Results of the Benthic Macroinvertebrate Community and Sediment Analyses Performed for the FDEP Southwest District Illegal Dredging Enforcement Case at Jewfish Key

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Major Findings: Unpermitted dredging at Jewfish Key was associated with significant changes in sediment composition, declines in taxa richness and density of benthic macroinvertebrates approximately two months after the disturbance. These alterations represent adverse impacts to the marine macroinvertebrate environment at the dredging site.

Background: In or around May 2004, a channel was illegally dredged through the mangrove fringe and mudflat adjacent to Jewfish Key in Sarasota Bay, just inside Longboat Key (Figure 1). There was no Florida Department of Environmental Protection (FDEP) permit issued for this dredging activity. The area dredged was approximately 24,600 square feet and the area covered by the dredge spoils was approximately 41,000 square feet. Benthic macroinvertebrate and sediment samples were collected by FDEP Southwest District personnel between 11:00 am and 3:00 pm on July 21, using a Petite Ponar. Low tide was at 11:19 am and high tide was at 5:30pm. The FDEP Biology Section in Tallahassee analyzed benthic macroinvertebrate and sediment samples to assess possible effects from the dredging activity. Benthic macroinvertebrates are major components of soft sediment communities and are fed upon by a wide range of fishes, crabs, and other marine life.



Figure 1. Site of illegal dredging at Jewfish Key

Goals: Data were analyzed to assess whether or not the dredging activity adversely affected the benthic macroinvertebrate community within the vicinity of the dredged area. The results of these analyses could then potentially be applied to rules which protect diversity, marine productivity, conservation of fish and wildlife including threatened or endangered species or their habitat, fishing and recreational values, or the value of functions provided to fish and wildlife and listed species by wetlands and other surface waters (see Subsection 373.414(1), F.S. and sections 40D-4.301 and 40D-4.302, 62-302.530(11) F.A.C.).

Methods: On July 21, 2004 (2-3 months after dredging), three sites were established along each of four transects, and three Petite Ponar samples were taken at each site (n = 36 samples total) (Figure 2). Each transect bisected the dredged channel (Dredged Sites), the spoil deposited from the dredging (Spoil Sites), and the adjacent undisturbed sediments (Background Sites) (Figure 2). Samples were preserved and sent to the Biology Section for analysis. Macroinvertebrates were extracted from the samples and identified to the lowest practical taxonomic level. A single Petite Ponar sample was collected for sediment analysis at each site, and analyzed for percent organic content and sediment grain size (n=12 samples total). Physical and chemical parameters were also collected at each site (Table 1). All sample collection, analysis, and taxonomic identification methods followed FDEP standard operating procedures (SOPs, **http://www.floridadep.org/labs/qa/2002sops.htm).**



Figure 2. Location of sampling sites at Jewfish Key.

The number of macroinvertebrate taxa and individuals were tallied from the Petite Ponar samples and analyzed for differences in the distribution and abundance of benthic macroinvertebrates associated with dredging. Shannon-Weaver diversity (H') was calculated on sets of three ponars from each site using collapsed taxa lists (See FDEP SOP LT 7100 sect. 4.2.1 for method on collapsing taxa) and log (2) as the base for calculation (n=4 values from Background, Dredged and Spoil Sites). Shannon-Weaver diversity (H') data were analyzed for differences among sites, and in accordance with Florida Administrative Code 62-302.530 (11), to test if H' was reduced by 25% or more at Dredged or Spoil Sites as compared with Background Sites. Sediment samples were analyzed for percent organic content and grain size as possible indicators of habitat alteration associated with dredging. Statistical tests were chosen based upon standard statistical methods (Sokal and Rohlf 1995); details are provided in Appendix 1.

Results : Community Composition

The benthic macroinvertebrate community in undisturbed shallow, soft sediments (Background Sites) at Jewfish Key was composed primarily of polychaetes (~43%) and oligochaetes (~31%) with smaller numbers of gastropods, bivalves, amphipods, decapods, isopods and a few additional taxa (Appendix 2, Table 3). The community as a whole was relatively productive, with 223 taxa identified from 2,342 individuals collected from twelve Petite Ponar samples. Overall benthic macroinvertebrate density was 32,561 individuals/m^2. Shannon-Weaver diversity ranged from 3.79-4.06 and averaged 3.93 among the four transects for the Background Sites.

The benthic macroinvertebrate community at the Dredged Sites was composed primarily of polychaetes (~72%), oligochaetes (~10%) and amphipods (~10%) with smaller numbers of gastropods, bivalves, decapods, isopods, and a few additional taxa (Appendix 2, Table 3). The community as a whole was less productive than the Background Sites, with 183 taxa identified from 1,755 macroinvertebrates collected from twelve Petite Ponar samples. Overall benthic macroinvertebrate density was 24,392 individuals/m^2. Shannon-Weaver diversity ranged from 3.12-4.25 and averaged 3.80 for the Dredged Sites along the four transects.

The benthic macroinvertebrate community in disturbed, spoil sediments (Spoil Sites) was composed primarily of polychaetes (~56%) and oligochaetes (~26%) with smaller numbers of gastropods, bivalves, amphipods, decapods, isopods and a few additional taxa (Appendix 2, Table 3). The community as a whole was depauperate compared to Background and Dredged Sites, with 53 taxa identified from 208 macroinvertebrates collected from twelve Petite Ponar samples. Overall benthic macroinvertebrate density was 2,897 individuals/m^2. Shannon-Weaver diversity at Background Sites ranged from 2.12-3.57 and averaged 2.72 for the Spoil Sites along the four transects.

Petite Ponar samples collected approximately 2-3 months after the illegal dredging at Jewfish Key indicated that the sediments and the benthic macroinvertebrates were statistically significantly impacted by dredging and spoil disposal.

Median number of taxa/sample decreased from 30.5 at Background Sites to 18.5 in Dredged Sites to 6.5 at Spoil Sites (Figure 3). Taxa richness decreased by an average of 39.3% at Dredged Sites and 78.7% at the Spoil Sites when compared with Background. The lower taxa richness at Spoil Sites was statistically different from values at Background and Dredged Sites (Appendix 1).

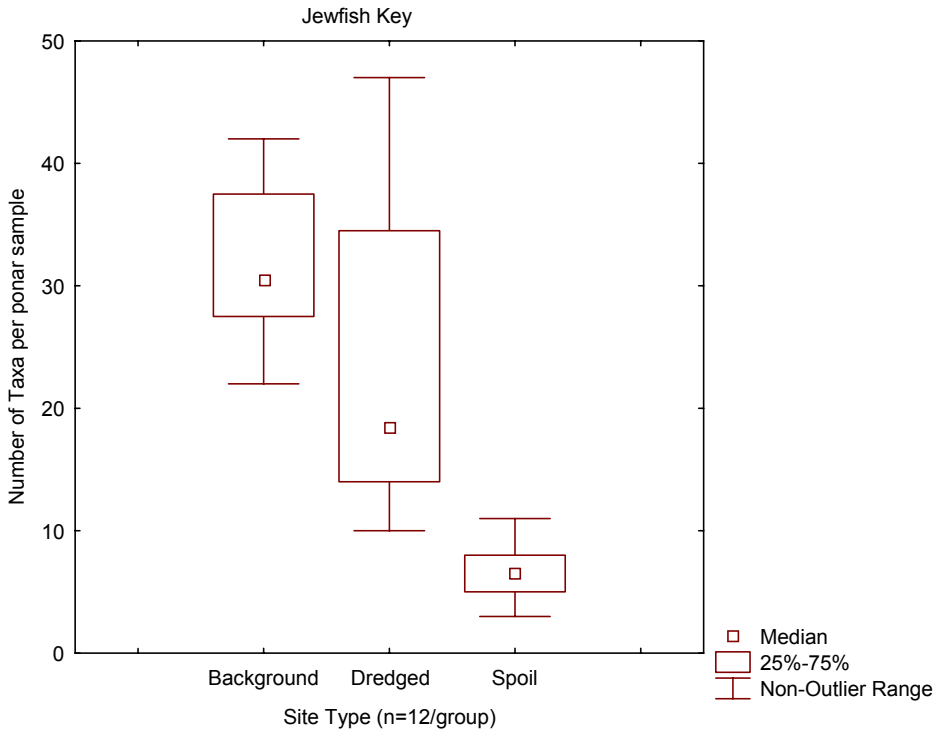


Figure 3. Box plot of number of taxa per ponar sample: Jewfish Key

Median number of individuals per sample decreased from 164 at Background Sites to 74.5 at Dredged Sites and 12.5 at Spoil Sites (Figure 4). Number of individuals per sample in Spoil Sites differed significantly from Background and Dredged Sites, with mean density reduced by 92.4% and 83.2% at Spoil Sites when compared to Background and Dredged Sites, respectively (Appendix 1). Although the median number of individuals per sample decreased by 54.6% in Dredged samples when compared to Background, these results were not statistically different due to the high variance among the four sites within the Background and Dredged areas.

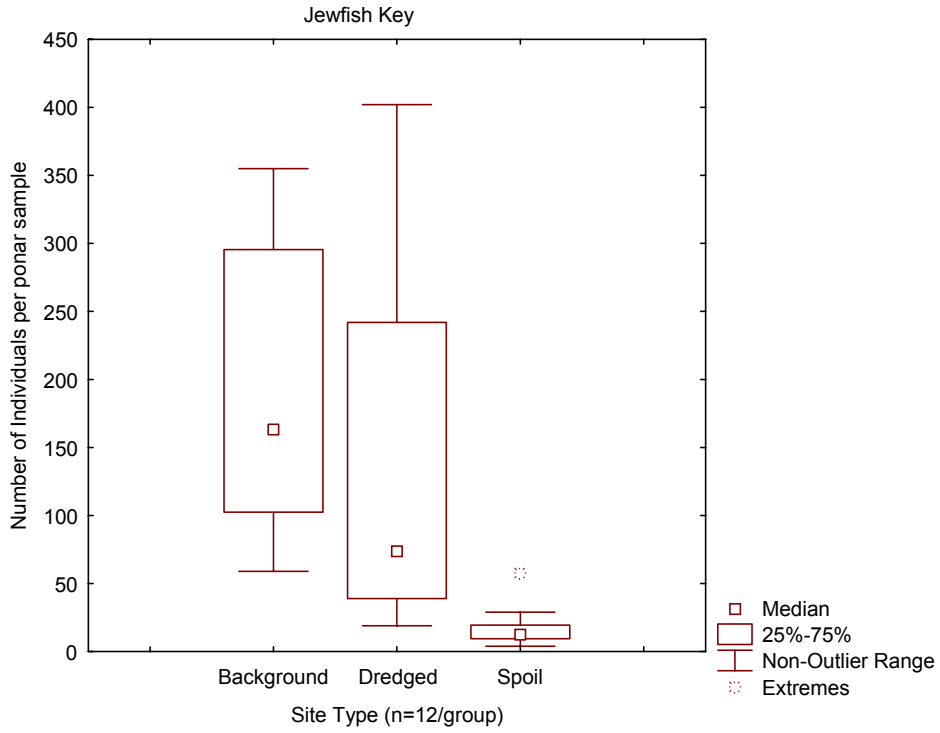


Figure 4. Box plot of number of individuals per ponar sample: Jewfish Key

Results: Sediments

Percent organic content of sediments at Background Sites was significantly higher than at Dredged Sites (Figure 5a, Table 2, see details Appendix 1). The percent of the total sample composed of <0.063 mm particles was significantly higher at the Background Sites compared to the Dredged and Spoil Sites (Figure 5b, Table 2, Appendix 1). Background Sites had a marginally significantly greater percent of total sample composed of 0.063-0.125 mm particles than at Dredged Sites (Figure 5b, Table 2, Appendix 1). Percent of total sample composed of 0.125-0.25mm particles was significantly lower at Background Sites than at Dredged or Spoil Sites (Figure 5b, Table 2, Appendix 1). The lack of finer particles in the Dredged and Spoil Sites indicates disturbance. Most benthic macroinvertebrates live in the upper few centimeters of sediment. Alterations in sediment grain size and organic content change the habitat characteristics for the macroinvertebrates. At Jewfish Key, dredging changed sediment composition, and thus the habitat quality for benthic macroinvertebrates at Dredged and Spoil Sites.

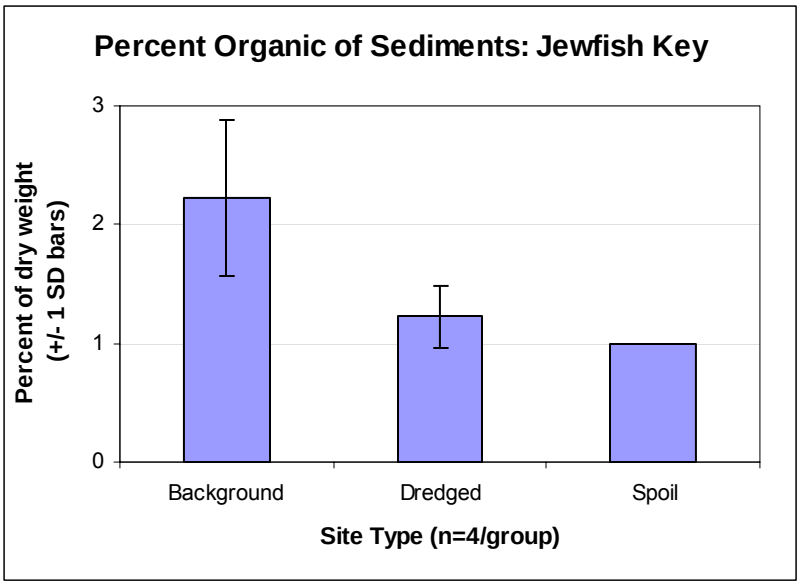


Figure 5a. Mean percent organic content of sediments at Background, Dredged and Spoil Sites.

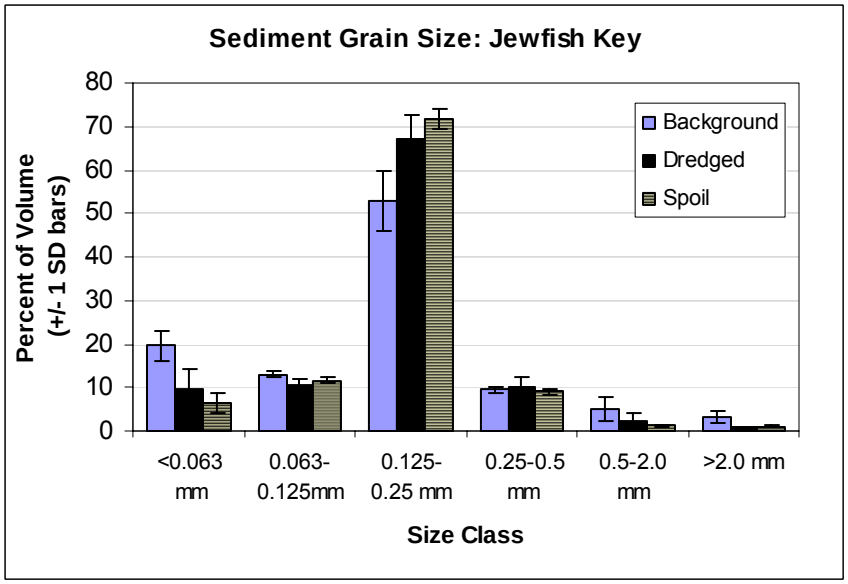


Figure 5b. Distribution of mean sediment grain size at Background, Dredged and Spoil Sites (n = 4 per sediment size class for each site type).

Results: Shannon-Weaver Diversity

For evaluation of the Biological Integrity Criterion (62.302-530(11), F.A.C.), Shannon-Weaver diversity (H') was calculated for the three areas from a set of three ponar samples (n=12 H' values).] At the Background Sites, the average H' was 3.93 (n=4), while at the Spoil Sites, the average H' was 30.8% lower (2.72, n=4) (Figure 6). At Dredged Sites,

average H' was 3.3% lower (3.8, n=4) than at Background Sites. The reduction of >25% diversity between the Background and Spoil Sites is a violation of Florida Administrative Code 62-302.530 (11).

There were statistically significant differences among the three site types (Background, Dredged and Spoil) in Shannon-Weaver diversity (Appendix 1). Post-hoc tests (Appendix 1) indicated that the mean Shannon-Weaver diversity score for Spoil Sites was significantly lower than those at Background and Dredged Sites. There was no significant difference between Background and Dredged Sites.

The H' analysis was statistically weak due to small sample sizes (n=12). There are also questions about the underlying model structure for analysis of H' scores, which makes the form of the correct analysis uncertain (Taylor and Bailey 1997). In addition, the two month delay between dredging and sampling allowed for macroinvertebrate recruitment, weakening the probability of detecting differences in H'.

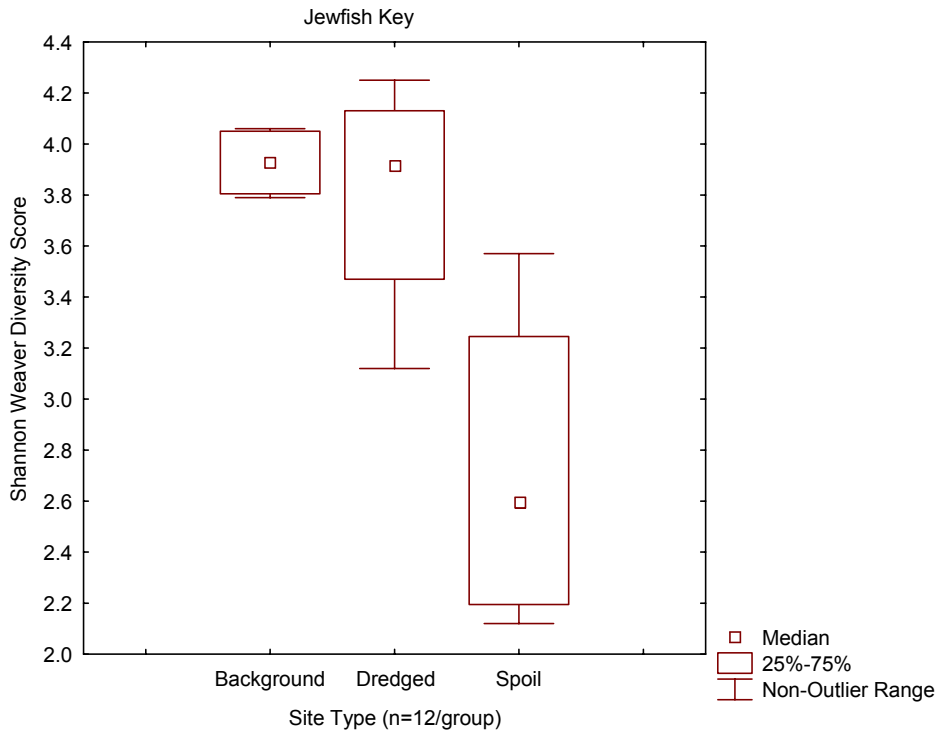


Figure 6. Box plot of Shannon Weaver Diversity scores: Jewfish Key

A major problem with application of the Biological Integrity Criterion (62-302.530 (11), F.A.C.) is the general weakness of Shannon-Weaver diversity as an indicator of ecological condition. As stated by Taylor and Bailey (1997) in a review of methods for monitoring effects of mine drainages on benthic macroinvertebrates in Canada, "The emerging

consensus is that the (Shannon-Weaver) diversity index will only reliably detect changes that are so conspicuous that the index is unnecessary anyway" (p.42). Having observed a greater than 25% reduction in H', one can be quite certain that the benthic macroinvertebrate community was significantly disturbed by the dredging activity.

Conclusions: The dredging activities at Jewfish Key adversely affected the benthic macroinvertebrate community in the spoil deposition areas and altered the associated sediments. The decrease in both taxa richness and density of organisms and the alteration of habitat could be interpreted as potential violations of Subsection 373.414(1) of the Florida Statutes and sections 40D-4.301 and 40D-4.302 of the Florida Administrative Code. Data indicate a violation of the Biological Integrity Criterion (62-302.530(11), F.A.C.) for Spoil Sites.

References:

Sokal, F. J. and R. R. Rohlf. 1995. Biometry. Freeman and Sons, New York.

Taylor, B. R. and R. C. Bailey. 1997. Technical evaluation on methods for benthic invertebrate data analysis and interpretation: Final Report. Canada Centre for Mineral and Energy Technology, Ottawa, Canada, 108 pp. http://www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/enviro/reports/2.1.3final-aete.pdf

Additional Information: Please contact David Whiting, Environmental Administrator, Biology Section, Bureau of Laboratories, FDEP with questions or requests for additional information (850-245-8191 or david.d.whiting@dep.state.fl.us).

Table 1. General physical and chemical parameters for Jewfish Key, July 21, 2004.

			Dissolved Oxygen (mg/L)	pH (S.U.)	Conductivity (umhos/cm)	Salinity (ppt)	Temperature (C)
		Class III Stds	≥ 4	6.5-8.5			
Transect	Site	Site Type					
1	1	Background	6.98	7.8	53384	35.1	29.3
1	3	Dredged	8	7.9	53347	35.1	29.5
1	2	Spoil	7.4	7.9	53256	35.0	29.4
2	4	Background	7.6	7.9	53409	35.1	29.6
2	6	Dredged	9.5	7.9	53403	35.1	29.7
2	5	Spoil	7.9	7.9	53395	35.1	29.7
3	7	Background	9.5	7.9	53451	35.1	30
3	9	Dredged	8.4	7.9	53193	34.9	30.1
3	8	Spoil	8.2	7.9	53270	35.0	30.3
4	10	Background	11.9	8.1	53463	35.1	30.5
4	12	Dredged	9.6	8.0	52373	34.7	30.3
4	11	Spoil	10.9	8.0	53375	35.1	30.7

Table 2. Sediment characteristics at Background, Dredged and Spoil sites

Site Type	Site	Percent Organic	Sediment Particle Size					
			% volume					% dry weight
		% dry weight	<0.063 mm	0.063-0.125mm	0.125-0.25 mm	0.25-0.5 mm	0.5-2.0 mm	>2.0 mm
Background	1	2.3	22.8	13.2	47.2	10	6.82	4.7
	4	2.5	20.3	13.8	48.8	9.64	7.5	4
	7	2.8	20.5	12.1	53.1	9.57	4.68	2.8
	10	1.3 A	14.8 A	12.6 A	62.6 A	8.6 A	1.31 A	1.6 A
	mean	2.225	19.6	12.925	52.925	9.4525	5.0775	3.275
Dredged	3	< 1	7.73	9.99	65.6	12	4.75	< 1
	6	1.5	15.8	12.6	62	8.42	1.14	< 1
	9	1.4	10.6	8.88	66.5	12.1	1.9	< 1
	12	< 1 A	5.08 A	10.7 A	75 A	8.38 A	0.86 A	< 1 A
	mean	1.45	9.8025	10.5425	67.275	10.225	2.1625	< 1
Spoil	2	< 1	4.14	12	73.4	9.11	1.31	1.3
	5	< 1	6.69	12.8	71	8.11	1.36	< 1
	8	< 1	9.42	10.8	68.5	9.86	1.42	< 1
	11	< 1	4.87	11.2	73.9	9.27	0.77	< 1
	mean	< 1	6.28	11.7	71.7	9.0875	1.215	1.3

Note: Samples given as "<1" were reported as "1 K " (true value known to be less than value given) in the original LIMS data.
A - Average

Table 3. Macroinvertebrate Ponar Samples - Quantitative

Jewfish Key	Background				Dredged				Spoil			
	Site 1	Site 4	Site 7	Site 10	Site 3	Site 6	Site 9	Site 12	Site 2	Site 5	Site 8	Site 11
Summary Statisics												
Shannon-Weaver Diversity	3.82	4.06	4.04	3.79	4.25	3.12	4.01	3.82	2.27	2.12	2.92	3.57
Number of Taxa	55	49	64	55	34	34	54	61	16	8	13	16
Percent Dominant Taxon	37.21	22.62	32.2	37.23	17.34	49.53	33.05	24.65	39.95	40.69	31.19	21.23
Dominant Taxon (name)	Tubificidae	Streblosoma hartmanae	Tubificidae	Tubificidae	Capitella capitata complex	Neanthes acuminata	Neanthes acuminata	Neanthes acuminata	Capitella capitata complex	Capitella capitata complex	Aricidea philbinae	Neanthes acuminata
Dominant Taxon (group)	Oligochaeta	Polychaeta	Oligochaeta	Oligochaeta	Polychaeta	Polychaeta	Polychaeta	Polychaeta	Polychaeta	Polychaeta	Polychaeta	Polychaeta
Number of samples/site	3	3	3	3	3	3	3	3	3	3	3	3
Total Number of Individuals	489	402	863	588	121	307	471	856	100	27	48	33
Community Composition: Percent of total												
Amphipoda	4.3	5.5	8.8	8.7	13.2	5.2	10.2	10.7	1.0	3.7	6.3	9.1
Decapoda	3.1	3.7	1.6	2.6	1.7	2.3	1.9	1.5	2.0	0.0	6.2	0.0
Gastropoda	14.5	13.4	8.9	10.4	5.0	1.0	3.0	3.6	4.0	7.5	4.2	9.1
Isopoda	1.6	2.0	0.4	0.9	0.8	0.3	0.4	0.1	0.0	0.0	2.1	0.0
Oligochaeta	37.2	12.7	32.2	37.2	4.1	6.8	3.2	14.7	39.0	36.9	8.3	3.0
Pelecypoda	3.9	1.3	1.4	1.7	0.8	1.3	4.7	0.8	1.0	0.0	2.1	6.1
Polychaeta	34.2	60.4	44.8	37.2	71.0	82.7	73.2	67.1	49.0	51.9	68.7	63.6
Other	1.2	1.0	1.8	1.4	3.3	0.3	3.4	1.4	4.0	0.1	2.1	9.1
Functional Feeding Groups: Percent of total												
Browser / Grazer	2.6	3.8	4.8	4.5	5.4	2.2	5.8	2.5	1.0	1.9	4.2	1.5
Burrowing Deposit Feeders	46.8	20.9	40.7	42.7	30.6	19.5	11.3	30.2	84.9	88.7	74.9	36.3
Parasite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	3.0
Piercers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predators	3.9	5.2	8.6	5.1	7.4	29.1	21.4	16.4	2.5	0.0	1.1	10.6
Scavengers	3.4	3.6	5.2	5.5	4.6	2.7	3.8	3.1	1.0	1.9	4.2	1.5
Scrapers	10.6	12.7	5.3	9.0	4.2	1.0	3.0	3.2	4.0	0.0	4.2	6.1
Shredders	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.5
Surface Deposit Feeders	16.6	29.0	14.4	14.5	19.0	35.3	36.9	30.0	2.5	1.9	1.1	22.7
Suspension Feeders	10.1	20.8	12.9	11.8	9.9	5.4	7.2	5.2	3.5	1.9	2.1	13.6
Unknown	6.0	4.1	8.2	6.9	19.0	4.8	10.7	9.4	0.0	0.0	8.3	3.0

Appendix 1

Analyses:

At each of four transects, three Petite Ponar samples were collected from the Dredged channel, the Spoil disposal site and from the adjacent undisturbed sediments (Background Sites). The number of taxa and the number of individuals per sample were totaled from the data. The data were checked for violations of assumptions of parametric tests and analyses were selected based upon the results (Sokal and Rolf 1995). All analyses were performed with Statistica ^{TM} Version 6.0.

Number of Taxa:

Number of taxa per sample was not normally distributed with homogenous variances (Hartley F max test, $p<0.008$) and data did not completely meet the assumptions of analysis of variance (ANOVA) after square root or logarithmic transformations. Square root transformed data did meet assumptions for homogeneity of variance (Hartley F max test, $p=0.09$) and improved normality (Shapiro-Wilks, $p=0.029$). To be conservative, data were analyzed using non-parametric Kruskal-Wallis ANOVA by Ranks test. Because ANOVA is robust to slight violations of the assumption of normality and produced the same result as the non-parametric Kruskal-Walis ANOVA by ranks test, the square root transformed data were used for post-hoc comparisons (Tukey post-hoc HSD tests).

Number of Individuals:

After log transformation, the number of individuals per sample was approximately normally distributed and groups had homogenous variances (Hartley F max test, $p=0.087$). Data were analyzed using nested analysis of variance (ANOVA) with Background, Dredged and Spoil (site type) as the main treatments, with transect nested within treatment (site type). Significant differences among treatments were analyzed using Tukey post-hoc HSD tests.

Sediment percent organic content and grain size:

Sediment percent organic content and sediment grain size data are given in Table 2 and Figure 5a, 5b. Percent organic content was not normally distributed and groups did not have homogeneous variances (Levene's test, $p< 0.05$). These assumptions were not met because the value of 1 was entered for data results of <1. All Spoil Sites had organic content results of <1, leaving no variance for the model to test. Therefore, Spoil Sites were removed from this analysis and the Background and Dredged Sites were compared using parametric one-way ANOVA.

Percent of sample composed of sediment grain sizes <0.63 mm, 0.63-0.125 mm, 0.125-0.25 mm, and 0.25-0.5 mm were all approximately normally distributed and groups had homogeneous variances (Hartley F max tests, $p>0.05$). Percent of sample composed of

0.5-2.0 mm particles were not normally distributed and groups did not have homogeneous variances (Hartley F max tests, $p<0.05$). After log transforming the 0.5-2.0 mm data, assumptions were met. Data for each category were analyzed using one-way ANOVA with site type as the grouping factor. Significant differences among treatments were analyzed using Tukey post-hoc HSD tests.

Percent of sample composed of >2.0 mm particles were not normally distributed and groups did not have homogeneous variances (Hartley F max tests, $p<0.05$). These assumptions were not met because the value of 1 was entered for data results of <1. All Dredged and Spoil Sites had >2.0 mm particle size results of <1, leaving no variance for the model to test. Statistical tests were not performed on >2.0 mm data

Shannon-Weaver Diversity:

Shannon-Weaver Diversity was analyzed using H' values calculated for each site from each set of three ponars (n=12 H' values). Data were approximately normally distributed and met the assumptions of homogeneity of variances (Hartley F max text, $p=0.0968$). A one-way ANOVA was performed followed by Tukey post-hoc HSD tests. As a back-up check, because data were approximately normally distributed (Shapiro Wilks-W $p=0.0406$) and transformations did not improve normality, a nonparametric Kruskal-Wallis ANOVA by Ranks test was also performed.

Results:

Number of Taxa:

The number of taxa per sample differed significantly among locations ($p<0.0001$). Data are summarized in a box plot (Figure 3). Median density dropped from 30.5 (range 22-42) at Background Sites to 18.5 (10-47) at Dredged Sites and 6.5 (3-11) at Spoil Sites. Post-hoc comparisons using square root transformed data indicate that Spoil Sites had significantly fewer taxa than Background and Dredged Sites ($p< 0.0001$). Background and Dredged Sites were not significantly different ($p=0.07$). Although these two comparisons were not significant, high variability and relatively low number of samples made the statistical power of the tests low.

Number of Individuals:

The number of individuals per sample differed significantly among locations ($p< 0.0001$). Data are summarized in a box plot (Figure 4). The results show a decrease in the number of individuals from Background to Dredged to Spoil Sites. Median number of individuals dropped from 164.0 (range 59-355) at Background Sites to 74.5 (19-402) at Dredged Sites and 12.5 (4-58) at Spoil Sites. Mean (± SE) number of individuals decreased from 195.2 (± 30.5) at Background Sites to 146.3 (± 39.0) at Dredged Sites to 17.3 (± 4.2) in Spoil Sites. Post-hoc comparisons indicate that Spoil Sites had significantly fewer individuals than Background and Dredged Sites ($p< 0.0001$). Background and Dredged Sites did not differ significantly ($p=0.162$).

Sediment percent organic content and grain size:

Percent organic content of sediments differed significantly between Background and Dredged Sites ($p=0.029$) (Table 2, Figure 5a).

Sediment grain size data is shown in Table 2 and Figure 5b. The percent of sample composed of particles <0.063 mm in size differed significantly among Background, Dredged and Spoil Sites ($p=0.001$). In post-hoc pairwise tests, sediments at Background Sites had significantly higher percent of sample composed of <0.063 mm grain size than sediments from Dredged or Spoil Sites ($p<0.009$ or smaller). Dredged and Spoil Sites did not differ in percent of sample composed of <0.063 mm grain size ($p=0.38$).

For percent of sample composed of particles 0.063-0.125 mm in size, there was a marginal significant difference among Background, Dredged and Spoil Sites ($p=0.04$). In post-hoc pairwise tests, sediments at Background Sites had significantly higher percent of sample composed of 0.063-0.125 mm grain size than sediments from Dredged Sites ($p=0.04$). There was no significant difference in percent of sample composed of 0.063-0.125 mm grain size between Background and Spoil Sites ($p=0.32$) or between Dredged and Spoil Sites ($p=0.38$).

The percent of sample composed of particles 0.125-0.25 mm in size differed significantly among Background, Dredged and Spoil Sites ($p=0.002$). In post-hoc pairwise tests, sediments at Background Sites had significantly lower percent of sample composed of 0.125-0.25 mm grain size than sediments from Dredged or Spoil ($p<0.01$). Dredged and Spoil Sites did not differ in percent of sample composed of 0.125-0.25 mm grain size ($p=0.49$).

The percent of sample composed of particles 0.25-0.5 mm and 0.5-2.0 mm in size did not differ significantly among Background, Dredged and Spoil Sites ($p>0.05$).

Shannon-Weaver Diversity:

Shannon-Weaver Diversity differed significantly among Background, Dredged and Spoil Sites ($p=0.0118$). Shannon-Weaver Diversity data are summarized in a box plot (Figure 6).

Post-hoc tests indicated that the mean Shannon-Weaver diversity score for Spoil Sites was significantly lower ($p<0.05$) than those at Background and Dredged Sites. There was no significant difference between Background and Dredged Sites ($p>0.05$).

Appendix 2a

Benthic macroinvertebrates collected from Petite Ponar samples at Jewfish Key (July 21, 2004). Taxa collected and density (average number of individuals/m^2) rounded to the nearest individual (n = 12 samples/site type). See SOP LT 7100 sect. 4.2.1 for method on collapsing taxa.

	Background	Dredged	Spoil
Annelida			
Oligochaeta			
Tubificidae	10139	2319	751
Polychaeta			
Americonuphis magna	42	-	-
Apoprionospio pygmaea	-	14	-
Aricidea catherinae	15	-	-
Aricidea philbinae	2263	1056	292
Aricidea sp.	-	-	14
Aricidea suecica	-	56	-
Autolytus sp.	-	14	-
Axiothella sp.	42	125	-
Bispira melanostigma	159	28	-
Capitella capitata complex	32	1870	917
Chone sp.	111	-	-
Cirratulidae	2445	3014	42
Dasybranchus sp.	-	14	-
Demonax sp.	57	-	-
Diopatra cuprea	14	-	-
Dipolydora socialis	45	29	-
Dorvilleidae	14	-	-
Exogone sp.	71	70	-
Fabricinuda sp.	605	153	-
Glycinde solitaria	-	84	-
Goniadidae	14	-	-
Grubeosyllis sp.	349	194	-
Hesionidae	14	-	-
Heteromastus filiformis	-	-	14
Heteromastus sp.	52	-	-
Kinbergonuphis sp.	15	-	-
Leitoscoloplos robustus	291	81	-
Leitoscoloplos sp.	42	81	167
Loimia medusa	-	21	-
Loimia sp.	-	14	-
Magelona sp.	84	56	-
Mediomastus sp.	14	14	-
Minuspio cirrifera	149	-	-
Minuspio sp.	83	28	-
Neanthes acuminata	276	7278	126
Nereis falsa	179	17	-
Notomastus sp.	-	19	-
Onuphidae	-	14	-
Owenia fusiformis	14	-	-
Phyllodoce sp.	-	14	-
Phyllodocidae	28	28	-
Platynereis dumerilii	169	109	-

Podarke obscura	-	51	-
Podarkeopsis levifuscina	-	19	-
Polydora cornuta	92	363	-
Polydora sp.	28	-	-
Prionospio cristata	177	30	-
Prionospio fallax	29	127	-
Prionospio heterobranchia	1718	1421	14
Prionospio perkinsi	-	45	-
Proscoloplos sp.	-	17	-
Proscoloplos sp. a	14	-	-
Pseudopolydora sp.	-	42	-
Sabaco americanus	14	-	-
Scolelepis sp.	-	29	14
Scoloplos rubra	-	42	-
Scoloplos sp.	-	16	-
Serpulidae	98	223	-
Sigambra tentaculata	-	14	-
Sphaerosyllis sp.	15	42	-
Spio sp.	-	-	14
Streblosoma hartmanae	3015	49	-
Syllidae	-	-	14
Terebellidae	-	14	-
Typosyllis sp.	1233	457	-
Arthropoda			
Arachnida			
Acariformes	-	-	14
Crustacea			
Amphipoda			
Acanthohaustorius uncinus	-	14	14
Ampelisca sp.	-	-	14
Ampelisca abdita	456	42	14
Ampelisca holmesi	-	83	-
Ampithoe sp.	30	-	-
Ampithoe longimana	169	-	-
Aoridae	14	-	14
Bemlos sp.	-	44	-
Bemlos setosus	-	333	-
Bemlos/Plesiolembos complex	15	153	-
Cerapus sp.	28	-	-
Cymadusa compta	931	250	14
Dulichiella sp.	-	42	-
Elasmopus sp.	57	42	-
Elasmopus balkomanus	44	-	-
Elasmopus levis	183	-	-
Ericthonius brasiliensis	-	14	-
Grandidierella bonnieroides	-	284	14
Hyalella azteca	-	-	28
Listriella barnardi	-	14	-
Melitidae	84	-	-
Shoemakerella cubensis	355	1074	-
Cumacea			
Almyracuma proximoculi	-	-	28
Decapoda			
Alpheidae	89	-	-
Alpheus sp.	191	182	-
Alpheus normanni	-	56	-

Callinectes larvatus	-	14	-
Hippolyte sp.	116	-	-
Hippolytidae	44	15	-
Lucifer faxoni	45	-	14
Majidae	16	-	-
Paguridae	135	-	-
Palaemonidae	-	14	-
Parapenaeus sp.	-	-	14
Penaeidae	-	15	-
Penaeus sp.	14	-	-
Pinnixa sp.	14	-	-
Portunidae	-	30	-
Processidae	14	-	-
Undetermined Decapoda	-	-	42
Xanthidae	144	106	-
Isopoda			
Amakusanthura magnifica	140	42	-
Cyathura polita	-	14	-
Erichsonella attenuata	42	14	-
Harrieta faxoni	154	-	-
Xenanthura brevitelson	-	-	14
Mysidacea			
Mysidacea	-	-	28
Tanaidacea			
Hargeria rapax	-	84	-
Leptochelia sp.	-	14	-
Leptochelia cf forresti	-	28	-
Leptochelia cf longichelipedis	-	28	-
Leptochelia dubia	42	-	-
Pseudonototanais sp.	56	42	14
Insecta			
Diptera	-	-	14
Pycnogonida			
Achelia sawayai	-	14	-
Echinodermata			
Holothuroidea			
Thyone sp.	14	-	-
Thyone deichmannae	42	-	-
Undetermined Holothuroidea	14	28	-
Stelleroidea			
Ophioderma sp.	125	-	-
Ophiophragmus sp.	28	70	-
Ophiostigma sp.	14	-	-
Ophiurida	28	-	-
Mollusca			
Bivalvia			
Chione cancellata	44	-	-
Chione elevata	67	269	-
Chione sp.	-	14	-
Laevicardium mortoni	-	16	-
Lucina nassula	116	14	-
Modiolus sp.	30	-	-
Musculus lateralis	31	-	-
Mysella planulata	30	-	-
Parvilucina multilineata	58	76	-
Pitar sp.	93	-	-

Tellina sp.	174	70	-
Tellinidae	-	-	28
Transennella conradina	-	14	-
Undetermined Bivalvia	-	-	28
Gastropoda			
Acteocina sp.	28	44	-
Astyris lunata	15	-	-
Bittium sp.	28	14	-
Bittium varium	14	14	-
Bulla sp.	-	14	-
Bulla striata	43	45	-
Caecum sp.	56	-	14
Costoanachis sp.	28	-	-
Crepidula maculosa	432	14	-
Crepidula plana	14	-	-
Crepidula sp.	225	-	-
Dentimargo aureocinctus	29	-	-
Granulina hadria	42	14	-
Haminoea sp.	-	44	-
Meioceras sp.	42	-	-
Melanella sp.	85	-	19
Nassariidae	28	28	-
Nassarius sp.	28	-	-
Olivella sp.	242	-	14
Prunum apicinum	1689	479	28
Prunum sp.	520	28	51
Pyramidellidae	-	-	28
Rictaxis punctostriatus	14	-	-
Turbonilla sp.	57	14	-
Polyplacophora			
Undetermined Polyplacophora	14	14	-
Nemertea			
Undetermined Nemertea	70	125	-
Platyhelminthes			
Undetermined Polycladida	14	14	-
Sipuncula			
Undetermined Sipuncula	14	-	14

Appendix 2b

Benthic macroinvertebrates collected in Petite Ponar samples from Jewfish Key (July 21, 2004). Taxa collected and total number of number individuals counted (n = 12 samples/site type).

	Background	Dredged	Spoil
Annelida			
Oligochaeta			
Tubificidae	730	167	54
Polychaeta			
Americonuphis magna	3	-	-
Apoprionospio pygmaea	-	1	-
Aricidea catherinae	1	-	-
Aricidea philbinae	162	76	21
Aricidea sp.	1	-	1
Aricidea suecica	-	4	-
Autolytus sp.	-	1	-
Axiothella sp.	3	9	-
Bispira melanostigma	8	2	-
Bispira sp.	3	-	-
Capitella capitata complex	2	133	66
Capitellidae	1	2	-
Chone sp.	8	-	-
Cirratulidae	176	217	3
Dasybranchus sp.	-	1	-
Demonax sp.	4	-	-
Diopatra cuprea	1	-	-
Dipolydora socialis	3	2	-
Dorvilleidae	1	-	-
Exogone sp.	5	5	-
Fabricinuda sp.	43	11	-
Glycinde solitaria	-	6	-
Goniadidae	1	-	-
Grubeosyllis sp.	24	14	-
Hesionidae	1	1	-
Heteromastus filiformis	-	-	1
Heteromastus sp.	3	-	-
Kinbergonuphis sp.	1	-	-
Leitoscoloplos robustus	18	4	-
Leitoscoloplos sp.	6	6	12
Loimia medusa	-	1	-
Loimia sp.	-	1	-
Magelona sp.	6	4	-
Mediomastus sp.	1	1	-
Minuspio cirrifera	5	-	-
Minuspio sp.	11	2	-
Neanthes acuminata	19	392	8
Nereididae	3	134	1
Nereis falsa	11	1	-
Notomastus sp.	-	1	-
Onuphidae	-	1	-
Orbiniidae	-	2	-

Owenia fusiformis	1	-	-
Phyllodoce sp.	-	1	-
Phyllodocidae	2	2	-
Platynereis dumerilii	12	6	-
Podarke obscura	-	3	-
Podarkeopsis levifuscina	-	1	-
Polydora cornuta	6	26	-
Polydora sp.	2	-	-
Prionospio cristata	12	2	-
Prionospio fallax	2	9	-
Prionospio heterobranchia	117	99	1
Prionospio perkinsi	-	3	-
Prionospio sp.	4	3	-
Proscoloplos sp.	-	1	-
Proscoloplos sp. a	1	-	-
Pseudopolydora sp.	-	3	-
Sabaco americanus	1	-	-
Sabellidae	1	-	-
Scolelepis sp.	-	2	1
Scoloplos rubra	-	3	-
Scoloplos sp.	-	1	-
Serpulidae	7	16	-
Sigambra tentaculata	-	1	-
Sphaerosyllis sp.	1	3	-
Spio sp.	-	-	1
Spionidae	5	1	-
Streblosoma hartmanae	213	2	-
Syllidae	5	2	1
Terebellidae	4	3	-
Typosyllis sp.	85	31	-
Arthropoda			
Arachnida			
Acariformes	-	-	1
Crustacea			
Amphipoda			
Acanthohaustorius uncinus	-	1	1
Ampelisca sp.	6	1	1
Ampelisca abdita	26	3	1
Ampelisca holmesi	-	5	-
Ampithoe sp.	8	-	-
Ampithoe longimana	3	-	-
Ampithoidae	14	5	-
Aoridae	1	4	1
Bemlos sp.	-	8	-
Bemlos setosus	-	15	-
Bemlos/Plesiolembos complex	1	11	-
Cerapus sp.	2	-	-
Cymadusa sp.	1	-	-
Cymadusa compta	54	13	1
Dulichiella sp.	-	3	-
Elasmopus sp.	14	3	-
Elasmopus balkomanus	3	-	-
Elasmopus levis	3	-	-
Ericthonius brasiliensis	-	1	-
Grandidierella bonnieroides	-	20	1
Hyalella azteca	-	-	2

Listriella barnardi	-	1	-
Lysianassidae	1	-	-
Melitidae	6	-	-
Shoemakerella cubensis	24	77	-
Undetermined Amphipoda	3	1	-
Cumacea			
Almyracuma proximoculi	-	-	2
Decapoda			
Alpheidae	7	1	-
Alpheus sp.	12	14	-
Alpheus normanni	-	1	-
Callinectes larvatus	-	1	-
Hippolyte sp.	4	-	-
Hippolytidae	7	1	-
Lucifer faxoni	3	-	1
Majidae	1	-	-
Paguridae	9	-	-
Palaemonidae	-	1	-
Parapenaeus sp.	-	-	1
Penaeidae	-	1	-
Penaeus sp.	1	-	-
Pinnixa sp.	1	-	-
Portunidae	-	2	-
Processidae	1	-	-
Undetermined Decapoda	3	2	3
Xanthidae	10	7	-
Isopoda			
Amakusanthura sp.	-	1	-
Amakusanthura magnifica	9	2	-
Anthuridae	1	-	-
Cyathura polita	-	1	-
Erichsonella attenuata	3	1	-
Harrieta faxoni	10	-	-
Sphaeromatidae	1	-	-
Xenanthura brevitelson	-	-	1
Mysidacea			
Mysidacea	-	-	2
Tanaidacea			
Hargeria rapax	-	6	-
Leptochelia sp.	-	2	-
Leptochelia cf forresti	-	2	-
Leptochelia cf longichelipedis	-	1	-
Leptochelia dubia	1	-	-
Leptocheliidae	2	-	-
Pseudonototanais	4	3	1
Insecta			
Diptera	-	-	1
Pycnogonida			
Achelia sawayai	-	1	-
Echinodermata			
Holothuroidea			
Thyone sp.	1	-	-
Thyone deichmannae	1	-	-
Undetermined Holothuroidea	3	2	-
Stelleroidea			
Ophioderma sp.	6	-	-

	Ophiophragmus sp.	2	4	-
	Ophiostigma sp.	1	-	-
	Ophiurida	5	1	-
Mollusca				
Bivalvia				
	Chione sp.	1	2	-
	Chione cancellata	2	-	-
	Chione elevata	4	16	-
	Laevicardium mortoni	-	1	-
	Lucina sp.	5	-	-
	Lucina nassula	1	1	-
	Lucinidae	1	-	-
	Modiolus sp.	2	-	-
	Musculus lateralis	2	-	-
	Mysella planulata	2	-	-
	Parvilucina multilineata	4	5	-
	Pitar sp.	6	-	-
	Tellina sp.	12	5	-
	Tellinidae	-	-	2
	Transennella conradina	-	1	-
	Undetermined Bivalvia	4	3	2
Gastropoda				
	Acteocina sp.	2	3	-
	Astyris lunata	1	-	-
	Bittium sp.	2	1	-
	Bittium varium	1	1	-
	Bulla sp.	-	3	-
	Bulla striata	3	1	-
	Caecum sp.	4	-	1
	Costoanachis sp.	2	-	-
	Crepidula sp.	16	-	-
	Crepidula maculosa	31	1	-
	Crepidula plana	1	-	-
	Dentimargo aureocinctus	2	-	-
	Granulina hadria	3	1	-
	Haminoea sp.	-	3	-
	Meioceras sp.	3	-	-
	Melanella sp.	6	-	1
	Nassariidae	2	2	-
	Nassarius sp.	2	-	-
	Olivella sp.	17	-	1
	Prunum sp.	137	31	3
	Prunum apicinum	20	5	2
	Pyramidellidae	-	-	2
	Rictaxis punctostriatus	1	-	-
	Turbonilla sp.	4	1	-
	Undetermined Gastropoda	3	1	1
Polyplacophora				
	Undetermined Polyplacophora	1	1	-
Nemertea				
	Undetermined Nemertea	5	9	-
Platyhelminthes				
	Undetermined Polycladida	1	1	-
Sipuncula				
	Undetermined Sipuncula	1	-	1