, fines increased to 15-20%, increased again to close to 60% eight months after dredging, then fell to 15% 14 months after dredging (Fig. 7A). This could reflect either the deposition of fines following by the flushing of fines from the borrow pit or the alternating deposition of sediments of higher and lower fine content over time. The very rapid refilling of the Joiner Shoals borrow areas (Van Dolah et al. 1998; Olsen and Associates Inc., unpublished data) suggests that flushing of sediments from the borrow area is unlikely. Further, vibracores collected from the area indicate that a layer of cleaner sand actually overlays a lens of buried mud (Olsen and Associates Inc., unpublished data). Van Dolah et al. (1998) hypothesized that mud initially fills borrow areas on Joiner Shoals, then as the pit becomes shallower, sands deposit on top forming a transition from mud to sand with decreasing depth in the shoal. Alternatively, the fluctuation between fine and sandy surficial sediments through time within the borrow pits may reflect some underlying pattern in sediment transport within the area. For example, a period of strong wind energy coming out of the west northwest, wave energy from the north northeast, and/or heavy rainfall may facilitate movement of fines out of Port Royal Sound and into the borrow pit. Strong wind and/or wave energy out of the south to west may facilitate transport of sands from surrounding Joiner Shoals into the borrow pit. Although the predominant direction of wind and wave energy varies seasonally along the South Carolina Coast (London et al. 1981), the patterns seen in the borrow area data (mud content highest during summer in 2006 borrow pit and lowest during summer in 1990 borrow pit) do not support this as the primary mechanism. These fluctuations may be driven much more by episodic storm events such as strong nor'easters or unusual rainfall events.

The biological community inhabiting the Joiner Shoals borrow area changed significantly following dredging and showed little evidence of recovering one year later. These changes were primarily driven by the loss of a dominant amphipod assemblage that was previously consistent across all four of the areas studied here. Immediately following dredging this resulted in a decline in overall infaunal densities and dominance by non-amphipod crustaceans (cumaceans, etc.). Over the next year, this resulted in a community dominated by polychaetes and molluscs and with a higher overall diversity. These highly altered communities, especially the dominance of polychaetes during the 6 mo Post time period, were associated with the elevated fines and organic matter that characterized the Joiner Shoals borrow area following dredging.

The post-dredging community identified at the Joiner Shoals borrow area was largely a subset of species already present in the nearshore zone (many of which were also found in the reference areas) but that were not dominant or particularly abundant prior to dredging. A strong shift in community composition, most commonly from amphipods to more opportunistic polychaetes and crustaceans, is a common response to borrow area dredging (Bergquist 2008, Palmer et al. 2008). For example, the cumacean *Oxyurostylis smithi* and the polychaete *Mediomastus californiensis* are known to rapidly recolonize disturbed benthic sediments (Santos and Simon 1980, Bell and Devlin 1983). These species were among the dominant taxa of the Joiner Shoals borrow area post-dredging but were rarely among the dominant taxa anywhere else. The impacts of these changes on the ecological function of the seafloor, such as sediment re-working, benthic-pelagic coupling and fishery value, are currently not well understood.

Response of the Barrett Shoals Borrow Area:

The Barrett Shoals borrow area sharply decreased in shell ($CaCO_3$) content and increased in finer sands immediately following dredging and then changed very little from that altered state over the next year. In this case, dredging activities likely uncovered deeper sediment layers with characteristics different from the surficial sediments that were initially present. One explanation for the persistence of the modified sediment characteristics one year later is that the pit is not refilling with new sediment. When Barrett Shoals was dredged in 1999 to nourish Daufuskie Island and the South Beach area of Hilton Head Island, close to two million cubic yards of material was removed. Eight months later, very little accretion had occurred over the entire dredged area, and most of that had occurred in the corner closest to shore (Olsen and Associates, 2000). The current Barrett Shoals borrow area was located seaward of the 1999 borrow area, so it is possible that accretion would proceed even more slowly here. A similar pattern was found in the nearby Gaskin Banks borrow area used to nourish Hilton Head in 1990 which showed little evidence of refilling when the area was resurveyed in 1996 (Van Dolah et al. 1998). If this is true of Barrett Shoals, it would contrast with other borrow areas located on depositional shoals at the southern ends of barrier island and/or beaches that have been shown to refill very rapidly as sand from the shoreface is transported in southerly alongshore currents (Van Dolah et al. 1998; Jutte et al. 2001b). Another possible explanation for the persistent change is that the pit is refilling with somewhat finer sands than were originally present. When Gaskin Banks was dredged to nourish Hilton Head Island in 1997, the resulting pit showed evidence of refilling with finer material (Jutte and Van Dolah, 2000). Whether the Barrett Shoals borrow area is not refilling or whether it is merely refilling with fine sand is not known, but analysis of site bathymetry should be able to help address this question. Regardless, the shift from courser sand and high shell content toward finer sand and lower shell content at this borrow area resulted in the borrow area taking on characteristics very similar to the nearby Gaskin as well as the Joiner reference areas. Consequently, unlike at Joiner Shoals, the changes in sediment characteristics observed at Barrett Shoals fall well within the range of values typical of the Hilton Head Island nearshore zone.

The biological impacts of dredging at Barrett Shoals were primarily limited to changes in community structure (the identities and abundances of the taxa present). Following dredging, amphipods and other crustaceans decreased and polychaetes and molluscs increased in relative abundance, but these changes were only significant immediately after dredging (Post time period). This initial shift was primarily due to an influx of opportunistic polychaetes into the recently disturbed sediments immediately following the dredging disturbance. The recolonization of Barrett Shoals by an amphipod fauna similar to that of the reference areas within six months contrasts with the general lack of amphipod recolonization at Joiner Shoals after a full year. Sand-burrowing amphipods can recolonize disturbed sediments very quickly (Grant 1981), and many of the species common to the nearshore zone of Hilton Head Island, including *P. deichmannae, A. millsi, R. hudsoni*, and *E. honduranus*, prefer sandy over silty sediments (Croker 1967; Bousfield 1973). This likely explains the presence of these taxa at the sandy Barrett Shoals borrow area and their absence from the muddy Joiner Shoals borrow area following dredging. The Barrett Shoals community changed relative to the reference areas following dredging, and these changes were associated with decreased shell content and increased fine sand and organic matter content of the sediments. When compared to the changes at Joiner Shoals, these changes were minor and resulted in a community more similar in composition to the reference areas.

Comparison of the Sustainability of Sand Resources

Based on the available data, Joiner Shoals does not represent a sustainable source of beach-compatible sand for nourishment while Barrett Shoals could represent a sustainable sand source. Joiner Shoals has served as a source of sand for three nourishment projects on Hilton Head Island over a period of 16 years, and following each of these events, the dredged pit refilled with fine and organic material not compatible with beach sediments. Available evidence suggests that mud fills dredge pits in this area and is then capped by a layer of sand. Because of this pattern, the sustainable use (and reuse) of this area is not likely possible. As several different borrow pit designs and orientations have been attempted here without successfully minimizing fine sediment accumulation, any new dredge pits on Joiner Shoals are likely to fill with mud as well. However, it should be noted that all borrow pit designs attempted to date have created vertical pits or fairly deep horizontal pockets into the Joiner Shoals complex. The effect of this essentially would be to create an area of dampened current and wave energy thus locally reducing the mobility of fine sediments and enhancing their deposition.

Reuse of previously dredged areas is likewise probably not possible and would depend on the thickness of any surficial beach compatible layer and the logistical and economic feasibility excavating that layer without including deeper muddier sediments. Even if this proves possible, the dredged sediments are likely to have higher mud and organic matter content that is typical for beach nourishment projects in this state. When beach compatible sediment is placed for a typical nourishment project, a large turbidity plume forms near the pipeline outfall, and these plumes have been shown to result in behavioral changes among surfzone fish (Wilber et al. 2003) and later deposition of fines in the nearshore subtidal zone (Rakocinski et al. 1996). A modestly elevated fines content would only exacerbate this problem.

By comparison, impacts to the compatibility of surficial sediments and to biological communities in the Barrett Shoals borrow area were minimal. The primary concern in this borrow pit is the refilling rate. Further bathymetric surveys and surficial sediment surveys could confirm whether or not this pit is refilling with beach compatible sediments. If the pit is refilling at an appropriate rate without the concomitant loss of surrounding shoals (in other words, the entire shoal complex is experiencing net accretion at a rate sufficient to offset losses due to dredging during the 8-10 nourishment cycle of the island), this area may represent a suitable and sustainable long-term source of beach fill. If it is not refilling, a different source of sediment may be needed for future projects.

The proposed installation of a terminal groin at the northeast corner of Hilton Head Island and nourishment of the surrounding shoreface, as currently planned, would involve excavating sediment from the channel edge of Bay Point Shoals. Being located on the updrift side of the Port Royal Sound entrance channel and in a large sand shoal complex downdrift of extensive active beach, this area could respond to dredging much like Barrett Shoals. If this area is dredged and the resulting pit is shown to refill with beach compatible sediments without compromising the integrity of the larger shoal complex (of which the Bay Point State Heritage Preserve is part), then Bay Point Shoals may represent a sustainable alternative to Joiner Shoals as a sand source for nourishment at the north end of Hilton Head Island.

CONCLUSIONS

Sediment composition and biological community structure changed significantly in both borrow areas following dredging while the reference areas changed very little. In the Joiner Shoals borrow area, fine sediments and organic matter rapidly accumulated, and the biological community changed substantially and remained heavily altered one year later. In fact, six months after dredging of this borrow area, fine content was the highest documented for any borrow area used in South Carolina. Accumulation of fines has a common trend in all three borrow areas excavated in Joiner Shoals and more generally in borrow areas located within or downdrift of estuarine water bodies. At Joiner Shoals, it is likely that ebb tidal transport from Port Royal Sound acted as the source of fine sediment and organic matter to this borrow pit. Periods of strong wind and/or wave energy from the south and east may periodically deposit sand from the surrounding shoal complex into the pit, creating caps of sand over the previously deposited fine sediment. Based on a history of Joiner Shoals borrow areas to recover from dredging, this shoal complex is not a sustainable source for beach fill and should not be used for future projects. In the Barrett Shoals borrow area, sediment composition shifted away from calcium carbonate and towards fine sands, and the biological community changed modestly but retained many characteristics in common with the reference areas. The surficial sediment composition of this borrow area following dredging was very similar to the reference areas through one year post-dredging, but whether this was due to the pit refilling with sand or to the failure of the pit to refill at all is not clear. If this borrow area is refilling with beach-compatible sediment and the entire shoal complex is experiencing net accretion at a rate equal to or greater than losses due to dredging during the 8-10 nourishment cycle, Barrett Shoals could represent a relatively low-impact and sustainable source of beach fill for Hilton Head Island.

RECOMMENDATIONS

1) Joiner Shoals should not be used as a sand source in future nourishment projects unless the design can be shown to not result in the accumulation fine sediments and organic matter within the dredge pit.

The Joiner Shoals complex has been dredged for beach fill three times in 16 years, and every instance has resulted in the accumulation of fine material not compatible with placement on the beach. Further use of previously undredged portions of this shoal would likely require excavation of less sediment (less than a meter deep) over a larger area. Reuse of previously dredged areas would require a) determining the thickness of the beach compatible sand lens that overlays the accumulated fine sediment and 2) careful dredging of only that beach compatible layer such that the fines are not placed on the beach.

2) Perform bathymetric surveys of the Barrett Shoals borrow area and calculate its refilling rate.

The Barrett Shoals borrow area shows little evidence of accumulating fine or organic material through one-year post-dredging. It is not clear whether this is due to a failure of the pit to refill or refilling of the pit with sandy material similar to native sediments. If bathymetric surveys indicate the pit is refilling without associated losses to other parts of the shoal complex, the data presented here suggests it may be a relatively low-impact, sustainable source of beach fill.

3) Perform a two-year post-dredging assessment of the borrow and reference areas.

Native surficial sediment characteristics had not recovered in the Joiner Shoals borrow area one year post-dredging, indicating a two-year post-dredging assessment should be performed. The biological communities in the Barrett Shoals borrow area changed only modestly relative to the reference areas. Demonstration that these modest changes reflect minor impact over the long term is important to determining whether this borrow area is both physically and biologically sustainable as a source of beach fill.

4) Minimize the depth of borrow pits, particularly near sources of fine sediment such as tidal rivers and inlets.

Consistent with several other previous studies in which borrow pits were greater than 1.0 m deep and located on the north end of a barrier island near a tidal inlet, silt and clay readily settled into the Joiner Shoals borrow pit used in this nourishment project. As this pit continues to fill, the fine material deposited within it may prevent this area from being used in future projects. Shallower pits in these areas may prevent the accumulation of fine sediments. This could be accomplished by using a hopper dredge to excavate to depths of one meter over a larger area of bottom while also working within accepted seasonal windows (ie. turtle nesting and migration window). Deeper pits should be restricted to those areas in which beach-compatible sand is actively depositing and exposure to suspended fines is minimized.

5) Perform studies of past borrow areas to determine the amount and vertical distribution of fines, the thickness of the fine layer, and the thickness of any overlying beach compatible sediment layer.

The consistent accumulation of fine material in deeply excavated (>1.0 m) borrow areas over the course of the year following dredging, indicates that future excavation of the same area to the same depth will result in placement of material incompatible with beach sand. However, if beach compatible sand forms a significant layer over top of the lens of fine sediment, future dredging of the borrow area may be possible. Currently, the amount of beach compatible material that accumulates near the surface of a refilling borrow area is not well understood and should be examined further.

6) Perform hydrologic and sediment transport modeling studies prior to borrow pit dredging to ensure sustainable use of borrow areas.

Detailed models could be used to determine optimum borrow pit depths that maximize material available for placement on the beach yet minimize the accumulation of fine sediments at various distances from sources of terrigenous sediment. For example, along Joiner Shoals, shallower and smaller pits that do not create low current velocity pockets may be necessary closer to Port Royal Sound while deeper pits may be possible further offshore. The goal should be to dredge only to the depth where beach compatible sands re-accumulate for later nourishment projects.

7) Improve pre-construction project coordination so that borrow area monitoring is performed at more than one time prior to dredging.

The very consistent sediment composition and biological characteristics seen in the reference areas during the course of this study strongly indicate that the large fluctuations documented in the borrow areas (particularly Joiner Shoals) were due to dredging. This consistency is unusual because pre-existing seasonal variation underlies most systems. Without data about the natural variation of the system prior to an impact, it can be very difficult to discern actual impacts from that pre-existing variability. Multiple pre-impact sampling times greatly reduce the chances of incorrectly classifying changes due to natural temporal variability as being due to dredging or nourishment activities.

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Appendix 1. List of station locations and depths for sites sampled at the Joiner Shoals Borrow (JB) and Barrett Shoals Borrow (BB) areas and Reference areas (JR and BR). Depth is reported in meters. Latitude and longitude are reported in decimal degrees. ND = no data available.

Station	Collection #	Date	Time	Depth	Latitude	Longitude
JB01	20064003	8/29/2006	Pre	4.0	32.18668	80.64851
JB02	20064004	8/29/2006	Pre	3.4	32.18667	80.65720
JB03	20064005	8/29/2006	Pre	3.0	32.19312	80.65392
JB04	20064006	8/29/2006	Pre	3.7	32.18685	80.65568
JB05	20064007	8/29/2006	Pre	3.4	32.18712	80.64950
JB06	20064008	8/29/2006	Pre	3.7	32.18704	80.64851
JB07	20064009	8/29/2006	Pre	3.0	32.18823	80.65222
JB08	20064010	8/29/2006	Pre	4.0	32.18921	80.65354
JB09	20064011	8/29/2006	Pre	3.4	32.18727	80.65231
JB10	20064012	8/29/2006	Pre	2.7	32.19372	80.65442
JR16	20064015	8/29/2006	Pre	5.8	32.11823	80.61955
JR19	20064016	8/29/2006	Pre	5.8	32.11905	80.61862
JR03	20064017	8/29/2006	Pre	5.5	32.11611	80.61769
JR17	20064018	8/29/2006	Pre	5.5	32.11987	80.61772
JR05	20064019	8/29/2006	Pre	6.1	32.11618	80.61820
JR06	20064020	8/29/2006	Pre	6.1	32.11259	80.61734
JR21	20064021	8/29/2006	Pre	5.5	32.11948	80.61299
JR08	20064022	8/29/2006	Pre	5.8	32.11443	80.62091
JR22	20064023	8/29/2006	Pre	5.5	32.11927	80.62123
JR23	20064024	8/29/2006	Pre	6.4	32.11789	80.60891
BB01	20064027	8/29/2006	Pre	4.0	32.08141	80.81323
BB02	20064028	8/29/2006	Pre	4.9	32.08152	80.81466
BB03	20064029	8/29/2006	Pre	5.2	32.08154	80.81511
BB04	20064030	8/29/2006	Pre	6.4	32.08122	80.81551
BB05	20064031	8/29/2006	Pre	4.0	32.08166	80.13333
BB06	20064032	8/29/2006	Pre	2.7	32.08100	80.81444
BB07	20064033	8/29/2006	Pre	3.0	32.08200	80.81556
BB08	20064034	8/29/2006	Pre	2.7	32.08095	80.81666
BB09	20064035	8/29/2006	Pre	4.3	32.08082	80.81611
BB10	20064036	8/29/2006	Pre	2.4	32.08060	80.81700
BR01	20064039	8/29/2006	Pre	2.7	32.09339	80.72154
BR02	20064040	8/29/2006	Pre	3.0	32.09696	80.71665
BR03	20064041	8/29/2006	Pre	3.7	32.09546	80.71776
BR04	20064042	8/29/2006	Pre	3.7	32.10073	80.72612
BR05	20064043	8/29/2006	Pre	2.7	32.09835	80.71750
BR06	20064044	8/29/2006	Pre	2.7	32.09881	80.72350
BR07	20064045	8/29/2006	Pre	3.7	32.10075	80.71865
BR08	20064046	8/29/2006	Pre	3.4	32.09777	80.72457
BR09	20064047	8/29/2006	Pre	3.7	32.09557	80.72118
BR10	20064048	8/29/2006	Pre	3.0	32.10029	80.72423
JB01	20074003	3/14/2007	Post	4.0	32.18668	80.64851
JB02	20074004	3/14/2007	Post	4.6	32.18667	80.65720
JB03	20074005	3/14/2007	Post	4.6	32.19312	80.65392
JB04	20074006	3/14/2007	Post	4.6	32.18685	80.65568
JB05	20074007	3/14/2007	Post	4.3	32.18712	80.64950
JB06	20074008	3/14/2007	Post	4.3	32.18704	80.64851
JB08	20074009	3/14/2007	Post	4.9	32.18921	80.65354
JB09	20074010	3/14/2007	Post	4.9	32.18727	80.65231

Appendix 1. List of station locations and depths for sites sampled at the Joiner Shoals Borrow (JB) and Barret Shoals Borrow (BB) areas and Reference areas (JR and BR). Depth is reported in meters. Latitude and longitude are reported in decimal degrees. ND = no data available.

Station	Collection #	Date	Time	Depth	Latitude	Longitude
JB10	20074011	3/14/2007	Post	4.6	32.19372	80.65442
JB11	20074012	3/14/2007	Post	4.9	32.19013	80.65484
JR03	20074015	3/14/2007	Post	4.3	32.11611	80.61769
JR05	20074016	3/14/2007	Post	4.6	32.11618	80.61280
JR06	20074017	3/14/2007	Post	4.6	32.11259	80.61734
JR08	20074018	3/14/2007	Post	6.1	32.11443	80.62091
JR16	20074019	3/14/2007	Post	4.0	32.11823	80.61955
JR17	20074020	3/14/2007	Post	3.7	32.11987	80.61772
JR19	20074021	3/14/2007	Post	4.0	32.11905	80.61862
JR21	20074022	3/14/2007	Post	3.7	32.11948	80.61299
JR24	20074023	3/14/2007	Post	4.0	32.11956	80.61144
JR23	20074024	3/14/2007	Post	4.9	32.11789	80.60891
BB03	20074027	3/14/2007	Post	5.2	32.08154	80.81511
BB09	20074028	3/14/2007	Post	5.2	32.08082	80.81611
BB11	20074029	3/14/2007	Post	4.9	32.08021	80.81942
BB12	20074030	3/14/2007	Post	4.3	32.08172	80.81941
BB13	20074031	3/14/2007	Post	4.6	32.08041	80.81893
BB14	20074032	3/14/2007	Post	4.9	32.07991	80.81563
BB15	20074033	3/14/2007	Post	4.9	32.08184	80.81680
BB16	20074034	3/14/2007	Post	5.2	32.08301	80.81832
BB17	20074035	3/14/2007	Post	4.3	32.07964	80.81645
BB18	20074036	3/14/2007	Post	4.9	32.07912	80.81643
BR01	20074039	3/14/2007	Post	1.5	32.09339	80.72154
BR02	20074040	3/14/2007	Post	1.8	32.09696	80.71665
BR03	20074041	3/14/2007	Post	2.1	32.09546	80.71776
BR04	20074042	3/14/2007	Post	2.1	32.10073	80.72612
BR05	20074043	3/14/2007	Post	2.1	32.09835	80.71750
BR06	20074044	3/14/2007	Post	1.5	32.09881	80.72350
BR07	20074045	3/14/2007	Post	2.4	32.10075	80.71865
BR08	20074046	3/14/2007	Post	2.1	32.09777	80.72457
BR09	20074047	3/14/2007	Post	1.8	32.09557	80.72118
BR10	20074048	3/14/2007	Post	1.2	32.10029	80.72423
JB01	20074091	8/29/2007	6 mo Post	5.5	32.18668	80.64851
JB02	20074092	8/29/2007	6 mo Post	6.1	32.18667	80.65720
JB03	20074093	8/29/2007	6 mo Post	4.6	32.19312	80.65392
JB04	20074094	8/29/2007	6 mo Post	7.8	32.18685	80.65568
JB05	20074095	8/29/2007	6 mo Post	5.5	32.18712	80.64950
JB06	20074096	8/29/2007	6 mo Post	2.4	32.18704	80.64851
JB08	20074097	8/29/2007	6 mo Post	5.5	32.18921	80.65354
JB09	20074098	8/29/2007	6 mo Post	2.7	32.18727	80.65231
JB10	20074099	8/29/2007	6 mo Post	2.8	32.19372	80.65442
JB11	20074100	8/29/2007	6 mo Post	5.8	32.19013	80.65484
JR03	20074103	8/29/2007	6 mo Post	5.8	32.11611	80.61769
JR05	20074104	8/29/2007	6 mo Post	6.1	32.11618	80.61280
JR06	20074105	8/29/2007	6 mo Post	6.7	32.11259	80.61734
JR08	20074106	8/29/2007	6 mo Post	6.7	32.11443	80.62091
JR16	20074107	8/29/2007	6 mo Post	5.8	32.11823	80.61955
JR17	20074108	8/29/2007	6 mo Post	5.2	32.11987	80.61772

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Station	Collection #	Date	Time	Depth	Latitude	Longitude
JR19	20074109	8/29/2007	6 mo Post	4.6	32.11905	80.61862
JR21	20074110	8/29/2007	6 mo Post	5.8	32.11948	80.61299
JR22	20074111	8/29/2007	6 mo Post	5.8	32.11927	80.61223
JR23	20074112	8/29/2007	6 mo Post	7.6	32.11789	80.60891
BB03	20074115	8/29/2007	6 mo Post	7.0	32.08154	80.81511
BB09	20074116	8/29/2007	6 mo Post	6.7	32.08082	80.81611
BB11	20074117	8/29/2007	6 mo Post	6.4	32.08021	80.81942
BB12	20074118	8/29/2007	6 mo Post	5.8	32.08172	80.81941
BB13	20074119	8/29/2007	6 mo Post	6.1	32.08041	80.81893
BB14	20074120	8/29/2007	6 mo Post	6.7	32.07991	80.81563
BB15	20074121	8/29/2007	6 mo Post	6.7	32.08184	80.81680
BB16	20074122	8/29/2007	6 mo Post	7.0	32.08301	80.81832
BB17	20074123	8/29/2007	6 mo Post	6.4	32.07964	80.81645
BB18	20074124	8/29/2007	6 mo Post	6.5	32.07912	80.81643
BR01	20074127	8/29/2007	6 mo Post	4.0	32.09339	80.72154
BR02	20074128	8/29/2007	6 mo Post	4.3	32.09696	80.71665
BR03	20074129	8/29/2007	6 mo Post	4.0	32.09546	80.71776
BR04	20074130	8/29/2007	6 mo Post	3.7	32.10073	80.72612
BR05	20074131	8/29/2007	6 mo Post	4.3	32.09835	80.71750
BR06	20074132	8/29/2007	6 mo Post	3.4	32.09881	80.72350
BR07	20074133	8/29/2007	6 mo Post	4.6	32.10075	80.71865
BR08	20074134	8/29/2007	6 mo Post	4.3	32.09777	80.72457
BR09	20074135	8/29/2007	6 mo Post	4.0	32.09557	80.72118
BR10	20074136	8/29/2007	6 mo Post	4.6	32.10029	80.72423
BR01	20083003	3/6/2008	12 mo Post	2.1	32.09339	80.72154
BR02	20083004	3/6/2008	12 mo Post	3.0	32.09696	80.71665
BR03	20083005	3/6/2008	12 mo Post	2.7	32.09546	80.71776
BR04	20083006	3/6/2008	12 mo Post	3.4	32.10073	80.72612
BR05	20083007	3/6/2008	12 mo Post	3.7	32.09835	80.71750
BR06	20083008	3/6/2008	12 mo Post	2.7	32.09881	80.72350
BR07	20083009	3/6/2008	12 mo Post	3.7	32.10075	80.71865
BR08	20083010	3/6/2008	12 mo Post	2.1	32.09777	80.72457
BR09	20083011	3/6/2008	12 mo Post	3.0	32.09557	80.72118
BR10	20083012	3/6/2008	12 mo Post	3.0	32.10029	80.72423
BB03	20083015	3/6/2008	12 mo Post	6.7	32.08154	80.81511
BB09	20083016	3/6/2008	12 mo Post	6.4	32.08082	80.81611
BB11	20083017	3/6/2008	12 mo Post	6.1	32.08021	80.81942
BB12	20083018	3/6/2008	12 mo Post	5.8	32.08172	80.81941
BB13	20083019	3/6/2008	12 mo Post	6.1	32.08041	80.81893
BB14	20083020	3/6/2008	12 mo Post	6.4	32.07991	80.81563
BB15	20083021	3/6/2008	12 mo Post	6.4	32.08184	80.81680
BB16	20083022	3/6/2008	12 mo Post	6.7	32.08301	80.81832
BB17	20083023	3/6/2008	12 mo Post	6.1	32.07964	80.81645
BB18	20083024	3/6/2008	12 mo Post	6.4	32.07912	80.81643
JR03	20083027	3/6/2008	12 mo Post	5.8	32.11611	80.61769
JR05	20083028	3/6/2008	12 mo Post	5.8	32.11618	80.61280
JR06	20083029	3/6/2008	12 mo Post	6.1	32.11259	80.61734
JR08	20083030	3/6/2008	12 mo Post	2.3	32.11443	80.62091

Appendix 1. List of station locations and depths for sites sampled at the Joiner Shoals Borrow (JB) and Barrett Shoals Borrow (BB) areas and Reference areas (JR and BR). Depth is reported in meters. Latitude and longitude are reported in decimal degrees. ND = no data available.

Station	Collection #	Date	Time	Depth	Latitude	Longitude
JR16	20083031	3/6/2008	12 mo Post	3.8	32.11823	80.61955
JR17	20083032	3/6/2008	12 mo Post	4.6	32.11987	80.61772
JR19	20083033	3/6/2008	12 mo Post	5.2	32.11905	80.61862
JR21	20083034	3/6/2008	12 mo Post	5.5	32.11948	80.61299
JR22	20083035	3/6/2008	12 mo Post	5.5	32.11927	80.61223
JR23	20083036	3/6/2008	12 mo Post	7.0	32.11789	80.60891
JB01	20083039	3/6/2008	12 mo Post	4.9	32.18668	80.64851
JB02	20083040	3/6/2008	12 mo Post	5.2	32.18667	80.65720
JB03	20083041	3/6/2008	12 mo Post	5.0	32.19312	80.65392
JB04	20083042	3/6/2008	12 mo Post	5.2	32.18685	80.65568
JB05	20083043	3/6/2008	12 mo Post	4.6	32.18712	80.64950
JB06	20083044	3/6/2008	12 mo Post	4.9	32.18704	80.64851
JB08	20083045	3/6/2008	12 mo Post	4.6	32.18921	80.65354
JB09	20083046	3/6/2008	12 mo Post	4.9	32.18727	80.65231
JB10	20083047	3/6/2008	12 mo Post	4.6	32.19372	80.65442
JB11	20083048	3/6/2008	12 mo Post	4.6	32.19013	80.65484

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at Joiner Shoals (JB) and Barrett Shoals (BB) Borrow Areas and Reference Areas (JR and BR) from August 2006 through March 2008. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sand %	Silt/Clay %	$CaCO^3$ %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
August 29, 2006 pre nourishment sampling									
JB01	93.0	4.0	3.0	2.0	3.0	F	0.449	W	3.5
JB02	97.0	1.5	1.5	1.4	2.8	F	0.401	W	3.0
JB03	94.9	0.9	4.1	1.1	3.1	VF	0.598	MW	3.5
JB04	96.0	2.7	1.3	1.4	2.7	F	0.426	W	3.0
JB05	94.0	3.5	2.5	1.3	2.9	F	0.455	W	3.0
JB06	96.5	0.6	2.9	1.2	3.0	F	0.418	W	3.0
JB07	50.9	2.5	46.5	0.8	2.7	F	0.494	W	3.0
JB08	78.7	14.6	6.7	5.6	3.2	VF	0.625	MW	3.5
JB09	93.6	0.3	6.1	1.1	2.7	F	0.484	W	3.0
JB10	92.3	2.5	5.2	1.3	2.4	F	0.635	MW	3.0
Mean	**88.7**	**3.3**	**8.0**	**1.7**	**2.9**				
August 29, 2006 pre nourishment sampling									
BB01	72.1	2.5	25.4	0.3	2.3				3.0
BB02	81.8	2.3	15.9	0.3	2.5				3.0
BB03	71.2	1.7	27.1	0.5	2.6	F	0.437		3.0
BB04	78.0	2.0	20.0	1.1	2.2	F	0.564	W	2.5
BB05	64.3	1.8	33.8	0.4	2.4	F	0.366	MW	2.5
BB06	66.8	2.7	30.5	0.4	2.5	F	0.541	W	3.0
BB07	80.3	1.0	18.7	0.4	2.6	F	0.504	MW	3.0
BB08	80.2	2.0	17.9	0.3	2.3	F	0.534	MW	3.0
BB09	77.5	7.9	14.6	0.3	2.2	F	0.682	MW	3.0
BB10	83.4	2.3	14.3	0.3	2.0	F	0.564	MW	2.0
Mean	**75.6**	**2.6**	**21.8**	**0.4**	**2.4**				
August 29, 2006 pre nourishment sampling									
JR16	94.7	2.7	2.6	3.1	2.7	F	0.370	W	3.0
JR19	66.9	1.7	31.3	3.2	2.7	F	0.353	W	3.0
JR03	95.6	1.8	2.7	5.4	2.6	F	0.380	W	3.0
JR17	94.9	2.4	2.7	1.8	2.6	F	0.343	VW	3.0
JR05	94.4	2.9	2.7	2.4	2.8	F	0.320	VW	3.0
JR06	95.5	1.7	2.8	2.5	2.6	F	0.428	W	3.0
JR21	95.4	1.7	2.9	2.2	2.5	F	0.461	W	3.0
JR08	94.2	2.1	3.7	3.2	2.8	F	0.323	VW	3.0
JR22	94.8	1.1	4.0	2.6	2.2	F	0.742	M	3.0
JR23	93.4	1.5	5.1	2.3	1.2	M	0.981	M	1.5
Mean	**92.0**	**2.0**	**6.1**	**2.9**	**2.5**				
August 29, 2006 pre nourishment sampling									
BR01	96.9	1.3	1.8	3.5	2.8	F	0.417	W	3.0
BR02	95.6	1.8	2.5	2.8	2.6	F	0.643	MW	3.0
BR03	96.7	0.9	2.4	4.6	2.7	F	0.486	W	3.0
BR04	97.6	0.3	2.1	2.9	2.6	F	0.439	W	3.0
BR05	96.4	1.4	2.2	2.9	2.7	F	0.470	W	3.0
BR06	96.0	1.9	2.1	2.7	2.6	F	0.520	MW	3.0
BR07	95.1	2.3	2.6	4.1	2.8	F	0.520	MW	3.0
BR08	94.5	3.9	1.7	3.0	2.6	F	0.519	MW	3.0
BR09	97.3	0.2	2.6	2.2	2.9	F	0.387	W	3.0
BR10	96.8	1.2	2.0	1.2	2.6	F	0.468	W	3.0
Mean	**96.3**	**1.5**	**2.2**	**3.0**	**2.7**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at Joiner Shoals (JB) and Barrett Shoals (BB) Borrow Areas and Reference Areas (JR and BR) from August 2006 through March 2008. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sand %	Silt/Clay %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
March 14, 2007 immediate post nourishment sampling									
JB01	92.7	4.2	3.2	1.4	3.1	VF	0.363	MW	3.5
JB02	76.0	20.2	3.8	4.8	3.0	VF	0.525	W	3.0
JB03	82.9	12.6	4.5	3.5	3.1	VF	0.501	MW	3.5
JB04	65.9	28.4	5.6	6.0	3.1	VF	0.648	MW	3.5
JB05	85.4	9.0	5.6	2.3	3.2	VF	0.390	MW	3.5
JB06	88.1	7.5	4.5	1.4	3.1	VF	0.403	W	3.5
JB08	67.0	25.8	7.1	6.9	3.1	VF	0.721	W	3.5
JB09	64.9	28.8	6.3	7.3	3.1	VF	0.695	M	3.5
JB10	91.0	6.1	2.8	0.8	2.9	F	0.381	MW	3.0
JB11	28.1	42.6	29.3	10.6	2.0	M	1.466	W	3.5
Mean	**74.2**	**18.5**	**7.3**	**4.5**	**3.0**				
March 14, 2007 immediate post nourishment sampling									
BB03	95.4	2.0	2.6	0.8	2.6	F	0.448	P	3
BB09	74.2	2.0	23.8	0.8	2.8	F	0.329	W	3.0
BB11	97.4	0.9	1.7	0.8	2.6	F	0.413	VW	3.0
BB12	95.9	2.3	1.8	0.7	2.6	F	0.414	W	3.0
BB13	95.7	2.4	2.0	0.6	2.8	F	0.325	W	3.0
BB14	95.0	2.8	2.2	0.6	2.7	F	0.407	VW	3.0
BB15	94.2	2.5	3.4	0.8	2.8	F	0.351	W	3.0
BB16	94.9	2.9	2.2	0.6	2.8	F	0.381	W	3.0
BB17	96.0	2.0	2.0	0.6	2.6	F	0.380	W	3.0
BB18	96.0	2.2	1.9	0.9	2.8	F	0.346	W	3.0
Mean	**93.5**	**2.2**	**4.4**	**0.7**	**2.7**				
March 14, 2007 immediate post nourishment sampling									
JR03	95.0	2.1	2.9	0.6	2.6	F	0.454	W	3.0
JR05	95.0	2.3	2.7	0.8	2.7	F	0.394	W	3.0
JR06	95.9	1.0	3.1	0.6	2.6	F	0.463	W	3.0
JR08	94.4	1.6	4.0	0.9	2.9	F	0.345	VW	3.0
JR16	96.9	0.7	2.4	1.1	2.6	F	0.467	W	3.0
JR17	95.3	1.8	2.9	1.0	2.7	F	0.364	W	3.0
JR19	95.6	1.5	2.8	0.5	2.6	F	0.397	W	3.0
JR21	95.9	1.3	2.8	0.8	2.6	F	0.392	W	3.0
JR24	95.3	0.7	3.9	0.7	2.2	F	0.529	MW	2.5
JR23	89.0	1.3	9.6	0.5	0.7	C	0.983	M	0.5
Mean	**94.9**	**1.4**	**3.7**	**0.7**	**2.4**				
March 14, 2007 immediate post nourishment sampling									
BR01	94.5	1.0	4.5	4.9	2.6	F	0.504	MW	3.0
BR02	97.3	0.5	2.1	0.8	2.7	F	0.557	MW	3.0
BR03	96.2	1.2	2.6	0.8	2.8	F	0.513	MW	3.0
BR04	96.2	1.0	2.7	1.0	2.6	F	0.480	W	3.0
BR05	97.3	1.2	1.5	1.0	2.5	F	0.532	MW	3.0
BR06	96.1	1.5	2.4	0.8	2.5	F	0.478	W	3.0
BR07	97.5	1.3	1.2	0.3	2.8	F	0.436	W	3.0
BR08	93.1	1.2	5.8	0.8	2.8	F	0.522	MW	3.0
BR09	96.0	1.3	2.7	0.7	2.9	F	0.428	W	3.0
BR10	96.8	1.0	2.1	0.4	1.8	M	0.938	M	3.0
Mean	**96.1**	**1.1**	**2.8**	**1.1**	**2.6**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at Joiner Shoals (JB) and Barrett Shoals (BB) Borrow Areas and Reference Areas (JR and BR) from August 2006 through March 2008. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sand %	Silt/Clay %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
August 29, 2007 6 months post nourishment sampling									
JB01	55.3	38.8	6.0	6.7	3.2	VF	0.322	VW	3.5
JB02	56.5	40.0	3.5	6.9	3.3	VF	0.419	VW	4.0
JB03	25.7	69.7	4.6	12.2	3.1	VF	0.679	W	3.5
JB04	25.9	71.1	3.1	12.5	3.5	VF	0.443	MW	4.0
JB05	49.1	45.2	5.6	8.9	3.2	VF	0.337	W	3.5
JB06	69.0	26.1	4.9	4.8	3.4	VF	0.396	VW	4.0
JB08	29.3	66.2	4.5	12.7	2.6	F	0.871	W	3.5
JB09	39.2	54.2	6.6	9.7	3.4	VF	0.426	M	4.0
JB10	24.0	71.8	4.3	12.4	3.0	F	0.575	W	3.5
JB11	21.2	74.5	4.3	13.7	3.1	VF	0.830	MW	4.0
Mean	**39.5**	**55.8**	**4.7**	**10.0**	**3.2**				
August 29, 2007 6 months post nourishment sampling									
BB03	95.4	2.4	2.2	1.0	2.7	F	0.336	M	3.0
BB09	95.5	2.2	2.3	0.8	2.8	F	0.375	VW	3.0
BB11	90.0	6.9	3.1	1.7	2.8	F	0.352	W	3.0
BB12	95.7	2.5	1.8	0.8	2.5	F	0.422	W	3.0
BB13	95.4	2.9	1.7	0.6	2.8	F	0.315	W	3.0
BB14	87.7	8.3	4.0	12.1	2.9	F	0.462	VW	3.0
BB15	95.4	2.5	2.1	0.6	2.7	F	0.313	W	3.0
BB16	94.7	2.3	3.0	0.7	2.3	F	0.412	VW	2.5
BB17	95.1	2.3	2.5	5.3	2.7	F	0.419	W	3.0
BB18	92.5	3.3	4.2	1.2	3.0	VF	0.411	W	3.0
Mean	**93.7**	**3.6**	**2.7**	**2.5**	**2.7**				
August 29, 2007 6 months post nourishment sampling									
JR03	95.1	1.8	3.1	0.7	2.6	F	0.383	W	3.0
JR05	95.6	1.3	3.1	0.7	2.7	F	0.408	W	3.0
JR06	95.6	1.5	2.9	0.8	2.6	F	0.422	W	3.0
JR08	93.2	1.9	4.9	1.0	2.8	F	0.368	W	3.0
JR16	95.8	1.8	2.4	1.5	2.7	F	0.317	VW	3.0
JR17	95.8	1.6	2.6	0.6	2.7	F	0.321	VW	3.0
JR19	95.2	1.6	3.2	0.9	2.7	F	0.317	VW	3.0
JR21	95.7	0.9	3.3	0.9	2.2	F	0.584	MW	3.0
JR22	91.8	1.5	6.7	0.9	1.4	M	0.884	M	1.5
JR23	91.6	2.3	6.1	1.2	2.6	F	0.552	MW	3.0
Mean	**94.5**	**1.6**	**3.8**	**0.9**	**2.5**				
August 29, 2007 6 months post nourishment sampling									
BR01	97.8	0.2	2.0	0.5	2.3	F	0.619	MW	3.0
BR02	97.0	1.2	1.8	0.6	2.6	F	0.495	W	3.0
BR03	94.9	2.5	2.5	0.6	2.8	F	0.479	W	3.0
BR04	95.7	2.0	2.3	0.5	2.6	F	0.457	W	3.0
BR05	96.8	1.4	1.8	0.5	2.7	F	0.410	W	3.0
BR06	96.1	1.6	2.3	0.5	1.9	M	0.533	MW	2.0
BR07	96.2	1.5	2.3	0.5	2.8	F	0.458	W	3.0
BR08	96.2	1.3	2.5	0.6	2.6	F	0.584	MW	3.0
BR09	96.7	1.3	2.0	0.9	2.8	F	0.421	W	3.0
BR10	95.4	1.1	3.5	0.6	2.7	F	0.449	W	3.0
Mean	**96.3**	**1.4**	**2.3**	**0.6**	**2.6**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at Joiner Shoals (JB) and Barrett Shoals (BB) Borrow Areas and Reference Areas (JR and BR) from August 2006 through March 2008. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

Station	Sand %	Silt/Clay %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
March 6, 2008 12 months post nourishment sampling									
JB01	93.5	4.3	2.2	0.8	2.9	F	0.412	W	3.0
JB02	84.6	11.4	3.9	2.0	3.1	F	0.385	W	3.5
JB03	84.6	11.8	2.7	2.2	2.9	F	0.628	W	3.0
JB04	88.6	7.0	4.4	1.6	3.2	F	0.358	MW	3.5
JB05	92.6	4.7	2.7	0.9	3.0	F	0.392	W	3.0
JB06	91.0	6.7	2.3	1.2	2.9	F	0.341	W	3.0
JB08	90.2	5.5	4.4	1.4	3.2	F	0.374	VW	3.5
JB09	87.4	9.6	3.0	2.3	3.1	M	0.726	W	3.5
JB10	70.5	26.5	3.0	5.1	3.0	F	0.504	M	3.0
JB11	52.4	44.1	3.6	4.3	3.0	C	0.978	MW	3.0
Mean	**83.5**	**13.2**	**3.2**	**2.2**	**3.0**				
March 6, 2008 12 months post nourishment sampling									
BB03	96.1	1.7	2.2	1.3	2.4	F	0.351	W	3.0
BB09	95.5	2.4	2.1	1.6	2.7	VF	0.360	W	3.0
BB11	94.5	3.2	2.4	1.1	2.7	F	0.349	W	3.0
BB12	96.5	1.9	1.6	1.1	2.5	VF	0.341	VW	3.0
BB13	95.2	2.7	2.1	1.3	2.7	F	0.331	VW	3.0
BB14	95.6	1.9	2.5	1.6	2.7	F	0.339	VW	3.0
BB15	96.9	1.4	1.7	1.2	2.7	VF	0.353	VW	3.0
BB16	95.4	2.2	2.4	1.4	2.5	VF	0.324	W	2.5
BB17	96.5	1.6	1.9	1.8	2.6	F	0.409	VW	3.0
BB18	95.2	1.7	3.1	1.6	2.9	VF	0.469	W	3.0
Mean	**95.7**	**2.1**	**2.2**	**1.4**	**2.6**				
March 6, 2008 12 months post nourishment sampling									
JR03	94.9	2.0	3.1	0.6	2.6	F	0.423	W	3.0
JR05	95.3	2.1	2.7	1.0	2.6	F	0.345	VW	3.0
JR06	94.3	2.0	3.7	1.2	2.3	F	0.369	W	3.0
JR08	92.6	2.7	4.6	1.6	2.8	F	0.396	W	3.0
JR16	94.8	2.7	2.5	1.3	2.6	F	0.374	W	3.0
JR17	93.6	2.4	4.0	0.8	2.7	F	0.353	W	3.0
JR19	95.1	2.0	2.9	0.6	2.5	F	0.336	VW	3.0
JR21	92.3	2.1	5.6	0.8	1.7	F	0.406	W	1.5
JR22	94.6	2.2	3.1	0.3	2.2	F	0.408	W	2.5
JR23	91.5	1.1	7.4	0.5	0.9	F	0.349	VW	0.5
Mean	**93.9**	**2.1**	**4.0**	**0.9**	**2.3**				
March 6, 2008 12 months post nourishment sampling									
BR01	95.8	1.5	2.7	0.4	1.9	M	0.580	MW	2.0
BR02	96.2	1.9	1.9	0.5	2.7	F	0.447	W	3.0
BR03	96.1	1.5	2.4	0.4	2.5	F	0.561	MW	3.0
BR04	96.7	1.9	1.5	0.5	2.5	F	0.585	MW	3.0
BR05	95.5	2.3	2.3	0.6	0.9	C	0.722	M	1.0
BR06	96.9	0.8	2.3	0.4	2.0	F	0.567	MW	2.5
BR07	96.1	1.2	2.6	0.5	2.8	F	0.531	MW	3.0
BR08	96.3	1.6	2.0	0.6	2.6	F	0.522	MW	3.0
BR09	95.5	1.2	3.4	0.5	2.8	F	0.378	W	3.0
BR10	96.5	1.3	2.2	0.5	2.7	F	0.476	W	3.0
Mean	**96.2**	**1.5**	**2.3**	**0.5**	**2.3**				

Appendix 3.1. Summary of benthic macrofauna in the Joiner Shoals Reference (JR) and Impact (JB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

		Reference (JR)				Impact (JB)			
Species Name	**Category**	**Pre**	**Post**	**6 month Post**	**12 month Post**	**Pre**	**Post**	**6 month Post**	**12 month Post**
Abra aequalis	M	6	0	0	0	0	0	0	5
Acanthohaustorius intermedius	A	218	352	242	454	0	0	1	0
Acanthohaustorius millsi	A	38	102	54	336	202	0	0	1
Acanthohaustorius shoemakeri	A	2	54	0	0	59	0	0	0
Acanthohaustorius sp.	A	48	6	0	0	25	0	0	0
Acetes americanus	O	0	0	0	0	1	0	0	0
Acteocina canaliculata	M	0	0	0	0	0	0	0	770
Acteocina candei	M	0	0	0	0	0	0	196	0
Aglaophamus verrilli	P	0	0	0	2	0	0	0	10
Americamysis almyra	O	0	0	2	0	0	0	0	0
Americamysis bahia	O	0	0	4	0	0	0	0	0
Americhelidium americanum	A	0	4	10	0	0	17	0	0
Amphipoda	A	0	0	0	0	1	0	1	0
Ancinus depressus	O	0	0	2	0	1	1	1	3
Ancistrosyllis sp.	P	0	0	0	2	0	0	0	0
Annelida	O	0	0	0	0	1	0	0	0
Aphelochaeta sp.	P	0	0	0	0	2	0	0	0
Arachnida	O	2	0	0	0	0	0	0	0
Arcidae	M	2	0	0	0	0	0	0	0
Armandia agilis	P	2	20	0	0	0	0	0	0
Armandia maculata	P	2	0	0	0	0	0	0	0
Astyris lunata	M	0	0	0	0	0	0	0	1
Batea catharinensis	A	0	0	2	0	0	0	0	1
Bathyporeia parkeri	A	2	70	36	112	0	0	0	22
Bathyporeia sp.	A	16	0	0	0	0	0	0	0
Bhawania heteroseta	P	0	0	0	0	2	0	0	0
Biffarius biformis	O	0	0	0	0	0	2	2	1
Bopyridae	O	0	0	0	0	0	0	1	0
Brachyura	O	2	0	0	0	0	0	0	0
Branchiostoma sp.	O	74	20	164	10	0	0	1	0
Campylaspis affinis	O	0	0	0	38	0	0	0	11
Capitella capitata	P	0	0	0	0	0	7	0	0
Capitellidae	P	0	0	0	0	0	3	0	0
Caprellidae	A	0	0	0	0	0	1	0	0

Appendix 3.1. Summary of benthic macrofauna in the Joiner Shoals Reference (JR) and Impact (JB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Carinomella lactea	O	0	0	0	0		0	0	0	26
Caulleriella sp.	P	8	0	0	0		0	0	0	0
Chiridotea coeca	O	0	2	0	4		0	0	0	0
Chiridotea sp.	O	0	2	0	0		0	0	0	0
Cirratulidae	P	2	0	2	0		1	0	0	0
Cirriformia sp.	P	0	0	0	0		1	4	0	0
Cirripedia	O	0	0	0	0		0	1	0	0
Clypeasteroida	O	0	2	24	0		0	0	0	0
Collembola	O	0	0	2	0		0	1	0	0
Copepoda	O	8	2	8	0		3	3	12	0
Corbula contracta	M	0	0	0	0		0	0	0	3
Corophium aquafuscum	A	0	0	0	0		0	0	0	2
Crassinella lunulata	M	2	0	2	2		0	0	0	0
Crassinella martinicensis	M	0	0	0	2		0	0	0	0
Cumacea	O	0	20	0	0		2	51	0	0
Cyclaspis pustulata	O	0	2	0	8		1	1	0	0
Cyclaspis sp.	O	0	8	0	0		0	0	0	0
Cyclaspis varians	O	0	0	0	0		0	20	0	0
Decapoda	O	10	0	0	0		3	1	15	0
Discoporella umbellata	O	2	0	0	0		0	0	0	0
Dissodactylus mellitae	O	18	4	0	0		4	0	0	0
Divaricella quadrisulcata	M	4	0	0	0		0	0	0	0
Donax variabilis	M	0	6	6	16		0	0	0	0
Dorvilleidae	P	2	0	0	0		0	0	0	0
Drilonereis longa	P	0	0	0	0		0	0	0	1
Echinoidea	O	0	2	0	0		0	0	0	0
Edotia montosa	O	0	0	0	0		0	19	0	2
Edotia triloba	O	0	0	0	2		0	0	0	3
Elasmopus sp.	A	0	0	0	0		1	1	0	0
Emerita talpoida	O	2	2	0	2		0	0	0	0
Eobrolgus spinosus	A	24	0	0	0		0	1	0	0
Ericthonius brasiliensis	A	0	0	0	0		0	0	0	14
Eteone heteropoda	P	0	0	0	0		5	2	0	7
Eteone lactea	P	4	0	2	0		0	15	0	0

Appendix 3.1. Summary of benthic macrofauna in the Joiner Shoals Reference (JR) and Impact (JB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post	Pre	Post	6 month Post	12 month Post
Euclymene sp.	P	0	0	0	0	0	1	0	0
Eudevenopus honduranus	A	240	252	174	102	0	6	0	9
Eurythoe sp.	P	0	6	0	0	0	0	0	0
Gammaridea	A	2	0	0	0	0	0	0	0
Gammarus sp.	A	0	0	0	0	1	0	0	0
Gastropoda	M	0	8	0	0	0	0	0	2
Glycera americana	P	0	0	4	28	1	3	2	9
Glycera oxycephala	P	4	26	0	0	0	2	0	0
Glycinde nordmanni	P	0	0	0	0	0	0	16	0
Glycinde solitaria	P	0	0	0	0	0	0	0	4
Glycymeris americana	M	0	0	0	0	0	0	1	0
Glycymeris pectinata	M	0	0	2	0	0	0	0	0
Goniada littorea	P	6	0	0	0	0	0	0	0
Goniadidae	P	0	0	0	0	0	0	1	0
Haminoea solitaria	M	0	0	0	0	0	0	0	5
Haustoriidae	A	12	56	24	0	43	7	0	0
Haustorius canadensis	A	0	0	0	0	33	0	0	0
Haustorius sp.	A	2	0	0	0	0	0	0	0
Hemipodus roseus	P	4	2	6	0	0	2	0	0
Insecta	O	2	12	2	0	0	0	1	0
Kinbergonuphis sp.	P	2	0	0	0	0	0	0	0
Leiocapitella glabra	P	0	0	0	0	0	3	0	0
Leitoscoloplos fragilis	P	0	2	2	0	3	21	0	306
Leitoscoloplos robustus	P	0	0	2	0	0	0	6	0
Leitoscoloplos sp.	P	4	2	2	0	4	18	0	0
Leptochela serratorbita	O	0	0	4	0	0	0	0	0
Leptonacea sp.	M	0	0	0	6	0	0	0	0
Leucon americanus	O	0	0	0	0	0	55	4	0
Listriella barnardi	A	0	0	0	0	0	3	0	2
Lucinidae	M	0	0	0	0	1	1	0	0
Macoma tenta	M	0	0	0	0	0	0	0	10
Magelona papillicornis	P	6	0	0	0	0	0	0	0
Magelona sp.	P	2	10	0	12	0	0	0	0
Magelonidae	P	0	0	16	0	0	0	0	0

Appendix 3.1. Summary of benthic macrofauna in the Joiner Shoals Reference (JR) and Impact (JB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	**Category**	**Pre**	**Post**	**6 month Post**	**12 month Post**	**Pre**	**Post**	**6 month Post**	**12 month Post**
Maldanidae	P	0	4	0	0	0	2	0	0
Mediomastus californiensis	P	4	2	4	0	0	133	108	0
Mediomastus sp.	P	8	2	0	12	0	0	0	5
Melitidae	A	74	0	16	0	0	1	0	0
Mellita quinquesperforata	O	0	0	6	0	2	0	0	0
Metharpinia floridana	A	0	0	0	0	7	0	0	0
Micronephthys minuta	P	0	0	0	0	0	0	0	0
Mulinia lateralis	M	0	0	0	0	0	5	0	1
Mysida	O	8	0	4	0	0	0	1	0
Nassarina glypta	M	0	0	0	0	2	0	0	0
Nassarius albus	M	0	0	0	2	0	0	0	30
Nassarius vibex	M	0	0	0	0	0	0	12	0
Natica pusilla	M	0	0	0	0	0	0	1	0
Naticidae	M	0	2	0	2	0	0	0	2
Nematoda	O	86	40	34	236	0	3	1	15
Nemertea	O	4	20	4	2	0	1	25	2
Nephtys bucera	P	2	0	0	0	0	0	0	0
Nephtys picta	P	16	0	10	6	7	1	0	1
Nereis acuminata	P	0	0	0	0	2	0	0	0
Nereis sp.	P	0	0	0	2	0	0	0	0
Nucula sp.	M	0	0	0	0	0	0	0	2
Nudibranchia	M	0	0	0	0	0	0	1	0
Oedicerotidae	A	2	0	0	0	0	2	0	0
Ogyrides alphaerostris	O	4	0	0	0	1	0	0	0
Ogyrides hayi	O	30	0	8	0	2	0	0	0
Ogyrides sp.	O	2	0	0	0	0	0	0	0
Oligochaeta	O	0	0	0	0	4	0	0	0
Oliva reticularis	M	0	0	0	0	1	0	0	0
Olivella mutica	M	4	6	16	12	0	1	0	1
Olivella sp.	M	2	0	0	0	6	0	0	0
Olividae	M	2	0	0	0	3	0	0	1
Onuphis eremita	P	0	0	0	0	0	0	1	0
Opheliidae	P	0	0	6	0	0	0	0	0
Ophelina acuminata	P	0	0	0	0	1	0	0	3

Appendix 3.1. Summary of benthic macrofauna in the Joiner Shoals Reference (JR) and Impact (JB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post	Pre	Post	6 month Post	12 month Post
Ophelina cylindricaudata	P	0	0	0	0	0	1	0	0
Ophiuroidea	O	0	0	0	0	0	1	0	0
Orbiniidae	P	0	0	0	0	1	5	0	0
Ostracoda	O	0	0	0	0	0	1	0	2
Ovalipes sp.	O	0	2	0	0	0	0	0	0
Oxyurostylis smithi	O	0	60	0	72	0	360	0	147
Paguridae	O	0	2	0	0	0	0	0	0
Pagurus annulipes	O	0	0	0	0	1	0	0	0
Pagurus longicarpus	O	0	0	0	2	0	0	0	11
Parahaustorius longimerus	A	0	0	2	0	0	0	0	0
Paraonis fulgens	P	0	14	28	2	0	5	1	0
Paraprionospio pinnata	P	0	0	0	2	0	3	0	49
Parvilucina multilineata	M	0	0	0	0	0	0	0	2
Pelecypoda	M	70	26	28	0	0	11	13	0
Phoxocephalidae	A	6	2	18	0	0	0	0	0
Pinnixa cristata	O	2	2	0	0	0	0	0	0
Pinnixa sp.	O	0	0	0	0	3	10	0	0
Pinnotheridae	O	2	0	0	0	2	0	3	0
Platyhelminthes	O	8	0	10	0	0	0	0	0
Pleuromeris tridentata	M	0	2	0	0	0	0	0	0
Polinices duplicatus	M	0	4	0	0	0	0	0	0
Polinices sp.	M	0	0	0	0	0	0	0	1
Polychaeta	P	0	0	0	0	4	0	0	0
Porifera	O	8	0	0	0	0	0	0	0
Prionospio pygmaea	P	0	0	0	0	0	0	77	0
Prionospio sp.	P	0	0	0	4	0	1	0	0
Processa sp.	O	2	0	0	0	0	0	0	0
Protohaustorius deichmannae	A	894	1148	750	1370	1057	48	0	526
Protohaustorius sp.	A	4	0	0	0	0	0	0	0
Ptilanthura tenuis	O	6	0	4	0	0	0	0	0
Pyura vittata	O	708	2	0	0	0	0	0	0
Renilla reniformis	O	0	0	52	2	0	2	0	0
Rhepoxynius epistomus	A	0	0	0	24	0	2	0	5
Rhepoxynius hudsoni	A	32	200	86	72	4	11	0	22

Appendix 3.1. Summary of benthic macrofauna in the Joiner Shoals Reference (JR) and Impact (JB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Rhepoxynius sp.	A	0	0	0	0		1	0	0	0
Scolecolepides viridis	P	0	0	0	0		0	1	0	0
Scolelepis squamata	P	0	0	0	0		0	3	0	7
Scolelepis texana	P	0	0	0	0		0	9	0	2
Sigalion arenicola	P	2	0	0	0		0	0	0	0
Sigalionidae	P	0	0	0	0		0	0	2	0
Sigambra wassi	P	0	0	0	0		0	0	2	0
Sipuncula	O	0	0	2	0		0	0	0	0
Solen viridis	M	0	34	2	0		0	3	1	1
Solenidae	M	2	0	2	0		1	0	0	0
Spionidae	P	0	0	0	0		0	4	0	0
Spiophanes bombyx	P	0	10	2	6		0	0	0	0
Spiophanes missionensis	P	0	0	0	0		1	1	0	0
Spiophanes wigleyi	P	0	0	0	0		0	0	5	0
Stomatopoda	O	0	0	0	2		0	0	0	0
Streblospio benedicti	P	0	0	0	0		0	1	0	0
Strigilla mirabilis	M	18	26	28	0		0	0	0	0
Syllidae	P	0	0	4	0		0	0	0	0
Tagelus plebeius	M	0	0	2	0		0	0	0	0
Tanaissus psammophilus	O	26	8	2	4		0	0	1	0
Tellina agilis	M	0	14	42	2		0	147	1	42
Tellina alternata	M	0	0	0	12		0	0	0	147
Tellina iris	M	4	0	0	0		0	0	0	0
Tellina probrina	M	14	0	0	0		108	0	0	0
Tellina sp.	M	0	28	0	0		42	0	0	0
Tellinidae	M	34	0	2	0		3	0	5	0
Terebra dislocata	M	0	0	6	8		0	0	0	1
Terebra sp.	M	2	0	0	0		0	0	0	0
Tharyx sp.	P	0	0	0	0		2	0	0	0
Thyonella gemmata	O	0	0	188	0		0	0	0	0
Tiron tropakis	A	0	0	0	14		0	0	0	41
Travisia parva	P	0	0	0	2		2	0	0	0
Trypanosyllis parvidentata	P	2	0	0	0		0	0	0	0
Veneridae	M	2	4	4	0		3	0	0	0

Appendix 3.2. Summary of benthic macrofauna in the Barrett Shoals Reference (BR) and Impact (BB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

		Reference (BR)					Impact (BB)			
Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Acanthohaustorius bousfieldi	A	2	0	0	0		0	0	0	N/A
Acanthohaustorius intermedius	A	184	380	38	124		34	11	1	N/A
Acanthohaustorius millsi	A	456	1084	380	800		36	4	0	N/A
Acanthohaustorius shoemakeri	A	56	120	0	126		3	2	0	N/A
Acanthohaustorius sp.	A	2	2	0	0		0	0	0	N/A
Acteocina candei	M	0	0	0	0		0	0	1	N/A
Actiniaria	O	0	0	0	2		0	1	0	N/A
Americamysis bahia	O	0	0	0	0		0	0	1	N/A
Americhelidium americanum	A	0	6	0	0		0	3	4	N/A
Ancinus depressus	O	0	0	2	0		2	1	1	N/A
Apanthura magnifica	O	0	0	0	2		4	1	0	N/A
Arachnida	O	0	0	4	0		0	0	0	N/A
Armandia agilis	P	0	2	0	0		2	0	6	N/A
Armandia maculata	P	0	0	0	0		0	0	1	N/A
Axiothella sp.	P	0	0	0	0		0	1	0	N/A
Batea catharinensis	A	0	0	2	12		0	0	1	N/A
Bathyporeia parkeri	A	2	174	68	172		1	3	0	N/A
Bathyporeia sp.	A	14	0	0	0		5	0	0	N/A
Biffarius biformis	O	0	0	0	0		5	0	0	N/A
Bowmaniella floridana	O	0	0	0	4		0	0	0	N/A
Branchiostoma sp.	O	8	0	34	0		2	0	5	N/A
Campylaspis affinis	O	0	0	0	12		0	0	0	N/A
Campylaspis sp.	O	0	2	0	0		0	0	0	N/A
Capitella capitata	P	0	0	0	0		0	3	0	N/A
Capitellidae	P	10	0	2	0		9	0	4	N/A
Caulleriella sp.	P	0	2	0	0		1	0	1	N/A
Chiridotea coeca	O	0	0	0	4		0	0	0	N/A
Chiridotea sp.	O	0	0	0	6		0	0	0	N/A
Cirratulidae	P	4	0	0	0		1	1	1	N/A
Cirrophorus lyriformis	P	0	0	0	0		0	0	1	N/A
Clypeasteroida	O	0	2	2	0		0	0	0	N/A
Copepoda	O	0	12	6	12		1	0	1	N/A
Corbula contracta	M	0	0	0	2		0	0	0	N/A
Crangonidae	O	0	0	2	0		0	0	0	N/A

Appendix 3.2. Summary of benthic macrofauna in the Barrett Shoals Reference (BR) and Impact (BB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Crangonyx richmondensis	A	0	0	0	0		0	0	3	N/A
Crassinella lunulata	M	2	0	0	0		0	0	0	N/A
Cumacea	O	0	6	2	6		1	1	3	N/A
Cyathura polita	O	0	0	2	0		1	0	1	N/A
Cyclaspis pustulata	O	4	2	8	6		1	0	1	N/A
Dasybranchus lunulatus	P	0	0	0	0		1	0	0	N/A
Decapoda	O	6	0	6	0		8	0	8	N/A
Dispio uncinata	P	0	18	8	0		0	0	0	N/A
Donax variabilis	M	6	6	80	118		137	0	0	N/A
Drilonereis longa	P	0	0	0	0		0	2	1	N/A
Edotia montosa	O	0	0	0	0		0	3	1	N/A
Elasmopus sp.	A	0	0	0	0		0	3	0	N/A
Emerita benedicti	O	0	0	2	0		1	0	0	N/A
Emerita talpoida	O	2	0	4	2		0	0	0	N/A
Eobrolgus spinosus	A	2	0	0	0		0	0	0	N/A
Eteone lactea	P	0	0	0	0		0	0	1	N/A
Eudevenopus honduranus	A	98	68	126	72		13	1	19	N/A
Exogone sp.	P	0	0	0	0		0	1	0	N/A
Gammaridae	A	0	2	0	0		0	0	0	N/A
Gammaridea	A	0	2	0	0		0	3	0	N/A
Gastropoda	M	0	2	0	0		0	2	0	N/A
Glycera americana	P	0	0	0	6		0	0	4	N/A
Glycera oxycephala	P	0	2	0	0		0	3	1	N/A
Glycera sp.	P	0	0	0	0		0	1	0	N/A
Glycinde nordmanni	P	0	0	2	0		0	0	17	N/A
Goniada sp.	P	0	0	0	0		0	0	1	N/A
Goniadidae	P	0	0	2	0		0	0	0	N/A
Haustoriidae	A	86	158	78	0		12	11	1	N/A
Haustorius sp.	A	2	0	0	0		0	0	0	N/A
Insecta	O	0	6	0	0		1	3	0	N/A
Leitoscoloplos fragilis	P	0	2	0	2		0	0	0	N/A
Leitoscoloplos robustus	P	0	2	0	0		0	1	0	N/A
Leitoscoloplos sp.	P	0	2	4	2		0	0	2	N/A
Lepidactylus dytiscus	A	6	2	0	10		0	0	0	N/A

Appendix 3.2. Summary of benthic macrofauna in the Barrett Shoals Reference (BR) and Impact (BB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Lepidopa websteri	O	0	0	0	0		0	0	1	N/A
Leucon americanus	O	0	4	0	2		0	0	0	N/A
Listriella barnardi	A	0	0	0	0		0	0	2	N/A
Lucinidae	M	0	0	4	0		1	43	1	N/A
Macroclymene sp.	P	0	0	0	0		0	2	0	N/A
Magelona sp.	P	4	6	18	12		2	0	0	N/A
Magelonidae	P	2	0	0	0		0	0	0	N/A
Maldanidae	P	0	8	0	0		0	5	0	N/A
Mancocuma sp.	O	0	0	0	0		0	3	0	N/A
Mediomastus californiensis	P	0	2	0	2		0	1	14	N/A
Melitidae	A	0	0	0	0		1	5	0	N/A
Mellita quinquesperforata	O	2	0	4	4		0	0	0	N/A
Metharpinia floridana	A	0	0	4	0		0	0	0	N/A
Micronephthys minuta	P	0	4	4	0		0	8	1	N/A
Mulinia lateralis	M	0	0	0	0		0	0	8	N/A
Mysida	O	4	0	36	0		3	2	2	N/A
Mysidae	O	2	0	0	0		1	0	0	N/A
Nassarius acutus	M	8	0	0	0		3	1	0	N/A
Nassarius vibex	M	0	0	8	0		0	0	9	N/A
Naticidae	M	0	0	0	2		0	2	1	N/A
Nematoda	O	14	86	10	180		10	9	4	N/A
Nemertea	O	2	38	12	20		1	20	21	N/A
Nephtyidae	P	0	2	0	0		0	0	0	N/A
Nephtys picta	P	4	2	8	0		10	0	10	N/A
Oedicerotidae	A	2	0	0	0		0	0	0	N/A
Ogyrides alphaerostris	O	0	0	2	0		0	0	0	N/A
Ogyrides hayi	O	34	4	8	2		4	0	1	N/A
Olivella mutica	M	20	10	12	6		2	10	12	N/A
Olivella sp.	M	0	0	0	2		1	0	0	N/A
Olividae	M	0	0	0	0		5	0	0	N/A
Onuphis eremita	P	16	0	0	2		0	0	2	N/A
Onuphis sp.	P	0	0	0	0		0	0	1	N/A
Opheliidae	P	0	0	0	0		0	0	8	N/A
Ophelina acuminata	P	0	2	0	0		0	0	7	N/A

Appendix 3.2. Summary of benthic macrofauna in the Barrett Shoals Reference (BR) and Impact (BB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Ophelina cylindricaudata	P	0	0	0	0		1	0	4	N/A
Ophiuroidea	O	0	0	2	0		0	0	1	N/A
Orbiniidae	P	0	0	0	4		0	0	0	N/A
Ovalipes ocellatus	O	0	0	0	2		0	0	0	N/A
Owenia fusiformis	P	0	0	0	0		0	1	2	N/A
Oxyurostylis smithi	O	4	42	2	58		0	11	3	N/A
Pagurus politus	O	0	0	0	0		0	0	1	N/A
Pagurus sp.	O	0	2	0	2		0	0	0	N/A
Parahaustorius longimerus	A	8	4	64	50		149	9	1	N/A
Paraonidae	P	0	0	0	2		0	0	0	N/A
Paraonis fulgens	P	0	126	82	16		0	17	1	N/A
Pelecypoda	M	6	2	4	2		10	5	13	N/A
Phoxocephalidae	A	10	0	20	2		3	0	8	N/A
Phyllodoce arenae	P	0	0	4	0		0	0	0	N/A
Pinnixa chaetopterana	O	0	0	0	0		1	0	0	N/A
Pinnixa cristata	O	2	0	0	0		1	0	1	N/A
Pinnixa sp.	O	0	0	0	0		6	0	1	N/A
Pinnotheres maculatus	O	0	0	10	0		0	0	0	N/A
Pinnotheres sp.	O	10	0	0	0		0	0	0	N/A
Pinnotheridae	O	2	0	0	0		8	3	6	N/A
Platyhelminthes	O	0	0	8	0		0	2	1	N/A
Portunus gibbesii	O	0	0	0	2		0	0	0	N/A
Prionospio sp.	P	0	0	0	0		0	0	27	N/A
Prionospio steenstrupi	P	0	0	0	0		0	0	2	N/A
Protohaustorius deichmannae	A	722	1118	838	1204		234	258	181	N/A
Protohaustorius sp.	A	0	0	0	0		4	0	0	N/A
Protohaustorius wigleyi	A	0	4	0	0		0	0	0	N/A
Renilla reniformis	O	0	0	36	4		1	0	3	N/A
Rhepoxynius epistomus	A	0	2	10	58		0	0	1	N/A
Rhepoxynius hudsoni	A	38	54	94	0		18	10	50	N/A
Rhepoxynius sp.	A	0	2	0	0		0	0	0	N/A
Saccoglossus kowalevskii	O	0	0	6	0		0	0	0	N/A
Scolelepis sp.	P	0	0	0	0		0	0	1	N/A
Scolelepis squamata	P	0	0	0	2		0	0	0	N/A

Appendix 3.2. Summary of benthic macrofauna in the Barrett Shoals Reference (BR) and Impact (BB) Borrow Areas. All values represent the total number of individuals in 10 grab samples. The higher taxa group of each species is indicated next to the species name (M=mollusc, A=amphipod, P=polychaete, O=other taxa).

Species Name	Category	Pre	Post	6 month Post	12 month Post		Pre	Post	6 month Post	12 month Post
Scolelepis texana	P	0	0	0	2		0	0	1	N/A
Sigambra wassi	P	0	0	0	0		0	0	2	N/A
Sipuncula	O	0	0	0	0		0	0	1	N/A
Solen viridis	M	0	0	0	0		0	0	11	N/A
Solenidae	M	0	0	0	0		0	0	12	N/A
Sphenia antillensis	M	0	0	0	0		0	1	0	N/A
Spionidae	P	0	0	0	0		0	0	2	N/A
Spiophanes bombyx	P	0	12	2	0		0	249	24	N/A
Spiophanes missionensis	P	0	0	0	0		0	0	4	N/A
Spiophanes sp.	P	0	0	0	0		0	0	1	N/A
Spiophanes wigleyi	P	0	0	4	0		0	0	0	N/A
Strigilla mirabilis	M	0	0	8	0		1	1	1	N/A
Syllidae	P	0	0	0	0		0	3	0	N/A
Tanaissus psammophilus	O	4	24	6	10		26	4	0	N/A
Tellina agilis	M	10	10	18	14		0	106	48	N/A
Tellina iris	M	0	0	0	2		0	0	0	N/A
Tellina sp.	M	0	0	8	2		0	0	0	N/A
Tellinidae	M	0	0	10	0		16	2	0	N/A
Terebra dislocata	M	2	0	0	0		0	0	0	N/A
Thalassinidea	O	0	0	0	0		0	0	3	N/A
Tiron tropakis	A	0	0	0	16		0	0	0	N/A
Travisia hobsonae	P	0	0	2	0		0	0	0	N/A
Travisia parva	P	0	0	0	4		0	0	0	N/A
Tubificidae	O	0	0	0	4		0	0	0	N/A
Tubificoides sp.	O	0	0	0	0		0	1	0	N/A
Veneridae	M	0	0	0	0		1	0	0	N/A

Appendix 4.1. Abundance of benthic species collected at the Joiner Shoals Borrow Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JB01	JB02	JB03	JB04	JB05	JB06	JB07	JB08	JB09	JB10
Protohaustorius deichmannae	A	1057	63.14	100	49	99	141	142	127	210	139	2	63	85
Acanthohaustorius millsi	A	202	12.07	70	0	0	45	39	15	24	44	0	5	30
Tellina probrina	M	108	6.45	50	0	0	18	0	9	0	20	33	0	28
Acanthohaustorius shoemakeri	A	59	3.52	60	0	0	1	4	7	1	30	0	0	16
Haustoriidae	A	43	2.57	50	1	6	0	15	0	14	7	0	0	0
Tellina sp.	M	42	2.51	50	4	2	0	3	0	23	0	0	10	0
Haustorius canadensis	A	33	1.97	10	0	33	0	0	0	0	0	0	0	0
Acanthohaustorius sp.	A	25	1.49	10	0	0	0	0	0	25	0	0	0	0
Metharpinia floridana	A	7	0.42	30	1	0	0	0	0	0	0	1	0	5
Nephtys picta	P	7	0.42	30	0	0	1	0	0	2	0	0	4	0
Olivella sp.	M	6	0.36	20	0	0	0	0	0	5	0	0	1	0
Eteone heteropoda	P	5	0.30	30	0	0	1	0	0	2	0	2	0	0
Dissodactylus mellitae	O	4	0.24	20	0	2	0	0	0	0	0	0	2	0
Leitoscoloplos sp.	P	4	0.24	30	2	0	0	0	1	1	0	0	0	0
Oligochaeta	O	4	0.24	10	0	0	0	4	0	0	0	0	0	0
Polychaeta	P	4	0.24	10	4	0	0	0	0	0	0	0	0	0
Rhepoxynius hudsoni	A	4	0.24	30	0	0	0	1	1	0	0	0	2	0
Copepoda	O	3	0.18	20	0	1	0	0	0	0	2	0	0	0
Decapoda	O	3	0.18	10	3	0	0	0	0	0	0	0	0	0
Leitoscoloplos fragilis	P	3	0.18	30	0	1	0	1	0	0	0	0	1	0
Olividae	M	3	0.18	10	3	0	0	0	0	0	0	0	0	0
Pinnixa sp.	O	3	0.18	20	0	0	0	0	2	0	0	1	0	0
Tellinidae	M	3	0.18	20	2	0	0	0	0	1	0	0	0	0
Veneridae	M	3	0.18	10	0	0	0	0	0	0	0	0	3	0
Aphelochaeta sp.	P	2	0.12	10	0	0	0	0	0	0	0	0	0	2
Bhawania heteroseta	P	2	0.12	10	0	0	0	2	0	0	0	0	0	0
Cumacea	O	2	0.12	20	1	0	0	0	1	0	0	0	0	0
Mellita quinquesperforata	O	2	0.12	20	0	1	0	0	0	0	0	0	1	0
Nassarina glypta	M	2	0.12	10	0	0	0	0	0	0	2	0	0	0
Nereis acuminata	P	2	0.12	10	0	2	0	0	0	0	0	0	0	0
Ogyrides hayi	O	2	0.12	10	0	0	0	0	0	0	0	0	0	2
Pinnotheridae	O	2	0.12	20	0	1	0	1	0	0	0	0	0	0
Tharyx sp.	P	2	0.12	10	0	0	0	0	0	0	0	0	2	0
Travisia parva	P	2	0.12	10	0	0	0	2	0	0	0	0	0	0

Appendix 4.1. Abundance of benthic species collected at the Joiner Shoals Borrow Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance/(# per grab ($0.04m^2$)	% Abundance	% stations where present	JB01	JB02	JB03	JB04	JB05	JB06	JB07	JB08	JB09	JB10
Acetes americanus	O	1	0.06	10	0	0	0	1	0	0	0	0	0	0
Amphipoda	A	1	0.06	10	0	0	0	0	1	0	0	0	0	0
Ancinus depressus	O	1	0.06	10	0	0	0	0	0	0	0	0	1	0
Annelida	O	1	0.06	10	0	1	0	0	0	0	0	0	0	0
Cirratulidae	P	1	0.06	10	0	0	0	1	0	0	0	0	0	0
Cirriformia sp.	P	1	0.06	10	0	0	0	0	1	0	0	0	0	0
Cyclaspis pustulata	O	1	0.06	10	0	0	0	1	0	0	0	0	0	0
Elasmopus sp.	A	1	0.06	10	1	0	0	0	0	0	0	0	0	0
Gammarus sp.	A	1	0.06	10	0	0	0	1	0	0	0	0	0	0
Glycera americana	P	1	0.06	10	0	0	0	0	0	0	0	1	0	0
Lucinidae	M	1	0.06	10	0	0	0	0	0	0	0	0	1	0
Ogyrides alphaerostris	O	1	0.06	10	1	0	0	0	0	0	0	0	0	0
Oliva reticularis	M	1	0.06	10	0	0	0	0	0	1	0	0	0	0
Ophelina acuminata	P	1	0.06	10	0	0	0	0	0	1	0	0	0	0
Orbiniidae	P	1	0.06	10	0	0	0	0	0	0	0	0	0	1
Pagurus annulipes	O	1	0.06	10	0	0	0	1	0	0	0	0	0	0
Rhepoxynius sp.	A	1	0.06	10	1	0	0	0	0	0	0	0	0	0
Solenidae	M	1	0.06	10	0	0	1	0	0	0	0	0	0	0
Spiophanes missionensis	P	1	0.06	10	0	0	0	0	1	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**73**	**149**	**208**	**219**	**166**	**310**	**244**	**40**	**96**	**169**
Mean density (#/m^2)					**1825**	**3725**	**5200**	**5475**	**4150**	**7750**	**6100**	**1000**	**2400**	**4225**
Species Richness (#/$0.04m^2$)					**13**	**11**	**7**	**16**	**11**	**13**	**7**	**6**	**13**	**8**
Species Diversity					**1.40**	**1.08**	**0.91**	**1.26**	**0.95**	**1.22**	**1.27**	**0.73**	**1.39**	**1.41**
Evenness					**0.55**	**0.45**	**0.47**	**0.45**	**0.40**	**0.48**	**0.65**	**0.41**	**0.54**	**0.68**

Appendix 4.2. Abundance of benthic species collected at the Joiner Shoals Borrow Area during post nourishment (Post) sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

Species Name	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JB01	JB02	JB03	JB04	JB05	JB06	JB08	JB09	JB10	JB11
Oxyurostylis smithi	O	360	34.22	80	4	27	72	103	6	0	70	43	2	33
Tellina agilis	M	147	13.97	70	35	13	0	1	9	53	5	2	28	1
Mediomastus californiensis	P	133	12.64	90	0	20	0	0	106	7	0	0	0	0
Leucon americanus	O	55	5.23	90	0	0	7	2	0	0	27	17	1	1
Cumacea	O	51	4.85	60	0	3	5	19	3	1	14	3	1	2
Protohaustorius deichmannae	A	48	4.56	60	16	0	0	0	5	14	8	1	4	0
Leitoscoloplos fragilis	P	21	2.00	60	4	0	0	0	5	9	0	0	3	0
Cyclaspis varians	O	20	1.90	70	0	14	1	0	3	2	0	0	0	0
Edotia montosa	O	19	1.81	70	0	0	12	3	0	0	0	2	0	2
Leitoscoloplos sp.	P	18	1.71	60	1	2	0	1	0	1	1	5	2	5
Americhelidium americanum	A	17	1.62	10	0	2	0	1	4	2	0	2	4	2
Eteone lactea	P	15	1.43	20	2	6	0	0	2	4	0	0	1	0
Pelecypoda	M	11	1.05	80	0	3	0	1	6	1	0	0	0	0
Rhepoxynius hudsoni	A	11	1.05	40	2	0	0	0	1	7	1	0	0	0
Pinnixa sp.	O	10	0.95	70	0	0	0	0	3	3	4	0	0	0
Scolelepis texana	P	9	0.86	40	7	0	0	0	1	0	0	0	1	0
Capitella capitata	P	7	0.67	90	7	0	0	0	0	0	0	0	0	0
Haustoriidae	A	7	0.67	80	1	0	0	0	0	4	1	0	1	0
Eudevenopus honduranus	A	6	0.57	10	0	0	0	0	0	0	6	0	0	0
Mulinia lateralis	M	5	0.48	50	0	0	0	0	0	0	1	0	4	0
Orbiniidae	P	5	0.48	30	0	0	0	0	2	3	0	0	0	0
Paraonis fulgens	P	5	0.48	60	0	0	0	0	1	4	0	0	0	0
Cirriformia sp.	P	4	0.38	40	4	0	0	0	0	0	0	0	0	0
Spionidae	P	4	0.38	40	0	0	0	0	1	1	0	2	0	0
Capitellidae	P	3	0.29	10	2	1	0	0	0	0	0	0	0	0
Copepoda	O	3	0.29	50	0	0	0	1	0	1	0	1	0	0
Glycera americana	P	3	0.29	40	0	1	1	1	0	0	0	0	0	0
Leiocapitella glabra	P	3	0.29	40	3	0	0	0	0	0	0	0	0	0
Listriella barnardi	A	3	0.29	30	0	0	0	0	0	1	2	0	0	0
Nematoda	O	3	0.29	40	0	0	0	0	0	3	0	0	0	0
Paraprionospio pinnata	P	3	0.29	50	0	0	0	0	3	0	0	0	0	0
Scolelepis squamata	P	3	0.29	20	1	1	0	0	0	1	0	0	0	0

Appendix 4.2. Abundance of benthic species collected at the Joiner Shoals Borrow Area during post nourishment (Post) sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (#/$0.04m^2$)	% Abundance	% stations where present	JB01	JB02	JB03	JB04	JB05	JB06	JB08	JB09	JB10	JB11
Solen viridis	M	3	0.29	20	1	0	1	0	0	0	0	0	0	1
Biffarius biformis	O	2	0.19	30	1	0	1	0	0	0	0	0	0	0
Eteone heteropoda	P	2	0.19	30	0	0	0	2	0	0	0	0	0	0
Glycera oxycephala	P	2	0.19	30	1	0	1	0	0	0	0	0	0	0
Hemipodus roseus	P	2	0.19	40	0	0	0	0	0	0	0	0	2	0
Maldanidae	P	2	0.19	30	0	0	0	0	0	0	0	0	2	0
Oedicerotidae	A	2	0.19	30	0	0	0	0	0	0	0	0	2	0
Renilla reniformis	O	2	0.19	10	1	0	0	0	0	0	0	1	0	0
Rhepoxynius epistomus	A	2	0.19	20	0	0	0	0	1	0	0	0	1	0
Ancinus depressus	O	1	0.10	10	0	0	0	0	1	0	0	0	0	0
Caprellidae	A	1	0.10	10	0	0	0	1	0	0	0	0	0	0
Cirripedia	O	1	0.10	20	0	0	0	0	0	0	1	0	0	0
Collembola	O	1	0.10	20	0	0	0	0	0	0	1	0	0	0
Cyclaspis pustulata	O	1	0.10	10	1	0	0	0	0	0	0	0	0	0
Decapoda	O	1	0.10	20	0	0	0	0	0	1	0	0	0	0
Elasmopus sp.	A	1	0.10	20	0	0	1	0	0	0	0	0	0	0
Eobrolgus spinosus	A	1	0.10	10	1	0	0	0	0	0	0	0	0	0
Euclymene sp.	P	1	0.10	10	0	0	0	0	0	0	0	0	1	0
Lucinidae	M	1	0.10	20	0	0	0	0	0	0	1	0	0	0
Melitidae	A	1	0.10	20	0	1	0	0	0	0	0	0	0	0
Nemertea	O	1	0.10	10	0	0	0	1	0	0	0	0	0	0
Nephtys picta	P	1	0.10	20	0	0	0	0	1	0	0	0	0	0
Olivella mutica	M	1	0.10	10	1	0	0	0	0	0	0	0	0	0
Ophelina cylindricaudata	P	1	0.10	20	0	0	0	0	0	1	0	0	0	0
Ophiuroidea	O	1	0.10	20	0	0	0	0	0	0	1	0	0	0
Ostracoda	O	1	0.10	20	0	0	0	0	0	0	0	1	0	0
Prionospio sp.	P	1	0.10	20	0	0	0	0	0	0	0	0	1	0
Scolecolepides viridis	P	1	0.10	20	1	0	0	0	0	0	0	0	0	0
Spiophanes missionensis	P	1	0.10	20	1	0	0	0	0	0	0	0	0	0
Streblospio benedicti	P	1	0.10	10	1	0	0	0	0	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**99**	**94**	**102**	**137**	**164**	**124**	**144**	**80**	**61**	**47**
Mean density (#/m^2)					**2475**	**2350**	**2550**	**3425**	**4100**	**3100**	**3600**	**2000**	**1525**	**1175**
Species Richness (#/$0.04m^2$)					**24**	**13**	**10**	**13**	**20**	**22**	**16**	**12**	**18**	**8**
Species Diversity					**2.37**	**2.00**	**1.10**	**0.98**	**1.60**	**2.21**	**1.74**	**1.55**	**2.14**	**1.14**
Evenness					**0.75**	**0.78**	**0.48**	**0.38**	**0.54**	**0.71**	**0.63**	**0.62**	**0.74**	**0.55**

Appendix 4.3. Abundance of benthic species collected at the Joiner Shoals Borrow Area during 6 month post (6 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JB01	JB02	JB03	JB04	JB05	JB06	JB08	JB09	JB10	JB11
Acteocina candei	M	196	37.55	90	2	46	1	36	14	5	36	52	0	4
Mediomastus californiensis	P	108	20.69	80	2	1	0	0	13	43	26	3	2	18
Prionospio pygmaea	P	77	14.75	90	0	18	3	7	12	1	17	8	4	7
Nemertea	O	25	4.79	60	2	6	0	8	1	6	0	2	0	0
Glycinde nordmanni	P	16	3.07	70	2	1	0	1	6	0	2	2	0	2
Decapoda	O	15	2.87	80	0	1	3	1	2	3	1	3	1	0
Pelecypoda	M	13	2.49	50	2	0	0	2	0	3	4	2	0	0
Copepoda	O	12	2.30	70	0	0	2	2	3	1	1	2	0	1
Nassarius vibex	M	12	2.30	50	2	2	1	4	3	0	0	0	0	0
Leitoscoloplos robustus	P	6	1.15	30	2	0	0	0	1	3	0	0	0	0
Spiophanes wigleyi	P	5	0.96	10	5	0	0	0	0	0	0	0	0	0
Tellinidae	M	5	0.96	30	0	0	0	0	1	2	0	2	0	0
Leucon americanus	O	4	0.77	40	0	1	0	1	0	0	0	1	0	1
Pinnotheridae	O	3	0.57	20	0	1	0	0	0	2	0	0	0	0
Biffarius biformis	O	2	0.38	20	0	1	0	0	0	1	0	0	0	0
Glycera americana	P	2	0.38	20	1	0	0	0	1	0	0	0	0	0
Sigalionidae	P	2	0.38	20	0	1	0	1	0	0	0	0	0	0
Sigambra wassi	P	2	0.38	20	0	1	0	1	0	0	0	0	0	0
Acanthohaustorius intermedius	A	1	0.19	10	0	0	0	1	0	0	0	0	0	0
Amphipoda	A	1	0.19	10	0	0	1	0	0	0	0	0	0	0
Ancinus depressus	O	1	0.19	10	0	0	1	0	0	0	0	0	0	0
Bopyridae	O	1	0.19	10	0	1	0	0	0	0	0	0	0	0
Branchiostoma sp.	O	1	0.19	10	0	0	0	0	0	0	0	1	0	0
Glycymeris americana	M	1	0.19	10	0	0	0	0	0	1	0	0	0	0
Goniadidae	P	1	0.19	10	0	0	0	1	0	0	0	0	0	0
Insecta	O	1	0.19	10	0	0	0	0	0	0	0	1	0	0
Mysida	O	1	0.19	10	0	0	0	0	0	0	0	1	0	0
Natica pusilla	M	1	0.19	10	0	1	0	0	0	0	0	0	0	0
Nematoda	O	1	0.19	10	0	0	0	0	0	1	0	0	0	0
Nudibranchia	M	1	0.19	10	0	0	0	0	0	0	0	0	0	1

Appendix 4.3. Abundance of benthic species collected at the Joiner Shoals Borrow Area during 6 month post (6 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JB01	JB02	JB03	JB04	JB05	JB06	JB08	JB09	JB10	JB11
Onuphis eremita	P	1	0.19	10	0	0	0	0	0	1	0	0	0	0
Paraonis fulgens	P	1	0.19	10	0	0	0	0	0	0	0	0	0	1
Solen viridis	M	1	0.19	10	0	1	0	0	0	0	0	0	0	0
Tanaissus psammophilus	O	1	0.19	10	0	0	0	0	0	0	0	1	0	0
Tellina agilis	M	1	0.19	10	0	0	0	1	0	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**20**	**83**	**12**	**67**	**57**	**73**	**87**	**81**	**7**	**35**
Mean density (#/m^2)					**500**	**2075**	**300**	**1675**	**1425**	**1825**	**2175**	**2025**	**175**	**875**
Species Richness (#/$0.04m^2$)					**9**	**15**	**7**	**14**	**11**	**14**	**7**	**14**	**3**	**8**
Species Diversity					**2.11**	**1.52**	**1.82**	**1.70**	**1.96**	**1.64**	**1.38**	**1.49**	**0.96**	**1.48**
Evenness					**0.96**	**0.56**	**0.94**	**0.65**	**0.82**	**0.62**	**0.71**	**0.56**	**0.87**	**0.71**

Appendix 4.4. Abundance of benthic species collected at the Joiner Shoals Borrow Area during 12 month post (12mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = Polychaete, A = Amphipod, M = Mollusc, and O = Other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JB01	JB02	JB03	JB04	JB05	JB06	JB08	JB09	JB10	JB11
Acteocina canaliculata	M	770	33.49	100	42	78	68	136	57	52	102	109	33	93
Protohaustorius deichmannae	A	526	22.88	90	217	74	0	15	117	63	11	24	4	1
Leitoscoloplos fragilis	P	306	13.31	100	7	52	35	55	25	4	28	18	43	39
Oxyurostylis smithi	O	147	6.39	100	1	55	7	43	5	6	9	5	14	2
Tellina alternata	M	147	6.39	80	22	28	1	9	41	7	13	26	0	0
Paraprionospio pinnata	P	49	2.13	70	0	3	7	6	0	0	1	5	13	14
Tellina agilis	M	42	1.83	50	0	0	8	4	0	3	23	0	0	4
Tiron tropakis	A	41	1.78	90	0	7	1	13	2	5	1	5	5	2
Nassarius albus	M	30	1.30	70	0	5	2	9	0	0	3	8	2	1
Carinomella lactea	O	26	1.13	50	0	9	1	8	0	0	0	0	4	4
Bathyporeia parkeri	A	22	0.96	40	15	2	0	0	0	4	0	1	0	0
Rhepoxynius hudsoni	A	22	0.96	60	7	2	1	0	2	8	2	0	0	0
Nematoda	O	15	0.65	40	1	12	0	0	1	1	0	0	0	0
Ericthonius brasiliensis	A	14	0.61	10	0	0	0	0	0	14	0	0	0	0
Campylaspis affinis	O	11	0.48	50	2	4	0	0	0	1	2	2	0	0
Pagurus longicarpus	O	11	0.48	20	0	0	0	0	1	10	0	0	0	0
Aglaophamus verrilli	P	10	0.43	50	0	0	0	6	1	1	0	1	0	1
Macoma tenta	M	10	0.43	20	0	0	0	0	0	0	0	0	8	2
Eudevenopus honduranus	A	9	0.39	30	2	6	0	0	1	0	0	0	0	0
Glycera americana	P	9	0.39	60	1	2	0	0	0	2	1	0	2	1
Eteone heteropoda	P	7	0.30	40	0	0	2	3	0	0	1	1	0	0
Scolelepis squamata	P	7	0.30	40	0	2	1	1	3	0	0	0	0	0
Abra aequalis	M	5	0.22	50	0	1	1	1	0	0	0	1	1	0
Haminoea solitaria	M	5	0.22	30	0	3	1	1	0	0	0	0	0	0
Mediomastus sp.	P	5	0.22	40	0	2	0	1	1	0	0	0	1	0
Rhepoxynius epistomus	A	5	0.22	30	0	3	0	0	1	1	0	0	0	0
Glycinde solitaria	P	4	0.17	30	0	1	0	2	0	0	0	0	1	0
Ancinus depressus	O	3	0.13	30	0	0	0	0	1	0	1	0	1	0
Corbula contracta	M	3	0.13	30	0	0	0	0	1	1	0	1	0	0
Edotia triloba	O	3	0.13	10	0	0	0	0	0	0	0	0	0	3

Appendix 4.4. Abundance of benthic species collected at the Joiner Shoals Borrow Area during 12 month post (12mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = Polychaete, A = Amphipod, M = Mollusc, and O = Other taxa.

SpeciesName	**Category**	**Total Abundance (# /$0.04m^2$)**	**Percent Abundance**	**Percent of Stations Where Present**	**JB01**	**JB02**	**JB03**	**JB04**	**JB05**	**JB06**	**JB08**	**JB09**	**JB10**	**JB11**
Ophelina acuminata	P	3	0.13	10	3	0	0	0	0	0	0	0	0	0
Corophium aquafuscum	A	2	0.09	10	0	0	0	0	0	2	0	0	0	0
Edotia montosa	O	2	0.09	10	0	2	0	0	0	0	0	0	0	0
Gastropoda	M	2	0.09	10	0	2	0	0	0	0	0	0	0	0
Listriella barnardi	A	2	0.09	20	1	0	1	0	0	0	0	0	0	0
Naticidae	M	2	0.09	20	0	1	0	0	0	0	0	1	0	0
Nemertea	O	2	0.09	20	0	0	1	0	1	0	0	0	0	0
Nucula sp.	M	2	0.09	10	0	2	0	0	0	0	0	0	0	0
Ostracoda	O	2	0.09	20	0	1	0	0	0	0	1	0	0	0
Parvilucina multilineata	M	2	0.09	20	0	0	0	0	0	1	1	0	0	0
Scolelepis texana	P	2	0.09	10	2	0	0	0	0	0	0	0	0	0
Acanthohaustorius millsi	A	1	0.04	10	0	0	0	0	1	0	0	0	0	0
Astyris lunata	M	1	0.04	10	0	0	0	0	0	1	0	0	0	0
Batea catharinensis	A	1	0.04	10	0	0	0	0	0	1	0	0	0	0
Biffarius biformis	O	1	0.04	10	1	0	0	0	0	0	0	0	0	0
Drilonereis longa	P	1	0.04	10	0	0	0	1	0	0	0	0	0	0
Mulinia lateralis	M	1	0.04	10	0	0	1	0	0	0	0	0	0	0
Nephtys picta	P	1	0.04	10	0	0	0	1	0	0	0	0	0	0
Olivella mutica	M	1	0.04	10	1	0	0	0	0	0	0	0	0	0
Olividae	M	1	0.04	10	0	0	0	0	0	0	1	0	0	0
Polinices sp.	M	1	0.04	10	0	1	0	0	0	0	0	0	0	0
Solen viridis	M	1	0.04	10	0	0	0	0	0	0	1	0	0	0
Terebra dislocata	M	1	0.04	10	0	0	0	0	0	0	0	0	1	0
Mean total abundance (#/$0.04m^2$)					**325**	**360**	**139**	**315**	**262**	**188**	**202**	**208**	**133**	**167**
Mean density (#/m^2)					**8125**	**9000**	**3475**	**7875**	**6550**	**4700**	**5050**	**5200**	**3325**	**4175**
Species Richness (#/$0.04m^2$)					**16**	**27**	**17**	**19**	**18**	**21**	**18**	**15**	**15**	**13**
Species Diversity					**1.27**	**2.31**	**1.64**	**1.90**	**1.62**	**2.08**	**1.73**	**1.65**	**1.99**	**1.41**
Evenness					**0.46**	**0.70**	**0.58**	**0.65**	**0.56**	**0.68**	**0.60**	**0.61**	**0.73**	**0.55**

Appendix 4.5. Abundance of benthic species collected at the Barrett Shoals Borrow Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BB01	BB02	BB03	BB04	BB05	BB06	BB07	BB08	BB09	BB10
Protohaustorius deichmannae	A	234	29.03	90	37	15	37	0	7	7	37	47	46	1
Parahaustorius longimerus	A	149	18.49	60	0	0	0	0	6	32	34	20	7	50
Donax variabilis	M	137	17.00	30	0	0	0	0	0	2	2	0	0	133
Acanthohaustorius millsi	A	36	4.47	40	0	0	0	0	2	1	0	32	1	0
Acanthohaustorius intermedius	A	34	4.22	60	18	0	2	0	1	9	2	0	2	0
Tanaissus psammophilus	O	26	3.23	40	5	0	0	0	15	3	0	3	0	0
Rhepoxynius hudsoni	A	18	2.23	40	11	0	0	0	0	1	1	5	0	0
Tellinidae	M	16	1.99	60	0	1	3	5	4	0	0	2	1	0
Eudevenopus honduranus	A	13	1.61	30	0	5	3	5	0	0	0	0	0	0
Haustoriidae	A	12	1.49	50	0	2	3	0	3	0	0	2	0	2
Nematoda	O	10	1.24	50	0	0	3	0	3	2	0	0	1	1
Nephtys picta	P	10	1.24	60	1	0	1	0	3	2	0	1	2	0
Pelecypoda	M	10	1.24	50	1	0	1	0	0	0	6	1	1	0
Capitellidae	P	9	1.12	60	0	1	3	1	0	1	2	1	0	0
Decapoda	O	8	0.99	30	0	0	0	0	0	2	4	0	0	2
Pinnotheridae	O	8	0.99	20	0	1	0	7	0	0	0	0	0	0
Pinnixa sp.	O	6	0.74	10	0	0	0	0	0	0	0	0	6	0
Bathyporeia sp.	A	5	0.62	10	0	0	0	0	0	5	0	0	0	0
Biffarius biformis	O	5	0.62	30	0	2	1	2	0	0	0	0	0	0
Olividae	M	5	0.62	10	0	0	0	0	5	0	0	0	0	0
Apanthura magnifica	O	4	0.50	20	0	2	0	0	0	0	0	0	2	0
Ogyrides hayi	O	4	0.50	20	0	0	0	0	0	1	0	0	3	0
Protohaustorius sp.	A	4	0.50	10	4	0	0	0	0	0	0	0	0	0
Acanthohaustorius shoemakeri	A	3	0.37	10	0	0	0	0	0	0	0	3	0	0
Mysida	O	3	0.37	20	0	2	0	1	0	0	0	0	0	0
Nassarius acutus	M	3	0.37	30	0	0	1	1	0	0	0	0	1	0
Phoxocephalidae	A	3	0.37	30	1	0	0	0	1	0	1	0	0	0
Ancinus depressus	O	2	0.25	20	0	0	1	1	0	0	0	0	0	0
Armandia agilis	P	2	0.25	10	0	2	0	0	0	0	0	0	0	0
Branchiostoma sp.	O	2	0.25	10	0	0	0	0	0	0	0	0	2	0

Appendix 4.5. Abundance of benthic species collected at the Barrett Shoals Borrow Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BB01	BB02	BB03	BB04	BB05	BB06	BB07	BB08	BB09	BB10
Magelona sp.	P	2	0.25	20	1	0	0	0	0	0	1	0	0	0
Olivella mutica	M	2	0.25	20	1	0	0	0	0	0	0	1	0	0
Bathyporeia parkeri	A	1	0.12	10	0	0	0	0	0	0	0	0	0	1
Caulleriella sp.	P	1	0.12	10	1	0	0	0	0	0	0	0	0	0
Cirratulidae	P	1	0.12	10	1	0	0	0	0	0	0	0	0	0
Copepoda	O	1	0.12	10	0	0	0	1	0	0	0	0	0	0
Cumacea	O	1	0.12	10	0	0	0	0	0	0	0	1	0	0
Cyathura polita	O	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Cyclaspis pustulata	O	1	0.12	10	0	0	0	0	0	1	0	0	0	0
Dasybranchus lunulatus	P	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Emerita talpoida	O	1	0.12	10	0	0	0	0	0	0	0	0	0	1
Insecta	O	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Lucinidae	M	1	0.12	10	0	0	0	0	1	0	0	0	0	0
Melitidae	A	1	0.12	10	0	0	0	1	0	0	0	0	0	0
Mysidae	O	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Nemertea	O	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Olivella sp.	M	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Ophelina cylindricaudata	P	1	0.12	10	0	1	0	0	0	0	0	0	0	0
Pinnixa chaetopterana	O	1	0.12	10	0	1	0	0	0	0	0	0	0	0
Pinnixa cristata	O	1	0.12	10	0	0	0	0	0	1	0	0	0	0
Renilla reniformis	O	1	0.12	10	0	0	0	1	0	0	0	0	0	0
Strigilla mirabilis	M	1	0.12	10	0	0	0	0	0	0	0	0	1	0
Veneridae	M	1	0.12	10	0	0	0	0	0	0	1	0	0	0
Mean total abundance (#/$0.04m^2$)					**82**	**35**	**59**	**26**	**51**	**70**	**91**	**119**	**82**	**191**
Mean density (#/m^2)					**2050**	**875**	**1475**	**650**	**1275**	**1750**	**2275**	**2975**	**2050**	**4775**
Species Richness (#/$0.04m^2$)					**12**	**12**	**12**	**11**	**12**	**15**	**11**	**13**	**20**	**8**
Species Diversity					**1.66**	**1.97**	**1.51**	**2.06**	**2.17**	**1.95**	**1.50**	**1.68**	**1.85**	**0.81**
Evenness					**0.67**	**0.79**	**0.61**	**0.86**	**0.87**	**0.72**	**0.63**	**0.65**	**0.62**	**0.39**

Appendix 4.6. Abundance of benthic species collected at the Barrett Shoals Borrow Area during Post nourishment sampling. Abundance values represent the number of individuals per grab (0.04m2). Density represents the number of individuals/m2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /0.04m^2)	Percent Abundance	Percent of Stations Where Present	BB03	BB09	BB11	BB12	BB13	BB14	BB15	BB16	BB17	BB18
Protohaustorius deichmannae	A	258	30.00	90	36	18	0	32	6	65	25	28	22	26
Spiophanes bombyx	P	249	28.95	100	10	21	10	16	58	34	18	2	18	62
Tellina agilis	M	106	12.33	100	5	16	14	1	9	13	13	2	12	21
Lucinidae	M	43	5.00	90	5	4	0	4	2	8	7	4	2	7
Nemertea	O	20	2.33	80	1	1	0	5	4	4	0	2	1	2
Paraonis fulgens	P	17	1.98	60	5	0	1	1	6	0	0	0	2	2
Acanthohaustorius intermedius	A	11	1.28	70	0	0	0	3	1	2	1	1	2	1
Haustoriidae	A	11	1.28	70	2	2	0	0	1	2	1	2	0	1
Oxyurostylis smithi	O	11	1.28	50	0	0	4	1	4	1	0	0	0	1
Olivella mutica	M	10	1.16	30	1	0	0	0	0	8	0	0	1	0
Rhepoxynius hudsoni	A	10	1.16	30	0	0	0	0	0	6	1	0	0	3
Nematoda	O	9	1.05	40	0	1	0	0	0	0	0	6	1	1
Parahaustorius longimerus	A	9	1.05	10	0	0	0	9	0	0	0	0	0	0
Micronephthys minuta	P	8	0.93	50	0	2	1	0	0	1	0	2	0	2
Maldanidae	P	5	0.58	20	0	0	3	0	2	0	0	0	0	0
Melitidae	A	5	0.58	20	0	0	0	0	4	0	0	0	0	1
Pelecypoda	M	5	0.58	30	0	0	0	2	0	0	2	0	0	1
Acanthohaustorius millsi	A	4	0.47	30	0	0	0	0	1	1	0	0	0	2
Tanaissus psammophilus	O	4	0.47	30	0	0	0	1	0	1	0	0	0	2
Americhelidium americanum	A	3	0.35	30	1	1	0	0	0	0	0	0	0	1
Bathyporeia parkeri	A	3	0.35	20	1	0	0	0	0	2	0	0	0	0
Capitella capitata	P	3	0.35	20	0	0	0	0	1	0	0	0	2	0
Edotia montosa	O	3	0.35	20	0	0	2	0	1	0	0	0	0	0
Elasmopus sp.	A	3	0.35	20	0	1	2	0	0	0	0	0	0	0
Gammaridea	A	3	0.35	10	0	0	0	0	0	0	0	0	0	3
Glycera oxycephala	P	3	0.35	30	0	1	0	0	0	0	1	0	1	0
Insecta	O	3	0.35	30	0	0	0	1	1	0	0	1	0	0
Mancocuma sp.	O	3	0.35	10	0	0	0	3	0	0	0	0	0	0
Pinnotheridae	O	3	0.35	20	0	0	2	1	0	0	0	0	0	0
Syllidae	P	3	0.35	20	0	0	0	2	1	0	0	0	0	0

Appendix 4.6. Abundance of benthic species collected at the Barrett Shoals Borrow Area during Post nourishment sampling. Abundance values represent the number of individuals per grab (0.04m2). Density represents the number of individuals/m2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /0.04m²)**	**Percent Abundance**	**Percent of Stations Where Present**	**BB03**	**BB09**	**BB11**	**BB12**	**BB13**	**BB14**	**BB15**	**BB16**	**BB17**	**BB18**
Acanthohaustorius shoemakeri	A	2	0.23	10	0	0	0	0	0	0	0	2	0	0
Drilonereis longa	P	2	0.23	20	0	0	1	0	1	0	0	0	0	0
Gastropoda	M	2	0.23	20	1	0	0	1	0	0	0	0	0	0
Macroclymene sp.	P	2	0.23	20	0	0	0	0	0	1	1	0	0	0
Mysida	O	2	0.23	10	2	0	0	0	0	0	0	0	0	0
Naticidae	M	2	0.23	20	0	1	1	0	0	0	0	0	0	0
Platyhelminthes	O	2	0.23	20	0	0	0	0	1	0	1	0	0	0
Tellinidae	M	2	0.23	20	1	1	0	0	0	0	0	0	0	0
Actiniaria	O	1	0.12	10	0	0	0	0	0	0	0	0	0	1
Ancinus depressus	O	1	0.12	10	0	0	0	0	0	0	1	0	0	0
Apanthura magnifica	O	1	0.12	10	0	1	0	0	0	0	0	0	0	0
Axiothella sp.	P	1	0.12	10	0	0	0	0	0	0	0	0	0	1
Cirratulidae	P	1	0.12	10	0	1	0	0	0	0	0	0	0	0
Cumacea	O	1	0.12	10	0	0	0	0	0	0	0	0	0	1
Eudevenopus honduranus	A	1	0.12	10	0	0	0	0	0	0	1	0	0	0
Exogone sp.	P	1	0.12	10	0	0	0	0	0	0	1	0	0	0
Glycera sp.	P	1	0.12	10	0	1	0	0	0	0	0	0	0	0
Leitoscoloplos robustus	P	1	0.12	10	0	0	0	0	0	0	1	0	0	0
Mediomastus californiensis	P	1	0.12	10	0	0	0	0	1	0	0	0	0	0
Nassarius acutus	M	1	0.12	10	0	1	0	0	0	0	0	0	0	0
Owenia fusiformis	P	1	0.12	10	0	0	0	0	1	0	0	0	0	0
Sphenia antillensis	M	1	0.12	10	0	0	0	1	0	0	0	0	0	0
Strigilla mirabilis	M	1	0.12	10	0	0	0	0	0	0	1	0	0	0
Tubificoides sp.	O	1	0.12	10	0	0	0	0	0	1	0	0	0	0
Mean total abundance (#/0.04m²)					**71**	**74**	**41**	**84**	**106**	**150**	**76**	**52**	**64**	**142**
Mean density (#/m²)					**1775**	**1850**	**1025**	**2100**	**2650**	**3750**	**1900**	**1300**	**1600**	**3550**
Species Richness (#/0.04m²)					**13**	**17**	**11**	**17**	**20**	**16**	**16**	**11**	**11**	**21**
Species Diversity					**1.74**	**2.03**	**1.93**	**2.07**	**1.87**	**1.82**	**1.95**	**1.68**	**1.73**	**1.92**
Evenness					**0.68**	**0.71**	**0.81**	**0.73**	**0.62**	**0.66**	**0.70**	**0.70**	**0.72**	**0.63**

Appendix 4.7. Abundance of benthic species collected at the Barrett Shoals Borrow Area during 6 month post (6 mo post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04 m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /$0.04m^2$)**	**Percent Abundance**	**Percent of Stations Where Present**	**BB03**	**BB09**	**BB11**	**BB12**	**BB13**	**BB14**	**BB15**	**BB16**	**BB17**	**BB18**
Protohaustorius deichmannae	A	181	29.38	80	6	15	0	47	8	0	29	60	15	1
Rhepoxynius hudsoni	A	50	8.12	60	3	24	0	2	13	0	0	0	5	3
Tellina agilis	M	48	7.79	60	3	17	0	7	5	0	1	0	15	0
Prionospio sp.	P	27	4.38	10	0	0	0	0	0	27	0	0	0	0
Spiophanes bombyx	P	24	3.90	10	0	0	24	0	0	0	0	0	0	0
Nemertea	O	21	3.41	80	1	0	4	1	0	5	4	1	3	2
Eudevenopus honduranus	A	19	3.08	50	5	0	0	5	1	0	7	1	0	0
Glycinde nordmanni	P	17	2.76	50	1	2	3	0	0	5	0	0	0	6
Mediomastus californiensis	P	14	2.27	40	0	2	0	0	4	1	0	0	0	7
Pelecypoda	M	13	2.11	70	1	3	0	2	3	0	1	0	1	2
Olivella mutica	M	12	1.95	40	0	2	0	4	0	0	0	4	2	0
Solenidae	M	12	1.95	40	0	5	2	4	0	0	0	0	0	1
Solen viridis	M	11	1.79	40	0	0	0	0	4	0	4	0	1	2
Nephtys picta	P	10	1.62	40	0	0	0	0	3	0	0	2	3	2
Nassarius vibex	M	9	1.46	50	0	0	2	0	1	0	4	1	1	0
Decapoda	O	8	1.30	60	1	0	0	2	0	1	2	0	1	1
Mulinia lateralis	M	8	1.30	40	0	2	0	0	2	0	1	0	3	0
Opheliidae	P	8	1.30	20	0	2	0	0	0	0	0	0	6	0
Phoxocephalidae	A	8	1.30	30	2	0	0	5	0	0	1	0	0	0
Ophelina acuminata	P	7	1.14	30	1	1	0	0	5	0	0	0	0	0
Armandia agilis	P	6	0.97	30	0	0	0	0	0	2	1	0	0	3
Pinnotheridae	O	6	0.97	20	0	0	2	0	0	0	0	0	0	4
Branchiostoma sp.	O	5	0.81	40	0	1	0	0	1	0	1	0	2	0
Americhelidium americanum	A	4	0.65	40	1	0	0	1	1	1	0	0	0	0
Capitellidae	P	4	0.65	10	0	0	0	0	0	0	0	0	0	4
Glycera americana	P	4	0.65	30	1	0	0	0	0	0	0	0	1	2
Nematoda	O	4	0.65	30	0	0	0	1	1	0	2	0	0	0
Ophelina cylindricaudata	P	4	0.65	20	0	0	0	1	0	0	0	0	3	0
Spiophanes missionensis	P	4	0.65	10	0	0	0	0	0	0	4	0	0	0
Crangonyx richmondensis	A	3	0.49	10	0	0	0	0	0	0	0	0	0	3

Appendix 4.7. Abundance of benthic species collected at the Barrett Shoals Borrow Area during 6 month post (6 mo post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04 m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BB03	BB09	BB11	BB12	BB13	BB14	BB15	BB16	BB17	BB18
Cumacea	O	3	0.49	20	2	0	0	1	0	0	0	0	0	0
Oxyurostylis smithi	O	3	0.49	30	1	0	0	0	0	0	1	1	0	0
Renilla reniformis	O	3	0.49	30	1	0	0	0	0	0	1	0	1	0
Thalassinidea	O	3	0.49	20	0	0	0	0	0	1	0	0	0	2
Leitoscoloplos sp.	P	2	0.32	20	1	0	0	0	1	0	0	0	0	0
Listriella barnardi	A	2	0.32	10	0	0	2	0	0	0	0	0	0	0
Mysida	O	2	0.32	20	0	0	1	1	0	0	0	0	0	0
Onuphis eremita	P	2	0.32	20	0	1	0	0	1	0	0	0	0	0
Owenia fusiformis	P	2	0.32	10	0	0	0	0	0	0	0	0	0	2
Prionospio steenstrupi	P	2	0.32	10	0	0	0	0	0	0	0	0	0	2
Sigambra wassi	P	2	0.32	10	0	0	0	2	0	0	0	0	0	0
Spionidae	P	2	0.32	10	0	0	0	0	0	0	0	0	0	2
Acanthohaustorius intermedius	A	1	0.16	10	0	0	0	0	0	0	0	1	0	0
Acteocina candei	M	1	0.16	10	0	0	1	0	0	0	0	0	0	0
Americamysis bahia	O	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Ancinus depressus	O	1	0.16	10	0	0	0	0	0	0	0	1	0	0
Armandia maculata	P	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Batea catharinensis	A	1	0.16	10	0	0	0	0	0	0	0	0	1	0
Caulleriella sp.	P	1	0.16	10	0	0	0	0	1	0	0	0	0	0
Cirratulidae	P	1	0.16	10	0	0	0	0	0	0	0	0	0	1
Cirrophorus lyriformis	P	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Copepoda	O	1	0.16	10	0	0	0	0	0	0	0	0	0	1
Cyathura polita	O	1	0.16	10	0	0	0	0	0	0	0	0	1	0
Cyclaspis pustulata	O	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Drilonereis longa	P	1	0.16	10	0	0	0	0	0	0	0	0	1	0
Edotia montosa	O	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Eteone lactea	P	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Glycera oxycephala	P	1	0.16	10	0	0	0	1	0	0	0	0	0	0
Goniada sp.	P	1	0.16	10	0	0	0	0	0	0	0	0	0	1
Haustoriidae	A	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Lepidopa websteri	O	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Lucinidae	M	1	0.16	10	0	0	0	1	0	0	0	0	0	0

Appendix 4.7. Abundance of benthic species collected at the Barrett Shoals Borrow Area during 6 month post (6 mo post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BB03	BB09	BB11	BB12	BB13	BB14	BB15	BB16	BB17	BB18
Micronephthys minuta	P	1	0.16	10	0	0	0	1	0	0	0	0	0	0
Naticidae	M	1	0.16	10	0	0	0	0	1	0	0	0	0	0
Ogyrides hayi	O	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Onuphis sp.	P	1	0.16	10	0	0	1	0	0	0	0	0	0	0
Ophiuroidea	O	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Pagurus politus	O	1	0.16	10	0	0	0	0	0	0	0	0	1	0
Parahaustorius longimerus	A	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Paraonis fulgens	P	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Pinnixa cristata	O	1	0.16	10	0	0	0	1	0	0	0	0	0	0
Pinnixa sp.	O	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Platyhelminthes	O	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Rhepoxynius epistomus	A	1	0.16	10	0	0	0	1	0	0	0	0	0	0
Scolelepis sp.	P	1	0.16	10	0	0	0	0	0	0	0	1	0	0
Scolelepis texana	P	1	0.16	10	0	1	0	0	0	0	0	0	0	0
Sipuncula	O	1	0.16	10	0	0	0	1	0	0	0	0	0	0
Spiophanes sp.	P	1	0.16	10	0	0	0	0	0	0	0	0	1	0
Strigilla mirabilis	M	1	0.16	10	0	0	0	0	0	0	1	0	0	0
Mean total abundance (#/$0.04m^2$)					**31**	**85**	**42**	**92**	**56**	**43**	**72**	**73**	**68**	**54**
Mean density (#/m^2)					**775**	**2125**	**1050**	**2300**	**1400**	**1075**	**1800**	**1825**	**1700**	**1350**
Species Richness (#/$0.04m^2$)					**16**	**21**	**10**	**22**	**18**	**8**	**24**	**10**	**21**	**22**
Species Diversity					**2.53**	**2.29**	**1.58**	**2.05**	**2.50**	**1.29**	**2.38**	**0.83**	**2.51**	**2.92**
Evenness					**0.91**	**0.75**	**0.69**	**0.66**	**0.87**	**0.62**	**0.75**	**0.36**	**0.83**	**0.94**

Appendix 4.8. Abundance of benthic species collected at the Joiner Shoals Reference Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /0.04m2)	Percent Abundance	Percent of Stations Where Present	JR03	JR05	JR06	JR08	JR16	JR17	JR19	JR21	JR22	JR23
Protohaustorius deichmannae	A	894	31.02	90	138	100	102	16	162	128	116	96	36	0
Pyura vittata	O	708	24.57	10	0	0	0	0	0	0	0	0	0	708
Eudevenopus honduranus	A	240	8.33	100	8	40	30	62	18	22	28	12	12	8
Acanthohaustorius intermedius	A	218	7.56	60	56	26	74	0	26	0	0	34	2	0
Nematoda	O	86	2.98	40	0	0	0	2	0	2	0	0	2	80
Branchiostoma sp.	O	74	2.57	60	2	2	0	0	0	0	2	2	4	62
Metharpinia floridana	A	74	2.57	90	4	14	10	2	8	12	4	8	12	0
Pelecypoda	M	70	2.43	50	0	4	0	0	0	6	4	2	0	54
Acanthohaustorius sp.	A	48	1.67	20	0	0	0	0	0	22	26	0	0	0
Acanthohaustorius millsi	A	38	1.32	40	10	6	0	0	0	14	8	0	0	0
Tellinidae	M	34	1.18	50	2	0	0	24	0	0	4	2	2	0
Rhepoxynius hudsoni	A	32	1.11	70	8	2	4	0	4	0	0	4	8	2
Ogyrides hayi	O	30	1.04	70	6	2	4	2	8	0	0	2	6	0
Tanaissus psammophilus	O	26	0.90	60	2	2	2	0	0	2	0	0	2	16
Eobrolgus spinosus	A	24	0.83	30	4	0	0	0	0	0	8	12	0	0
Dissodactylus mellitae	O	18	0.62	30	0	10	0	0	0	6	0	0	2	0
Strigilla mirabilis	M	18	0.62	60	0	2	2	0	0	2	4	0	4	4
Bathyporeia sp.	A	16	0.56	20	0	0	0	0	0	0	0	0	14	2
Nephtys picta	P	16	0.56	40	6	0	0	4	0	2	4	0	0	0
Tellina probrina	M	14	0.49	20	0	8	0	0	6	0	0	0	0	0
Haustoriidae	A	12	0.42	10	12	0	0	0	0	0	0	0	0	0
Decapoda	O	10	0.35	30	6	0	0	2	0	2	0	0	0	0
Caulleriella sp.	P	8	0.28	20	0	0	0	0	0	6	0	0	0	2
Copepoda	O	8	0.28	20	6	0	0	0	0	0	0	0	0	2
Mellita quinquesperforata	O	8	0.28	30	0	2	0	0	0	4	0	0	2	0
Mysida	O	8	0.28	20	0	0	0	0	0	0	6	2	0	0
Platyhelminthes	O	8	0.28	10	0	0	0	0	0	0	0	0	0	8
Porifera	O	8	0.28	10	0	0	0	0	0	0	0	0	0	8
Abra aequalis	M	6	0.21	10	0	0	0	0	6	0	0	0	0	0
Goniada littorea	P	6	0.21	10	0	0	0	6	0	0	0	0	0	0
Magelona papillicornis	P	6	0.21	20	0	2	0	0	4	0	0	0	0	0
Phoxocephalidae	A	6	0.21	30	0	0	0	2	0	0	0	2	0	2
Ptilanthura tenuis	O	6	0.21	10	6	0	0	0	0	0	0	0	0	0

Appendix 4.8. Abundance of benthic species collected at the Joiner Shoals Reference Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04 m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /0.04m2)**	**Percent Abundance**	**Percent of Stations Where Present**	**JR03**	**JR05**	**JR06**	**JR08**	**JR16**	**JR17**	**JR19**	**JR21**	**JR22**	**JR23**
Divaricella quadrisulcata	M	4	0.14	10	0	0	0	0	4	0	0	0	0	0
Eteone lactea	P	4	0.14	20	0	2	0	0	0	2	0	0	0	0
Glycera oxycephala	P	4	0.14	20	0	0	0	0	0	0	0	2	0	2
Hemipodus roseus	P	4	0.14	10	0	0	0	0	0	0	0	0	0	4
Leitoscoloplos sp.	P	4	0.14	10	0	0	4	0	0	0	0	0	0	0
Mediomastus californiensis	P	4	0.14	10	0	0	0	0	0	0	0	0	0	4
Nemertea	O	4	0.14	20	0	0	0	2	0	0	0	0	2	0
Ogyrides alphaerostris	O	4	0.14	10	4	0	0	0	0	0	0	0	0	0
Olivella mutica	M	4	0.14	10	0	4	0	0	0	0	0	0	0	0
Protohaustorius sp.	A	4	0.14	10	0	0	0	4	0	0	0	0	0	0
Tellina iris	M	4	0.14	10	0	0	4	0	0	0	0	0	0	0
Acanthohaustorius shoemakeri	A	2	0.07	10	0	0	0	0	2	0	0	0	0	0
Arachnida	O	2	0.07	10	2	0	0	0	0	0	0	0	0	0
Arcidae	M	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Armandia agilis	P	2	0.07	10	2	0	0	0	0	0	0	0	0	0
Armandia maculata	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Bathyporeia parkeri	A	2	0.07	10	0	0	2	0	0	0	0	0	0	0
Brachyura	O	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Cirratulidae	P	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Crassinella lunulata	M	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Discoporella umbellata	O	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Dorvilleidae	P	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Emerita talpoida	O	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Gammaridea	A	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Haustorius sp.	A	2	0.07	10	0	0	0	0	2	0	0	0	0	0
Insecta	O	2	0.07	10	0	0	0	0	0	0	0	2	0	0
Kinbergonuphis sp.	P	2	0.07	10	0	0	0	0	0	0	2	0	0	0
Magelona sp.	P	2	0.07	10	0	0	0	0	0	0	2	0	0	0
Nephtys bucera	P	2	0.07	10	0	0	0	0	2	0	0	0	0	0
Oedicerotidae	A	2	0.07	10	0	2	0	0	0	0	0	0	0	0
Ogyrides sp.	O	2	0.07	10	0	0	0	0	0	0	0	2	0	0
Olivella sp.	M	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Olividae	M	2	0.07	10	0	0	0	0	2	0	0	0	0	0

Appendix 4.8. Abundance of benthic species collected at the Joiner Shoals Reference Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /0.04m2)**	**Percent Abundance**	**Percent of Stations Where Present**	**JR03**	**JR05**	**JR06**	**JR08**	**JR16**	**JR17**	**JR19**	**JR21**	**JR22**	**JR23**
Pinnotheridae	O	2	0.07	10	0	0	0	0	0	0	2	0	0	0
Processa sp.	O	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Sigalion arenicola	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Solenidae	M	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Terebra sp.	M	2	0.07	10	0	0	0	0	0	0	2	0	0	0
Trypanosyllis parvidentata	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Veneridae	M	2	0.07	10	2	0	0	0	0	0	0	0	0	0
Mean total abundance (#/0.04m^2)					**286**	**230**	**238**	**134**	**256**	**232**	**222**	**184**	**116**	**984**
Mean density (#/m^2)					**7150**	**5750**	**5950**	**3350**	**6400**	**5800**	**5550**	**4600**	**2900**	**24600**
Species Richness (#/0.04m^2)					**20**	**18**	**11**	**15**	**15**	**15**	**16**	**15**	**18**	**25**
Species Diversity					**1.91**	**1.94**	**1.52**	**1.83**	**1.49**	**1.70**	**1.76**	**1.67**	**2.36**	**1.20**
Evenness					**0.64**	**0.67**	**0.63**	**0.68**	**0.55**	**0.63**	**0.64**	**0.62**	**0.82**	**0.37**

Appendix 4.9. Abundance of benthic species collected at the Joiner Shoals Reference Area during post (Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04 m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JR03	JR05	JR06	JR08	JR16	JR17	JR19	JR21	JR23	JR24
Protohaustorius deichmannae	A	1148	42.21	100	176	114	130	232	184	136	70	84	2	20
Acanthohaustorius intermedius	A	352	12.94	80	50	26	94	0	14	40	40	44	0	44
Eudevenopus honduranus	A	252	9.26	100	36	32	38	56	14	26	10	34	2	4
Rhepoxynius hudsoni	A	200	7.35	80	26	36	10	48	16	16	26	22	0	0
Acanthohaustorius millsi	A	102	3.75	70	38	4	0	4	18	18	16	4	0	0
Bathyporeia parkeri	A	70	2.57	80	8	4	6	14	16	2	12	8	0	0
Oxyurostylis smithi	O	60	2.21	80	4	0	8	32	6	2	0	4	2	2
Haustoriidae	A	56	2.06	90	22	0	2	8	4	8	2	6	2	2
Acanthohaustorius shoemakeri	A	54	1.99	60	6	2	0	0	18	22	0	2	0	4
Nematoda	O	40	1.47	60	2	2	0	0	0	8	0	4	20	4
Solen viridis	M	34	1.25	20	2	0	0	32	0	0	0	0	0	0
Tellina sp.	M	28	1.03	30	0	0	0	20	0	2	0	6	0	0
Glycera oxycephala	P	26	0.96	30	0	0	2	0	0	0	0	0	22	2
Pelecypoda	M	26	0.96	30	0	8	0	0	0	0	14	0	0	4
Strigilla mirabilis	M	26	0.96	40	0	0	4	0	2	8	12	0	0	0
Armandia agilis	P	20	0.74	10	0	0	0	20	0	0	0	0	0	0
Branchiostoma sp.	O	20	0.74	20	0	2	0	0	0	0	0	0	18	0
Cumacea	O	20	0.74	30	2	0	0	16	0	0	0	0	0	2
Nemertea	O	20	0.74	70	2	2	2	0	0	4	2	2	6	0
Paraonis fulgens	P	14	0.51	30	4	0	0	0	0	4	0	6	0	0
Tellina agilis	M	14	0.51	50	2	2	0	0	2	0	4	0	4	0
Insecta	O	12	0.44	20	0	10	0	0	0	0	0	2	0	0
Magelona sp.	P	10	0.37	20	0	0	4	0	6	0	0	0	0	0
Spiophanes bombyx	P	10	0.37	30	0	0	2	0	0	4	4	0	0	0
Cyclaspis sp.	O	8	0.29	20	0	0	0	0	0	2	0	6	0	0
Gastropoda	M	8	0.29	20	0	0	0	0	0	0	6	2	0	0
Tanaissus psammophilus	O	8	0.29	40	2	0	0	0	0	2	0	2	2	0
Acanthohaustorius sp.	A	6	0.22	10	0	0	6	0	0	0	0	0	0	0
Donax variabilis	M	6	0.22	20	0	0	0	0	4	0	0	0	0	2
Eurythoe sp.	P	6	0.22	10	0	0	0	0	0	0	0	0	6	0
Olivella mutica	M	6	0.22	30	0	2	2	0	2	0	0	0	0	0
Americhelidium americanum	A	4	0.15	20	0	2	2	0	0	0	0	0	0	0

Appendix 4.9. Abundance of benthic species collected at the Joiner Shoals Reference Area during post (Post) nourishment sampling. Abundance values represent the number of individuals per grab (0.04m^2). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (#/0.04m^2)	Percent Abundance	Percent of Stations Where Present	JR03	JR05	JR06	JR08	JR16	JR17	JR19	JR21	JR23	JR24
Dissodactylus mellitae	O	4	0.15	10	0	0	4	0	0	0	0	0	0	0
Maldanidae	P	4	0.15	10	0	0	4	0	0	0	0	0	0	0
Polinices duplicatus	M	4	0.15	10	0	0	4	0	0	0	0	0	0	0
Veneridae	M	4	0.15	10	0	0	0	0	0	0	0	0	4	0
Chiridotea coeca	O	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Chiridotea sp.	O	2	0.07	10	0	0	2	0	0	0	0	0	0	0
Clypeasteroida	O	2	0.07	10	0	2	0	0	0	0	0	0	0	0
Copepoda	O	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Cyclaspis pustulata	O	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Echinoidea	O	2	0.07	10	0	0	2	0	0	0	0	0	0	0
Emerita talpoida	O	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Hemipodus roseus	P	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Leitoscoloplos fragilis	P	2	0.07	10	2	0	0	0	0	0	0	0	0	0
Leitoscoloplos sp.	P	2	0.07	10	0	2	0	0	0	0	0	0	0	0
Mediomastus californiensis	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Mellita quinquesperforata	O	2	0.07	10	0	0	2	0	0	0	0	0	0	0
Naticidae	M	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Ovalipes sp.	O	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Paguridae	O	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Phoxocephalidae	A	2	0.07	10	0	0	0	0	0	2	0	0	0	0
Pinnixa cristata	O	2	0.07	10	0	0	0	0	0	2	0	0	0	0
Pleuromeris tridentata	M	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Pyura vittata	O	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Mean total abundance (#/0.04m^2)					**384**	**252**	**330**	**490**	**306**	**308**	**218**	**238**	**100**	**94**
Mean density (#/m^2)					**9600**	**6300**	**8250**	**12250**	**7650**	**7700**	**5450**	**5950**	**2500**	**2350**
Species Richness (#/0.04m^2)					**17**	**17**	**21**	**15**	**14**	**19**	**13**	**17**	**17**	**13**
Species Diversity					**1.85**	**1.85**	**1.86**	**1.86**	**1.60**	**2.03**	**2.09**	**2.07**	**2.34**	**1.80**
Evenness					**0.65**	**0.65**	**0.61**	**0.69**	**0.60**	**0.69**	**0.81**	**0.73**	**0.83**	**0.70**

Appendix 4.10. Abundance of benthic species collected at the Joiner Shoals Reference Area during 6 month post (6 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /$0.04m^2$)**	**Percent Abundance**	**Percent of Stations Where Present**	**JR03**	**JR05**	**JR06**	**JR08**	**JR16**	**JR17**	**JR19**	**JR21**	**JR22**	**JR23**
Protohaustorius deichmannae	A	750	34.53	90	82	108	94	38	140	182	86	18	0	2
Acanthohaustorius intermedius	A	242	11.14	60	98	20	78	0	8	22	0	16	0	0
Thyonella gemmata	O	188	8.66	20	0	0	0	0	0	0	0	0	8	180
Eudevenopus honduranus	A	174	8.01	100	10	10	12	66	34	8	14	4	4	12
Branchiostoma sp.	O	164	7.55	80	14	16	24	12	8	4	0	0	46	40
Rhepoxynius hudsoni	A	86	3.96	70	8	24	18	0	28	2	4	2	0	0
Acanthohaustorius millsi	A	54	2.49	50	30	0	2	0	2	8	12	0	0	0
Renilla reniformis	O	52	2.39	50	2	0	6	40	0	2	0	0	0	2
Tellina agilis	M	42	1.93	70	6	6	8	12	0	4	4	2	0	0
Bathyporeia parkeri	A	36	1.66	50	8	14	0	0	2	0	6	6	0	0
Nematoda	O	34	1.57	20	0	0	0	2	0	0	0	0	32	0
Paraonis fulgens	P	28	1.29	70	6	0	6	2	2	4	0	0	6	2
Pelecypoda	M	28	1.29	50	10	8	0	2	2	0	6	0	0	0
Strigilla mirabilis	M	28	1.29	50	0	2	6	0	4	0	0	14	0	2
Clypeasteroida	O	24	1.10	40	8	8	0	0	0	4	4	0	0	0
Haustoriidae	A	24	1.10	60	2	2	6	0	2	8	4	0	0	0
Phoxocephalidae	A	18	0.83	30	0	4	10	0	4	0	0	0	0	0
Magelonidae	P	16	0.74	50	4	0	0	4	4	2	2	0	0	0
Metharpinia floridana	A	16	0.74	20	0	0	0	12	0	0	0	4	0	0
Olivella mutica	M	16	0.74	50	4	6	2	0	0	0	2	2	0	0
Americhelidium americanum	A	10	0.46	20	0	0	0	4	0	0	0	0	0	6
Nephtys picta	P	10	0.46	30	0	0	0	0	0	6	2	2	0	0
Platyhelminthes	O	10	0.46	30	0	0	0	0	4	2	4	0	0	0
Copepoda	O	8	0.37	10	0	0	0	0	0	0	0	0	8	0
Ogyrides hayi	O	8	0.37	40	0	0	2	0	2	2	0	0	2	0
Donax variabilis	M	6	0.28	30	0	0	0	0	2	0	0	2	2	0
Hemipodus roseus	P	6	0.28	10	0	0	0	0	0	0	0	6	0	0
Micronephthys minuta	P	6	0.28	20	2	4	0	0	0	0	0	0	0	0
Opheliidae	P	6	0.28	10	0	0	0	0	0	0	0	0	6	0
Terebra dislocata	M	6	0.28	30	2	0	0	2	2	0	0	0	0	0
Americamysis bahia	O	4	0.18	10	0	0	0	0	0	0	0	0	0	4
Glycera americana	P	4	0.18	20	0	0	0	0	0	2	2	0	0	0

Appendix 4.10. Abundance of benthic species collected at the Joiner Shoals Reference Area during 6 month post (6 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JR03	JR05	JR06	JR08	JR16	JR17	JR19	JR21	JR22	JR23
Leptochela serratorbita	O	4	0.18	20	0	0	0	0	2	0	0	0	0	2
Mediomastus californiensis	P	4	0.18	10	0	0	0	4	0	0	0	0	0	0
Mysida	O	4	0.18	20	0	0	0	0	0	0	2	0	2	0
Nemertea	O	4	0.18	20	2	0	0	2	0	0	0	0	0	0
Ptilanthura tenuis	O	4	0.18	20	0	0	2	0	2	0	0	0	0	0
Syllidae	P	4	0.18	10	0	0	0	0	0	0	0	0	4	0
Veneridae	M	4	0.18	10	0	0	0	4	0	0	0	0	0	0
Americamysis almyra	O	2	0.09	10	0	0	0	2	0	0	0	0	0	0
Ancinus depressus	O	2	0.09	10	0	0	0	0	0	0	0	0	2	0
Batea catharinensis	A	2	0.09	10	0	0	0	0	0	0	0	0	0	2
Cirratulidae	P	2	0.09	10	0	0	0	0	0	0	0	0	0	2
Collembola	O	2	0.09	10	0	0	0	0	0	0	2	0	0	0
Crassinella lunulata	M	2	0.09	10	0	0	0	0	0	0	0	0	2	0
Eteone lactea	P	2	0.09	10	0	0	0	2	0	0	0	0	0	0
Glycymeris pectinata	M	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Insecta	O	2	0.09	10	0	0	0	0	0	0	0	0	2	0
Leitoscoloplos fragilis	P	2	0.09	10	0	0	0	2	0	0	0	0	0	0
Leitoscoloplos robustus	P	2	0.09	10	0	0	0	0	2	0	0	0	0	0
Leitoscoloplos sp.	P	2	0.09	10	0	2	0	0	0	0	0	0	0	0
Parahaustorius longimerus	A	2	0.09	10	0	0	0	0	0	0	0	2	0	0
Sipuncula	O	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Solen viridis	M	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Solenidae	M	2	0.09	10	0	0	0	2	0	0	0	0	0	0
Spiophanes bombyx	P	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Tagelus plebeius	M	2	0.09	10	0	0	0	0	0	2	0	0	0	0
Tanaissus psammophilus	O	2	0.09	10	2	0	0	0	0	0	0	0	0	0
Tellinidae	M	2	0.09	10	0	0	0	2	0	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**300**	**234**	**284**	**216**	**256**	**264**	**156**	**80**	**126**	**256**
Mean density (#/m^2)					**7500**	**5850**	**7100**	**5400**	**6400**	**6600**	**3900**	**2000**	**3150**	**6400**
Species Richness (#/$0.04m^2$)					**19**	**15**	**19**	**20**	**20**	**17**	**16**	**13**	**14**	**12**
Species Diversity					**2.08**	**1.93**	**1.99**	**2.15**	**1.73**	**1.38**	**1.80**	**2.11**	**1.97**	**1.10**
Evenness					**0.71**	**0.71**	**0.68**	**0.72**	**0.58**	**0.49**	**0.65**	**0.82**	**0.75**	**0.44**

Appendix 4.11. Abundance of benthic species collected at the Joiner Shoals Reference Area during 12 month post (12 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab (0.04m^2). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /0.04m^2)	Percent Abundance	Percent of Stations Where Present	JR03	JR05	JR06	JR08	JR16	JR17	JR19	JR21	JR22	JR23
Protohaustorius deichmannae	A	1370	45.48	90	180	140	132	106	274	230	300	6	0	2
Acanthohaustorius intermedius	A	454	15.07	90	56	48	144	40	74	24	40	18	10	0
Acanthohaustorius millsi	A	336	11.16	40	12	0	0	0	40	80	204	0	0	0
Nematoda	O	236	7.84	60	2	0	6	2	0	6	2	0	0	218
Bathyporeia parkeri	A	112	3.72	80	6	22	18	24	10	10	16	0	6	0
Eudevenopus honduranus	A	102	3.39	80	12	8	10	34	12	22	2	0	2	0
Oxyurostylis smithi	O	72	2.39	70	8	16	8	16	10	6	8	0	0	0
Rhepoxynius hudsoni	A	72	2.39	70	6	16	16	14	4	8	8	0	0	0
Campylaspis affinis	O	38	1.26	70	6	4	2	0	0	0	2	6	10	8
Glycera americana	P	28	0.93	40	0	0	4	0	2	0	0	2	0	20
Rhepoxynius epistomus	A	24	0.80	50	6	0	4	0	4	4	6	0	0	0
Donax variabilis	M	16	0.53	50	0	0	4	0	4	2	4	2	0	0
Tiron tropakis	A	14	0.46	50	6	2	0	2	2	0	0	2	0	0
Magelona sp.	P	12	0.40	50	2	2	2	2	4	0	0	0	0	0
Mellita quinquesperforata	O	12	0.40	50	2	0	4	0	2	0	2	2	0	0
Olivella mutica	M	12	0.40	30	0	2	0	6	4	0	0	0	0	0
Tellina alternata	M	12	0.40	30	0	2	0	8	0	0	0	0	0	2
Branchiostoma sp.	O	10	0.33	40	2	0	0	0	0	0	2	2	0	4
Cyclaspis pustulata	O	8	0.27	30	2	4	0	2	0	0	0	0	0	0
Terebra dislocata	M	8	0.27	20	0	0	0	6	2	0	0	0	0	0
Leptonacea sp.	M	6	0.20	20	0	4	0	0	0	2	0	0	0	0
Nephtys picta	P	6	0.20	30	0	2	0	2	0	2	0	0	0	0
Spiophanes bombyx	P	6	0.20	20	4	0	0	0	2	0	0	0	0	0
Chiridotea coeca	O	4	0.13	20	0	2	0	0	0	0	0	0	0	2
Prionospio sp.	P	4	0.13	10	0	0	0	4	0	0	0	0	0	0
Tanaissus psammophilus	O	4	0.13	10	0	0	4	0	0	0	0	0	0	0
Aglaophamus verrilli	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Ancistrosyllis sp.	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Crassinella lunulata	M	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Crassinella martinicensis	M	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Edotia triloba	O	2	0.07	10	2	0	0	0	0	0	0	0	0	0
Emerita talpoida	O	2	0.07	10	0	0	0	0	0	0	0	0	2	0

Appendix 4.11. Abundance of benthic species collected at the Joiner Shoals Reference Area during 12 month post (12 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	JR03	JR05	JR06	JR08	JR16	JR17	JR19	JR21	JR22	JR23
Nassarius albus	M	2	0.07	10	0	0	0	2	0	0	0	0	0	0
Naticidae	M	2	0.07	10	0	0	0	0	0	0	2	0	0	0
Nemertea	O	2	0.07	10	0	0	0	0	0	2	0	0	0	0
Nereis sp.	P	2	0.07	10	0	0	0	0	0	0	0	0	0	2
Pagurus longicarpus	O	2	0.07	10	0	0	0	0	0	0	0	2	0	0
Paraonis fulgens	P	2	0.07	10	0	0	0	0	2	0	0	0	0	0
Paraprionospio pinnata	P	2	0.07	10	0	0	2	0	0	0	0	0	0	0
Renilla reniformis	O	2	0.07	10	0	0	2	0	0	0	0	0	0	0
Stomatopoda	O	2	0.07	10	0	0	0	0	0	0	0	0	2	0
Tellina agilis	M	2	0.07	10	0	2	0	0	0	0	0	0	0	0
Travisia parva	P	2	0.07	10	0	0	0	0	2	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**314**	**276**	**362**	**270**	**454**	**398**	**598**	**42**	**32**	**266**
Mean density (#/m^2)					**7850**	**6900**	**9050**	**6750**	**11350**	**9950**	**14950**	**1050**	**800**	**6650**
Species Richness (#/$0.04m^2$)					**17**	**16**	**16**	**16**	**18**	**13**	**14**	**9**	**6**	**12**
Species Diversity					**1.60**	**1.72**	**1.64**	**2.00**	**1.45**	**1.42**	**1.30**	**1.79**	**1.56**	**0.82**
Evenness					**0.56**	**0.62**	**0.59**	**0.72**	**0.50**	**0.55**	**0.49**	**0.81**	**0.87**	**0.33**

Appendix 4.12. Abundance of benthic species collected at the Barrett Shoals Reference Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /0.04m2)	Percent Abundance	Percent of Stations Where Present	BR01	BR02	BR03	BR04	BR05	BR06	BR07	BR08	BR09	BR10
Protohaustorius deichmannae	A	722	38.32	100	28	48	66	56	50	80	178	104	60	52
Acanthohaustorius millsi	A	456	24.20	100	18	76	38	8	162	28	8	104	8	6
Acanthohaustorius intermedius	A	184	9.77	100	2	44	6	26	8	38	6	34	2	18
Eudevenopus honduranus	A	98	5.20	100	16	8	20	8	2	4	2	16	10	12
Haustoriidae	A	86	4.56	80	2	20	18	6	0	6	20	12	2	0
Acanthohaustorius shoemakeri	A	56	2.97	80	0	4	4	0	20	6	10	6	4	2
Rhepoxynius hudsoni	A	38	2.02	60	0	2	4	0	0	16	10	4	2	0
Ogyrides hayi	O	34	1.80	80	0	2	4	2	2	0	4	2	6	12
Olivella mutica	M	20	1.06	60	4	2	0	0	2	0	8	2	2	0
Onuphis eremita	P	16	0.85	20	0	0	0	0	0	0	2	0	14	0
Bathyporeia sp.	A	14	0.74	30	0	6	0	0	0	2	0	6	0	0
Nematoda	O	14	0.74	50	0	4	2	0	0	4	0	0	2	2
Capitellidae	P	10	0.53	30	0	0	0	4	0	0	4	0	2	0
Phoxocephalidae	A	10	0.53	30	0	0	4	2	0	0	0	4	0	0
Pinnotheres sp.	O	10	0.53	40	0	0	0	2	0	2	2	0	4	0
Tellina agilis	M	10	0.53	30	0	4	0	2	0	0	0	0	0	4
Branchiostoma sp.	O	8	0.42	40	0	0	2	0	2	2	0	0	0	2
Nassarius acutus	M	8	0.42	40	2	0	0	0	0	2	2	2	0	0
Parahaustorius longimerus	A	8	0.42	30	2	0	4	2	0	0	0	0	0	0
Decapoda	O	6	0.32	30	0	2	0	0	0	2	0	0	0	2
Donax variabilis	M	6	0.32	30	0	0	0	0	0	2	0	2	2	0
Lepidactylus dytiscus	A	6	0.32	10	0	6	0	0	0	0	0	0	0	0
Pelecypoda	M	6	0.32	20	2	0	0	0	4	0	0	0	0	0
Cirratulidae	P	4	0.21	10	0	0	0	0	0	4	0	0	0	0
Cyclaspis pustulata	O	4	0.21	20	0	2	2	0	0	0	0	0	0	0
Magelona sp.	P	4	0.21	20	0	0	0	2	0	0	0	0	0	2
Mysida	O	4	0.21	20	0	0	0	0	2	0	0	2	0	0
Nephtys picta	P	4	0.21	20	0	0	0	2	0	0	0	0	2	0
Oxyurostylis smithi	O	4	0.21	20	2	0	0	0	0	0	0	2	0	0
Tanaissus psammophilus	O	4	0.21	20	0	0	0	0	2	0	0	0	0	2
Acanthohaustorius bousfieldi	A	2	0.11	10	2	0	0	0	0	0	0	0	0	0
Acanthohaustorius sp.	A	2	0.11	10	0	0	0	0	0	0	0	0	2	0
Bathyporeia parkeri	A	2	0.11	10	0	0	0	0	0	0	0	0	2	0

Appendix 4.12. Abundance of benthic species collected at the Barrett Shoals Reference Area during Pre nourishment sampling. Abundance values represent the number of individuals per grab (0.04m^2). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /0.04m2)**	**Percent Abundance**	**Percent of Stations Where Present**	**BR01**	**BR02**	**BR03**	**BR04**	**BR05**	**BR06**	**BR07**	**BR08**	**BR09**	**BR10**
Crassinella lunulata	M	2	0.11	10	0	2	0	0	0	0	0	0	0	0
Emerita talpoida	O	2	0.11	10	0	0	0	0	0	2	0	0	0	0
Eobrolgus spinosus	A	2	0.11	10	0	0	0	0	0	0	2	0	0	0
Haustorius sp.	A	2	0.11	10	0	0	0	0	0	0	2	0	0	0
Magelonidae	P	2	0.11	10	0	2	0	0	0	0	0	0	0	0
Mellita quinquesperforata	O	2	0.11	10	0	0	0	0	0	0	0	0	0	2
Mysidae	O	2	0.11	10	2	0	0	0	0	0	0	0	0	0
Nemertea	O	2	0.11	10	0	0	0	0	0	0	0	0	2	0
Oedicerotidae	A	2	0.11	10	0	0	0	0	0	0	2	0	0	0
Pinnixa cristata	O	2	0.11	10	0	0	0	0	0	0	0	2	0	0
Pinnotheridae	O	2	0.11	10	0	0	0	0	0	0	0	0	0	2
Terebra dislocata	M	2	0.11	10	0	0	0	0	0	0	0	0	2	0
Mean total abundance (#/0.04m^2)					**82**	**234**	**174**	**122**	**256**	**200**	**262**	**304**	**130**	**120**
Mean density (#/m^2)					**2050**	**5850**	**4350**	**3050**	**6400**	**5000**	**6550**	**7600**	**3250**	**3000**
Species Richness (#/0.04m^2)					**12**	**17**	**13**	**13**	**11**	**16**	**16**	**16**	**19**	**14**
Species Diversity					**1.80**	**2.01**	**1.89**	**1.78**	**1.21**	**1.93**	**1.40**	**1.76**	**2.03**	**1.92**
Evenness					**0.72**	**0.71**	**0.74**	**0.69**	**0.50**	**0.69**	**0.50**	**0.64**	**0.69**	**0.73**

Appendix 4.13. Abundance of benthic species collected at the Barrett Shoals Reference Area during post (Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BR01	BR02	BR03	BR04	BR05	BR06	BR07	BR08	BR09	BR10
Protohaustorius deichmannae	A	1118	30.75	90	184	94	116	92	16	42	336	106	132	0
Acanthohaustorius millsi	A	1084	29.81	100	96	46	222	54	16	272	202	60	100	16
Acanthohaustorius intermedius	A	380	10.45	100	16	92	34	76	52	2	24	42	22	20
Bathyporeia parkeri	A	174	4.79	90	44	16	26	16	14	16	18	6	18	0
Haustoriidae	A	158	4.35	100	12	6	10	20	6	30	40	20	12	2
Paraonis fulgens	P	126	3.47	90	16	4	10	28	12	0	12	2	16	26
Acanthohaustorius shoemakeri	A	120	3.30	70	38	10	18	2	6	0	0	12	34	0
Nematoda	O	86	2.37	80	6	2	12	0	4	0	18	4	10	30
Eudevenopus honduranus	A	68	1.87	80	6	12	12	4	0	2	2	14	16	0
Rhepoxynius hudsoni	A	54	1.49	70	14	2	12	8	0	0	2	6	10	0
Oxyurostylis smithi	O	42	1.16	90	4	4	4	4	4	8	8	0	4	2
Nemertea	O	38	1.05	60	0	4	0	2	8	10	6	0	8	0
Tanaissus psammophilus	O	24	0.66	60	2	6	6	0	6	0	2	2	0	0
Dispio uncinata	P	18	0.50	60	0	0	2	2	0	2	2	6	4	0
Copepoda	O	12	0.33	20	0	0	0	0	0	0	2	0	0	10
Spiophanes bombyx	P	12	0.33	50	2	2	4	0	0	0	0	0	2	2
Olivella mutica	M	10	0.28	40	0	2	0	0	0	2	4	2	0	0
Tellina agilis	M	10	0.28	40	4	0	2	0	0	0	0	0	2	2
Maldanidae	P	8	0.22	30	2	0	4	0	0	0	0	0	2	0
Americhelidium americanum	A	6	0.17	30	2	0	0	0	0	0	2	2	0	0
Cumacea	O	6	0.17	30	2	0	2	0	0	0	0	0	0	2
Donax variabilis	M	6	0.17	20	0	0	0	0	2	4	0	0	0	0
Insecta	O	6	0.17	20	0	0	4	0	2	0	0	0	0	0
Magelona sp.	P	6	0.17	30	0	0	0	0	2	0	2	2	0	0
Leucon americanus	O	4	0.11	10	0	0	0	0	0	0	0	0	0	4
Micronephthys minuta	P	4	0.11	10	0	0	0	0	0	0	0	4	0	0
Ogyrides hayi	O	4	0.11	20	0	0	0	0	0	0	2	0	2	0
Parahaustorius longimerus	A	4	0.11	10	0	0	0	0	0	0	0	0	0	4
Protohaustorius wigleyi	A	4	0.11	10	0	0	0	0	0	4	0	0	0	0
Acanthohaustorius sp.	A	2	0.06	10	0	0	2	0	0	0	0	0	0	0
Armandia agilis	P	2	0.06	10	0	0	0	0	0	0	0	2	0	0
Campylaspis sp.	O	2	0.06	10	0	0	0	0	0	0	0	2	0	0

Appendix 4.13. Abundance of benthic species collected at the Barrett Shoals Reference Area during post (Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	**Category**	**Total Abundance (# /$0.04m^2$)**	**Percent Abundance**	**Percent of Stations Where Present**	**BR01**	**BR02**	**BR03**	**BR04**	**BR05**	**BR06**	**BR07**	**BR08**	**BR09**	**BR10**
Caulleriella sp.	P	2	0.06	10	0	0	2	0	0	0	0	0	0	0
Clypeasteroida	O	2	0.06	10	0	0	2	0	0	0	0	0	0	0
Cyclaspis pustulata	O	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Gammaridae	A	2	0.06	10	0	0	0	0	2	0	0	0	0	0
Gammaridea	A	2	0.06	10	0	2	0	0	0	0	0	0	0	0
Gastropoda	M	2	0.06	10	0	0	0	0	0	0	2	0	0	0
Glycera oxycephala	P	2	0.06	10	0	0	0	0	0	0	2	0	0	0
Leitoscoloplos fragilis	P	2	0.06	10	0	0	0	0	2	0	0	0	0	0
Leitoscoloplos robustus	P	2	0.06	10	0	2	0	0	0	0	0	0	0	0
Leitoscoloplos sp.	P	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Lepidactylus dytiscus	A	2	0.06	10	2	0	0	0	0	0	0	0	0	0
Mediomastus californiensis	P	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Nephtyidae	P	2	0.06	10	0	0	2	0	0	0	0	0	0	0
Nephtys picta	P	2	0.06	10	0	0	0	0	0	2	0	0	0	0
Ophelina acuminata	P	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Pagurus sp.	O	2	0.06	10	0	0	2	0	0	0	0	0	0	0
Pelecypoda	M	2	0.06	10	0	0	0	2	0	0	0	0	0	0
Rhepoxynius epistomus	A	2	0.06	10	0	0	0	0	0	0	0	2	0	0
Rhepoxynius sp.	A	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Mean total abundance (#/$0.04m^2$)					**452**	**306**	**510**	**310**	**154**	**396**	**688**	**296**	**400**	**124**
Mean density (#/m^2)					**11300**	**7650**	**12750**	**7750**	**3850**	**9900**	**17200**	**7400**	**10000**	**3100**
Species Richness (#/$0.04m^2$)					**18**	**17**	**23**	**13**	**16**	**13**	**20**	**19**	**20**	**14**
Species Diversity					**1.89**	**1.86**	**1.95**	**1.89**	**2.15**	**1.22**	**1.51**	**2.01**	**2.07**	**1.99**
Evenness					**0.65**	**0.66**	**0.62**	**0.74**	**0.77**	**0.48**	**0.50**	**0.68**	**0.69**	**0.75**

Appendix 4.14. Abundance of benthic species collected at the Barrettt Shoals Reference Area during 6 month post (6 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BR01	BR02	BR03	BR04	BR05	BR06	BR07	BR08	BR09	BR10
Protohaustorius deichmannae	A	838	37.54	100	10	176	60	64	72	4	96	82	188	86
Acanthohaustorius millsi	A	380	17.03	90	10	156	26	12	48	0	16	28	74	10
Eudevenopus honduranus	A	126	5.65	80	6	14	6	0	2	0	20	20	18	40
Rhepoxynius hudsoni	A	94	4.21	80	4	16	6	0	0	2	14	4	42	6
Paraonis fulgens	P	82	3.67	70	4	0	4	0	10	14	2	26	0	22
Donax variabilis	M	80	3.58	70	18	0	16	14	2	20	0	6	4	0
Haustoriidae	A	78	3.49	70	4	24	14	0	8	0	2	6	20	0
Bathyporeia parkeri	A	68	3.05	90	4	18	2	2	12	6	0	4	8	12
Parahaustorius longimerus	A	64	2.87	70	0	2	2	6	0	2	4	26	22	0
Acanthohaustorius intermedius	A	38	1.70	80	2	10	0	2	2	0	4	6	8	4
Mysida	O	36	1.61	70	0	8	2	8	2	0	6	4	6	0
Renilla reniformis	O	36	1.61	30	0	0	0	0	0	0	18	0	2	16
Branchiostoma sp.	O	34	1.52	60	8	10	2	6	0	0	4	0	0	4
Phoxocephalidae	A	20	0.90	30	0	6	0	0	0	0	6	0	8	0
Magelona sp.	P	18	0.81	50	4	0	2	0	0	0	6	0	2	4
Tellina agilis	M	18	0.81	40	0	6	0	0	0	2	0	0	8	2
Nemertea	O	12	0.54	60	2	2	0	2	0	2	0	0	2	2
Olivella mutica	M	12	0.54	50	2	2	0	0	0	0	0	2	4	2
Nematoda	O	10	0.45	30	6	0	0	0	0	2	2	0	0	0
Pinnotheres maculatus	O	10	0.45	20	0	0	8	2	0	0	0	0	0	0
Rhepoxynius epistomus	A	10	0.45	20	0	0	0	0	0	0	0	0	6	4
Tellinidae	M	10	0.45	30	0	0	0	0	0	0	6	2	0	2
Cyclaspis pustulata	O	8	0.36	20	0	0	4	0	0	0	0	0	4	0
Dispio uncinata	P	8	0.36	20	0	6	0	2	0	0	0	0	0	0
Nassarius vibex	M	8	0.36	20	0	0	0	0	0	0	4	4	0	0
Nephtys picta	P	8	0.36	40	0	2	0	0	2	2	0	0	2	0
Ogyrides hayi	O	8	0.36	20	2	6	0	0	0	0	0	0	0	0
Platyhelminthes	O	8	0.36	20	0	6	0	0	0	0	0	0	0	2
Strigilla mirabilis	M	8	0.36	20	0	0	0	0	0	0	0	4	0	4
Tellina sp.	M	8	0.36	30	0	0	2	2	0	0	4	0	0	0
Copepoda	O	6	0.27	20	4	0	0	0	0	0	0	0	0	2
Decapoda	O	6	0.27	20	0	0	2	0	0	0	0	0	4	0

Appendix 4.14. Abundance of benthic species collected at the Barrettt Shoals Reference Area during 6 month post (6 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BR01	BR02	BR03	BR04	BR05	BR06	BR07	BR08	BR09	BR10
Saccoglossus kowalevskii	O	6	0.27	20	0	0	0	0	0	0	0	4	2	0
Tanaissus psammophilus	O	6	0.27	30	0	2	2	0	0	0	0	2	0	0
Arachnida	O	4	0.18	10	0	0	0	0	4	0	0	0	0	0
Emerita talpoida	O	4	0.18	10	4	0	0	0	0	0	0	0	0	0
Leitoscoloplos sp.	P	4	0.18	20	0	0	0	2	0	0	0	2	0	0
Lucinidae	M	4	0.18	20	0	0	0	2	0	0	0	0	2	0
Mellita quinquesperforata	O	4	0.18	20	0	2	2	0	0	0	0	0	0	0
Metharpinia floridana	A	4	0.18	10	4	0	0	0	0	0	0	0	0	0
Micronephthys minuta	P	4	0.18	20	0	0	2	0	0	0	2	0	0	0
Pelecypoda	M	4	0.18	20	0	2	0	0	2	0	0	0	0	0
Phyllodoce arenae	P	4	0.18	10	0	0	0	0	0	0	0	4	0	0
Spiophanes wigleyi	P	4	0.18	20	0	0	0	0	2	0	0	2	0	0
Ancinus depressus	O	2	0.09	10	2	0	0	0	0	0	0	0	0	0
Batea catharinensis	A	2	0.09	10	0	0	0	0	0	0	0	0	0	2
Capitellidae	P	2	0.09	10	0	0	0	0	2	0	0	0	0	0
Clypeasteroida	O	2	0.09	10	0	2	0	0	0	0	0	0	0	0
Crangonidae	O	2	0.09	10	0	0	0	0	0	0	0	0	2	0
Cumacea	O	2	0.09	10	0	0	0	0	0	0	2	0	0	0
Cyathura polita	O	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Emerita benedicti	O	2	0.09	10	0	0	0	0	0	0	0	0	0	2
Glycinde nordmanni	P	2	0.09	10	2	0	0	0	0	0	0	0	0	0
Goniadidae	P	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Ogyrides alphaerostris	O	2	0.09	10	0	0	2	0	0	0	0	0	0	0
Ophiuroidea	O	2	0.09	10	0	0	0	0	0	0	0	2	0	0
Oxyurostylis smithi	O	2	0.09	10	0	0	0	0	2	0	0	0	0	0
Spiophanes bombyx	P	2	0.09	10	0	0	0	2	0	0	0	0	0	0
Travisia hobsonae	P	2	0.09	10	0	0	0	0	2	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**102**	**478**	**170**	**128**	**174**	**56**	**218**	**240**	**438**	**228**
Mean density (#/m^2)					**2550**	**11950**	**4250**	**3200**	**4350**	**1400**	**5450**	**6000**	**10950**	**5700**
Species Richness (#/$0.04m^2$)					**20**	**22**	**22**	**15**	**16**	**10**	**19**	**21**	**23**	**20**
Species Diversity					**2.36**	**1.87**	**2.16**	**1.79**	**1.61**	**1.86**	**2.09**	**2.11**	**2.02**	**2.16**
Evenness					**0.79**	**0.60**	**0.70**	**0.66**	**0.58**	**0.81**	**0.71**	**0.69**	**0.64**	**0.72**

Appendix 4.15. Abundance of benthic species collected at the Barrett Shoals Reference Area during 12 month post (12 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04 m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BR01	BR02	BR03	BR04	BR05	BR06	BR07	BR08	BR09	BR10
Protohaustorius deichmannae	A	1204	37.65	90	6	88	164	42	0	6	478	150	142	128
Acanthohaustorius millsi	A	800	25.02	80	0	0	196	20	2	4	124	180	132	142
Nematoda	O	180	5.63	60	14	0	2	152	0	0	0	2	8	2
Bathyporeia parkeri	A	172	5.38	80	0	12	46	44	0	2	30	12	12	14
Acanthohaustorius shoemakeri	A	126	3.94	10	0	126	0	0	0	0	0	0	0	0
Acanthohaustorius intermedius	A	124	3.88	80	4	46	0	16	0	2	10	4	8	34
Donax variabilis	M	118	3.69	90	26	0	52	6	4	14	2	8	4	2
Eudevenopus honduranus	A	72	2.25	60	0	18	2	2	0	0	14	0	12	24
Oxyurostylis smithi	O	58	1.81	90	0	24	4	8	2	2	2	6	8	2
Rhepoxynius epistomus	A	58	1.81	70	0	20	2	0	0	2	8	6	8	12
Parahaustorius longimerus	A	50	1.56	40	18	0	12	4	0	16	0	0	0	0
Nemertea	O	20	0.63	50	0	0	0	0	4	0	4	4	6	2
Paraonis fulgens	P	16	0.50	50	2	0	6	2	4	2	0	0	0	0
Tiron tropakis	A	16	0.50	60	0	2	4	0	0	0	2	4	2	2
Tellina agilis	M	14	0.44	40	0	2	0	2	0	0	8	0	0	2
Batea catharinensis	A	12	0.38	10	0	0	0	0	0	0	12	0	0	0
Campylaspis affinis	O	12	0.38	40	2	0	4	2	0	0	0	4	0	0
Copepoda	O	12	0.38	20	10	0	0	2	0	0	0	0	0	0
Magelona sp.	P	12	0.38	30	0	4	0	2	0	0	0	0	0	6
Lepidactylus dytiscus	A	10	0.31	30	4	0	2	4	0	0	0	0	0	0
Tanaissus psammophilus	O	10	0.31	50	0	2	2	2	2	2	0	0	0	0
Chiridotea sp.	O	6	0.19	10	0	0	0	0	0	0	0	0	6	0
Cumacea	O	6	0.19	20	0	0	0	0	0	0	0	0	2	4
Cyclaspis pustulata	O	6	0.19	20	0	0	0	2	0	0	0	4	0	0
Glycera americana	P	6	0.19	20	0	2	0	0	0	0	0	0	0	4
Olivella mutica	M	6	0.19	30	0	0	0	2	2	0	0	2	0	0
Bowmaniella floridana	O	4	0.13	20	0	2	0	0	0	0	0	0	2	0
Chiridotea coeca	O	4	0.13	20	0	2	0	2	0	0	0	0	0	0
Mellita quinquesperforata	O	4	0.13	20	0	2	0	2	0	0	0	0	0	0
Orbiniidae	P	4	0.13	10	0	0	0	4	0	0	0	0	0	0
Renilla reniformis	O	4	0.13	20	0	0	0	0	0	2	2	0	0	0
Travisia parva	P	4	0.13	20	0	0	0	2	2	0	0	0	0	0

Appendix 4.15. Abundance of benthic species collected at the Barrett Shoals Reference Area during 12 month post (12 mo Post) nourishment sampling. Abundance values represent the number of individuals per grab ($0.04m^2$). Density represents the number of individuals/m^2. Higher taxa codes are P = polychaete, A = amphipod, M = mollusc, and O = other taxa.

SpeciesName	Category	Total Abundance (# /$0.04m^2$)	Percent Abundance	Percent of Stations Where Present	BR01	BR02	BR03	BR04	BR05	BR06	BR07	BR08	BR09	BR10
Tubificidae	O	4	0.13	20	0	0	0	2	2	0	0	0	0	0
Actiniaria	O	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Apanthura magnifica	O	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Corbula contracta	M	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Emerita talpoida	O	2	0.06	10	0	0	0	0	2	0	0	0	0	0
Leitoscoloplos fragilis	P	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Leitoscoloplos sp.	P	2	0.06	10	0	0	0	0	2	0	0	0	0	0
Leucon americanus	O	2	0.06	10	2	0	0	0	0	0	0	0	0	0
Mediomastus californiensis	P	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Naticidae	M	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Ogyrides hayi	O	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Olivella sp.	M	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Onuphis eremita	P	2	0.06	10	0	0	0	0	0	0	2	0	0	0
Ovalipes ocellatus	O	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Pagurus sp.	O	2	0.06	10	0	0	0	0	0	0	0	0	0	2
Paraonidae	P	2	0.06	10	0	2	0	0	0	0	0	0	0	0
Pelecypoda	M	2	0.06	10	0	0	0	0	0	0	2	0	0	0
Phoxocephalidae	A	2	0.06	10	2	0	0	0	0	0	0	0	0	0
Portunus gibbesii	O	2	0.06	10	0	0	0	0	0	0	2	0	0	0
Scolelepis squamata	P	2	0.06	10	0	0	0	0	2	0	0	0	0	0
Scolelepis texana	P	2	0.06	10	0	0	0	2	0	0	0	0	0	0
Tellina iris	M	2	0.06	10	0	0	0	0	0	0	0	0	2	0
Tellina sp.	M	2	0.06	10	2	0	0	0	0	0	0	0	0	0
Mean total abundance (#/$0.04m^2$)					**92**	**354**	**498**	**328**	**30**	**54**	**702**	**386**	**362**	**392**
Mean density (#/m^2)					**2300**	**8850**	**12450**	**8200**	**750**	**1350**	**17550**	**9650**	**9050**	**9800**
Species Richness (#/$0.04m^2$)					**12**	**16**	**14**	**24**	**12**	**11**	**16**	**13**	**19**	**21**
Species Diversity					**1.90**	**1.85**	**1.56**	**1.94**	**1.89**	**2.00**	**1.11**	**1.33**	**1.63**	**1.69**
Evenness					**0.77**	**0.67**	**0.59**	**0.61**	**0.76**	**0.83**	**0.40**	**0.52**	**0.55**	**0.55**