A Reassessment of the Benthic Macrofaunal Community and Sediment Quality Conditions in Clam Bayou, Pinellas County, Florida: 2008 vs. 2016

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Introduction

The Tampa Bay Estuary Program (TBEP) started the annual bay-wide Tampa Bay Benthic Monitoring Program in 1993 to evaluate and monitor the health of the sediment environment of Tampa Bay. Monitoring in Boca Ciega Bay was added to the program in 1995. The program is a cooperative effort between the Environmental Protection Commission of Hillsborough County (EPCHC), the Manatee County Natural Resources Department (MCNRD), and the Pinellas County Public Works Department, Environmental Management Division. Each agency assists in the annual field sampling within their respective jurisdictions in Tampa Bay. Sample processing and data analysis is conducted by the EPCHC.

The benthic monitoring program's objectives and sampling design were reevaluated in 2003 (Janicki Environmental, 2003). As a result of this assessment, the reporting period was increased from one year to four years and the number of samples collected annually was cut in half (from 124 to 64 samples per year). This reduced sampling allowed for the redirecting of efforts towards collecting samples from areas of concern ("Special Studies") and typically two sites are picked each year. Clam Bayou was chosen as one of the Special Study site in 2008 because of concerns about increased siltation in the bayou and because it was a planned restoration site for the Southwest Florida Water Management District/ Surface Water Improvement Program (SWFWMD/SWIM). Results from the 2008 Clam Bayou special study found high levels of sediment contaminants and particularly of polycyclic aromatic hydrocarbons (PAHs) and several chlorinated pesticides including Lindane and DDT (Karlen et al. 2009). The Florida Department of Environmental Protection (FDEP) conducted a study of Clam Bayou in 2011 which evaluated water quality, epibenthic invertebrate and fish communities, contaminants in fish tissue and accumulation of sediment contaminants (FDEP, 2012). The FDEP study also found several PAHs and pesticides (Lindane, DDT) exceeded state sediment quality guidelines and found elevated PAH levels in fish tissues (FDEP 2012). Clam Bayou was selected as a Special Study site at the request of FDEP for the 2016 TBEP Bay-wide Benthic Monitoring sampling to document any temporal changes in the benthic infaunal community and sediment contaminant levels. This report will primarily focus on comparisons between the 2008 and 2016 special study results.

Materials and Methods

Site Selection

Ten sites in Clam Bayou were sampled by Pinellas County staff in 2008. Six of the sites roughly corresponded to the six locations sampled by FDEP in 2001. The other four sites were selected from randomly generated coordinates. The same 10 sites were resampled in 2016 to evaluate changes in the benthic community and sediment contaminants since 2008 (Figure 1).

Field Collection

The field collection of sediment samples and water quality data was conducted by PCDEM staff. Samples were collected on three dates: 25 August 2016 (sites #7 and 8), 29 August 2016 (sites# 1, 2,3,10, and 12), and 30 August 2016 (sites #4, 5 and 6) (Figure 1).

Figure 1. TBEP 2016 Clam Bayou sampling locations.

Field and laboratory methods were adopted from the EMAP-E Louisianan Province operations manual (Macauley, 1993) and modified for the Tampa Bay monitoring program (Versar, 1993; Courtney *et al.* 1995). A hydrographic profile was taken at each site using a Hydrolab® multi-probe sonde. Measurements were taken from the surface (0.1 meters) to the bottom at 1 meter intervals for temperature, salinity, pH, and dissolved oxygen.

Sediment samples for benthic macrofaunal community analysis were taken at each site using a Young-Modified Van Veen grab sampler (or Young grab). The grab sample was taken to a sediment depth of 15 cm and covered an area of 0.04 m^2. A 60 cc corer was used to take a subsample for Silt+Clay analysis. Samples were sieved through a 0.5 mm mesh sieve and the remaining fraction was rinsed into plastic sample jars. Samples were fixed in NOTOXhisto (Scientific Device Laboratory, Inc.) for a minimum of 72 hours and then transferred into 70% isopropyl alcohol for preservation and storage. Rose Bengal was added to the isopropyl alcohol solution to stain the organisms.

Sediment Chemistry: A second sediment grab sample was taken at each site for sediment contaminant analysis. The grab sampler and all sampling utensils were field cleaned with Liqui-Nox® detergent (Alconox, Inc. White Plains, NY), rinsed with ambient seawater and decontaminated with 99% pesticide grade isopropyl alcohol (2-Propanol, FisherChemicals, Fisher Scientific Fair Lawn, NJ) prior to sampling and all equipment and samples were handled wearing latex gloves. The top 2 cm layer of sediment was removed from each grab using a stainless steel or Teflon coated spoon and placed in a stainless steel beaker. The removed layers of sediment were composited in the stainless steel beaker and homogenized by stirring. The homogenized sample was then split, with one fraction being placed in a HDPE sample bottle for metals analysis and the second fraction being placed in a glass sample jar with Teflon® lined lid for analysis of organic compounds (pesticides, PCBs, PAHs).

Laboratory Procedures

Field data

Hydrographic and other field data were entered into a Microsoft® Access database maintained by the Environmental Protection Commission of Hillsborough County.

Sediment Chemistry

All sediment chemistry samples were analyzed by the EPCHC. The sediment metal samples were processed using a total digestion method with hydrofluoric acid using a CEM MARS Xpress microwave digester. Analysis was performed on a Perkin Elmer Optima 2000 Optical Emission Spectrometer according to EPA Method 200.7. The organic samples were extracted using EPA Method 3545A (Accelerated Solvent Extraction), followed by the cleanup methods, EPA 3630C (Silica gel) and EPA 3660B (copper). Analysis was completed using EPA Method 8081 (organochlorine pesticides) and EPA Method 8082 (PCB congeners) on a gas chromatograph equipped with dual Electron Capture Detectors (ECDs). Polycyclic aromatic hydrocarbons (PAHs) were analyzed using EPA Method 8270c on a mass spectrometer.

Benthic Community Analysis

Benthic sorting and identification work was conducted by EPCHC staff. Benthic sediment samples were rough sorted under a dissecting microscope into general taxonomic categories (Annelids, Molluscs, Crustaceans, and Miscellaneous Taxa). Resorting was done on 10% of the samples completed by each technician for QA/QC. The sorted animals were identified to the lowest practical taxonomic level (species level when possible) and counted. Taxonomic identifications were conducted using available identification keys and scientific literature. All identification and count data were recorded on laboratory bench sheets and entered into a Microsoft Access® database maintained by the EPCHC.

Data Analysis

Data Categorization

Potential toxicity levels for sediment contaminants followed the sediment quality guidelines established for Florida coastal waters and utilized the Threshold Effects Levels (TELs) and Probable Effects Levels (PELs) established for individual contaminants (MacDonald 1994; MacDonald *et al*. 1996). The metal:aluminum ratio was used to determine if individual sediment metals were elevated relative to background levels (Schropp *et al*. 1990). The Tampa Bay Benthic Index (TBBI) was calculated for each site following the methods established in Janicki Environmental (2005) and Malloy *et al.* (2007). The TBBI threshold scores for "Degraded" (< 73), "Intermediate" (between 73 to 87) and "Healthy" (> 87) benthic habitats were established by Janicki Environmental (2005) and Malloy *et al*. (2007).

Univariate Statistical Analysis

Parametric and non-parametric statistical analysis was done with SigmaStat ® 3.5 (SYSTAT Software, Inc. 2006). Data were transformed for normality where needed for the parametric tests. One-way repeated measures (RM) Analysis of Variance (ANOVA) with a Holm-Sidak method pair-wise post hoc test was used to test for differences between sampling events. A non-parametric Friedman Repeated Measures ANOVA on Ranks test and Dunn's Pairwise Multiple Comparison test was used where the assumptions of the ANOVA could not be met by the data transformation.

Multivariate Statistical Analysis and Benthic Community Indices

PRIMER v7 software (PRIMER-E, Ltd. 2015; Clarke and Gorley 2015) was used for all multivariate statistical analysis and for calculating univariate biological metrics (species richness, abundance, Shannon diversity index and Evenness). Species richness (*S*) was defined as the total number of taxa. Abundance (*N*) was expressed as the number of individuals per m^2 (calculated as the raw count x 25) except for colonial organisms which were counted as present/absent. The Shannon diversity index (*H'*) calculations employed the natural logarithm opposed to log base 2 (Clarke and Warwick 2001). The zero-adjusted Bray-Curtis similarity (Clarke *et al.* 2006) was calculated on square root transformed abundance data and the resulting similarity matrix was used for running Cluster Analysis, Non-metric Multi-Dimensional Scaling (MDS), Similarity Percentage (SIMPER), and Analysis of Similarity (ANOSIM). The BIO-ENV procedure (Clarke and Ainsworth 1993) was used to find correlations between the environmental parameters and benthic community structure. All environmental parameters were normalized and log transformed prior to analysis.

Spatial and Graphical Analysis

Graphs were generated using SigmaPlot® 13.0 software (Systat Software, Inc. 2014). Maps were generated by the Environmental Protection Commission of Hillsborough County using ArcGIS 10.3 (ESRI 2015).

Results

Physical Parameters

The water quality measurements and silt/clay results are presented in Table 1. The site depths in 2016 ranged from 0.45 to 1.34 meters with a median value of 0.9 meters. There was no significant difference in the depth between 2008 and 2016 ($p = 0.497$; Figure 2). Bottom water temperatures ranged from 29.68 to 32.03°C in 2016 and were significantly higher than in 2008 (Table 1; Figure 3). This may have been due in part to the 2008 samples being collected over a longer period of time from August to September while 2016 samples were collected in August. Bottom salinities in 2016 ranged between 24.35 to 31.19 psu and were significantly lower than in 2008 ($p<0.001$). Eight of the ten sites still had bottom salinities in the euhaline range (>30 psu), the exceptions being sites 16CLB07 and 16CLB08 which were much lower than the other sites (Table 1; Figure 4). These two sites were sampled the week before the other locations and the lower salinities may have been due to a recent rain event prior to sampling. Bottom pH in 2016 ranged from 7.85 to 8.13, with the two lowest pH levels corresponding with the lower salinities observed at sites 16CLB07 and 16CLB08 (Table 1; Figure 5). The pH levels were generally higher at most sites in 2016, but there was no significant difference between sampling years (Figure 5; $p=0.110$). The bottom dissolved oxygen (DO) ranged from 3.16 to 4.52 mg/l in 2016 and the DO saturation ranged from 49.6 to 70.7% (Table 1). There was no significant difference in the bottom DO or DO saturation between 2008 and 2016 ($p=0.364$ and $p=0.467$ respectively), however most sites did show higher values for both parameters in 2016. All of the 2016 sites were above the 2 mg/l threshold for hypoxia, and only 4 fell below the 4 mg/l threshold for normoxic conditions (Table 1; Figure 6). The 2016 sites were above the state water quality criteria for DO saturation of >42% (Table 1; Figure 7). The percent silt+clay values in 2016 ranged from 2.6 to 54.2% and were not significantly different from 2008 ($p=0.08$), although sites CLB02 and CLB10 were substantially lower in 2016 (Table 1; Figure 8). The highest silt+clay values were at CLB03 in both years and was the only site with sediments classified as “muds” (>25.95% silt+clay) in 2016 (Table 1; Figure 8). The sediment total organic carbon (TOC) was not measured in 2008. The TOC in 2016 ranged from 0.5 to 3.7%. The highest TOC values were at the sites with the highest percent silt+clay (Table 1; Figure 9).

Table 1. Clam Bayou 2008 and 2016 bottom water quality and sediment parameters.

Salinity: Blue = polyhaline (18-30 psu); Unhighlighted = euhaline

Dissolved Oxygen: Green > 4.0 mg/l; Yellow = subnominal (2-4 mg/l); Red = hypoxic (<2 mg/l)

DO Saturation: Green = meets state water quality criteria (>42%); Red = below state water quality criteria (<42%)

Site	Depth (meters)		Temperature °C		Salinity psu		pH		Dissolved Oxygen mg/L		DO Saturation %		Silt+Clay %		TOC %	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	0.55	0.80	30.91	30.40	33.71	30.34	7.90	8.02	3.25	3.80	52.5	59.9	8.4	3.7	ND	0.9
CLB02	1.08	1.29	30.53	30.48	34.34	30.82	7.91	8.11	3.33	4.16	53.7	65.7	44.2	16.3	ND	3.7
CLB03	1.26	0.97	25.89	30.69	35.28	30.98	8.03	8.13	4.06	4.39	61.0	69.6	51.3	54.2	ND	3.6
CLB04	0.82	0.96	28.37	29.90	34.46	31.17	7.68	8.09	2.19	4.09	34.1	64.2	3.2	3.0	ND	2.5
CLB05	0.49	0.84	28.35	30.03	33.87	30.70	7.60	8.06	1.61	3.80	25.0	59.5	7.1	7.4	ND	1.0
CLB06	0.80	1.29	26.95	29.68	35.61	31.19	8.24	8.10	6.14	4.52	94.0	70.7	15.8	3.5	ND	0.5
CLB07	1.20	0.82	31.06	31.32	33.85	27.05	7.81	7.85	3.72	3.16	60.3	49.6	6.2	2.6	ND	0.7
CLB08	0.98	0.45	27.11	32.03	35.53	24.35	8.20	7.89	5.34	4.34	81.9	67.9	2.2	5.5	ND	0.5
CLB10	1.14	1.34	28.48	30.95	34.74	30.68	7.73	8.01	2.42	3.24	37.8	51.5	37.2	16.8	ND	3.6
CLB12	0.42	0.76	31.73	30.36	33.18	30.55	7.94	8.09	3.90	4.07	63.6	64.0	9.0	6.5	ND	2.1
Mean	0.87	0.95	28.94	30.58	34.46	29.78	7.90	8.04	3.60	3.96	56.4	62.3	18.5	12.0	ND	1.9
Median	0.90	0.90	28.43	30.44	34.40	30.69	7.91	8.08	3.53	4.08	57.0	64.1	8.7	6.0	ND	1.6
Min	0.42	0.45	25.89	29.68	33.18	24.35	7.60	7.85	1.61	3.160	25.0	49.6	2.2	2.6	ND	0.5
Max	1.26	1.34	31.73	32.03	35.61	31.19	8.24	8.13	6.14	4.52	94.0	70.7	51.3	54.2	ND	3.7

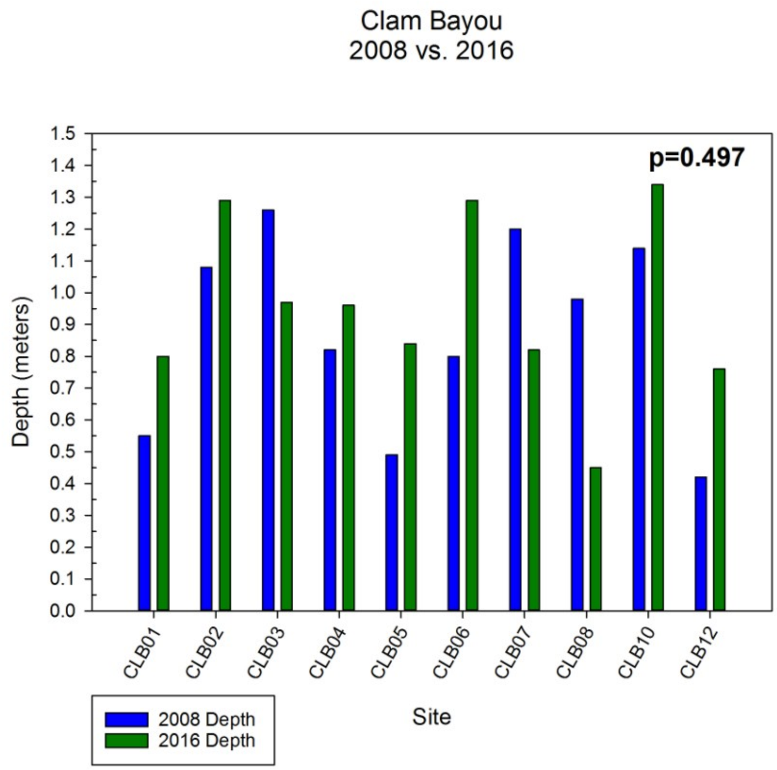

Figure 2. Clam Bayou 2008 vs. 2016 sample depth.

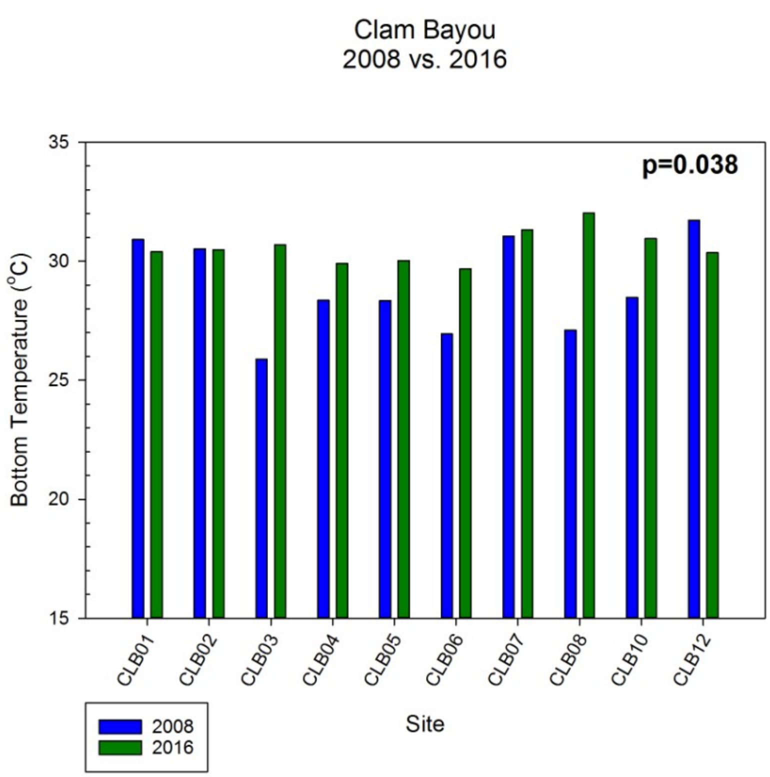

Figure 3. Clam Bayou 2008 vs. 2016 bottom temperature.

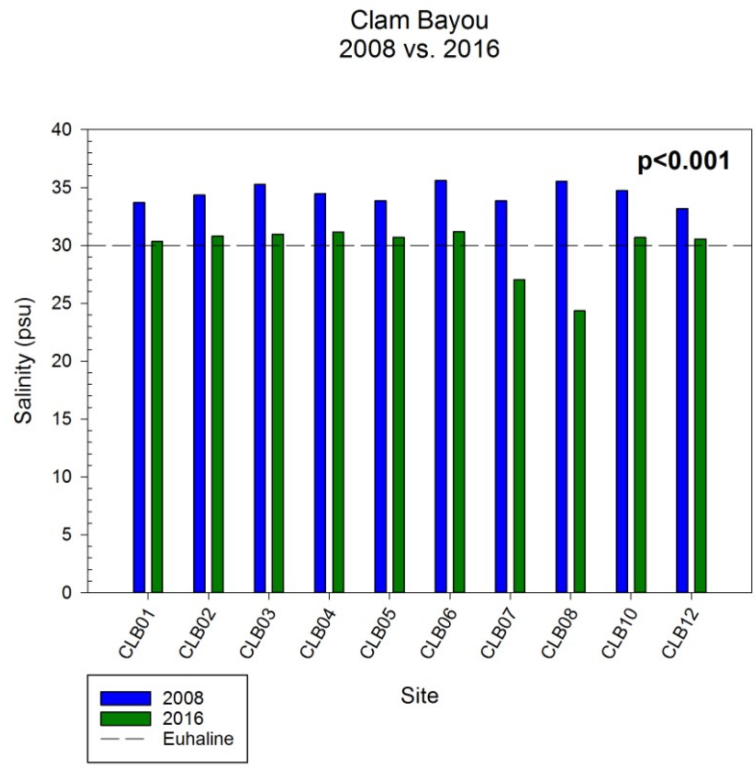

Figure 4. Clam Bayou 2008 vs. 2016 bottom salinities.

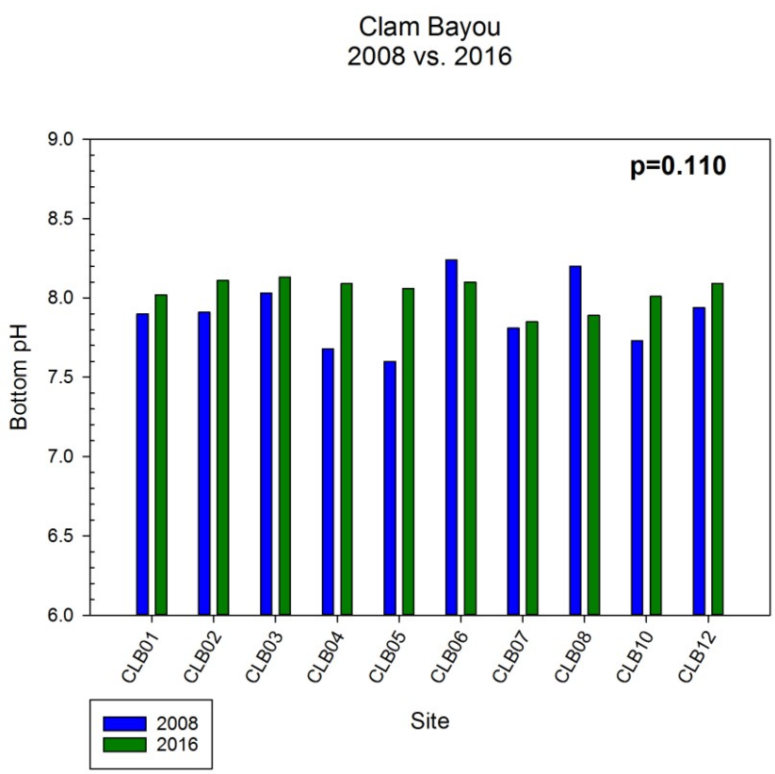

Figure 5. Clam Bayou 2008 vs. 2016 bottom pH.

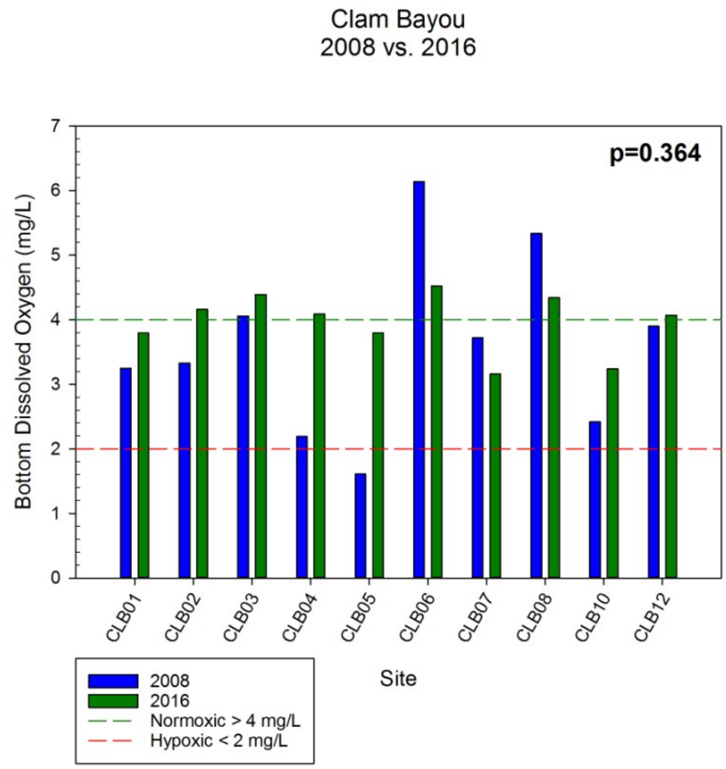

Figure 6. Clam Bayou 2008 vs. 2016 bottom dissolved oxygen.

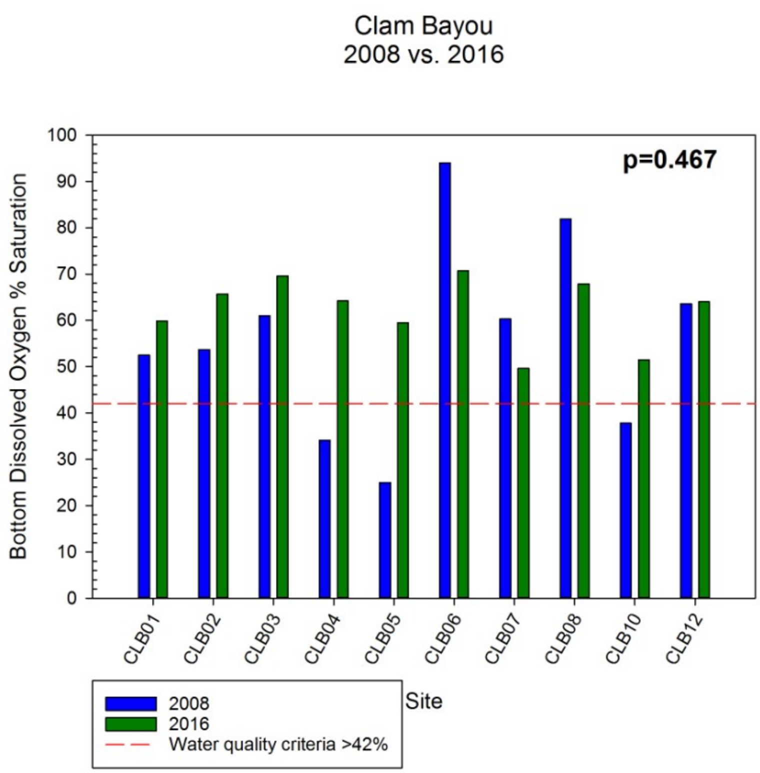

Figure 7. Clam Bayou 2008 vs. 2016 bottom dissolved oxygen saturation.

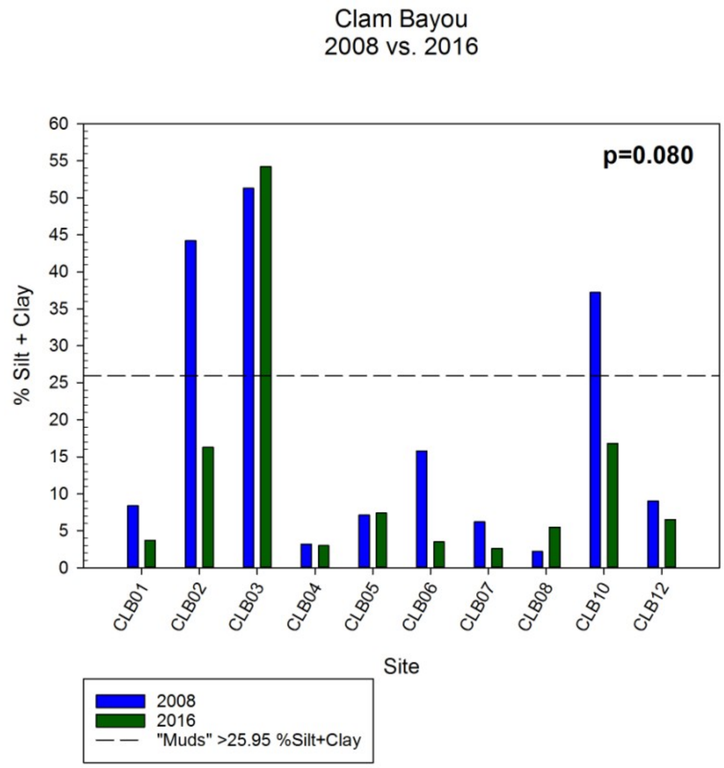

Figure 8. Clam Bayou 2008 vs. 2016 sediment percent silt + clay.

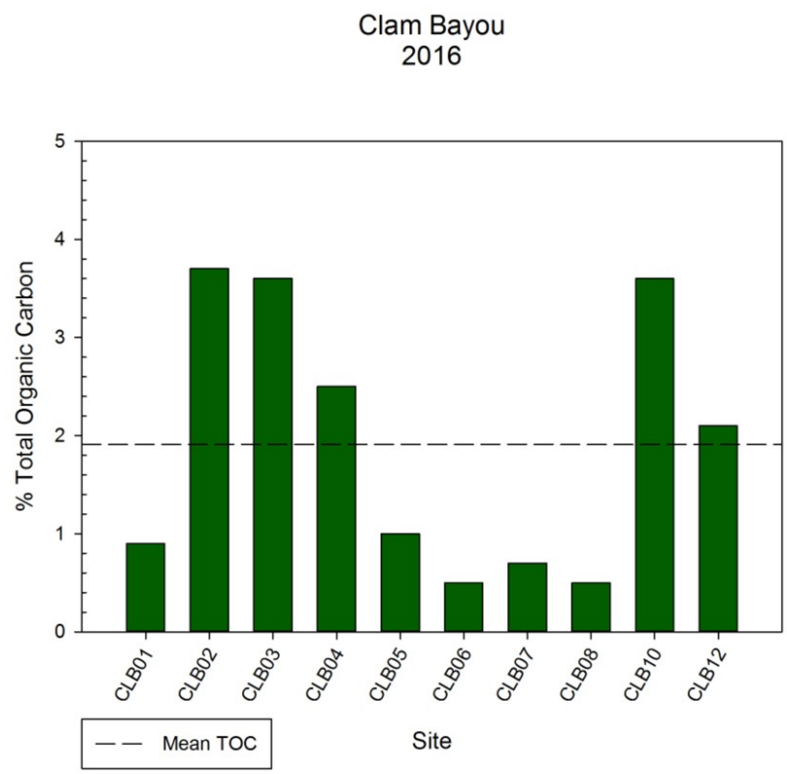

Figure 9. Calm Bayou 2016 total organic carbon.

Benthic Macrofaunal Community Analysis

A total of 149 taxa were identified in the 2016 Clam Bayou samples, while 108 taxa were identified in 2008 (excluding unidentified damaged/juvenile Gastropoda, Bivalvia, and Tellininae). The polychaete *Mediomastus* sp. is not included in this total since it may represent incomplete specimens of *M. californiensis* which was also present in both years. Annelids were the most diverse taxonomic group in both the 2016 and 2008 samples with 72 taxa (48% of total) identified in 2016 and 44 taxa (41% of the total) identified in 2008. Mollusks were the next most diverse group with 48 taxa in 2016 and 34 taxa in 2008 representing approximately 32% of the species total in both years. Species richness (*S*) ranged from 3 taxa at site 16CLB03 to 65 taxa at site 16CLB06 in 2016 (Table 2). The maximum number of taxa at any site in 2008 was 44 at 08CLB06 (Table 2). Species richness increases between 2016 and 2008 were most evident at sites CLB06, CLB07 and CLB 08, while several other sites showed a decrease in species richness (Table 2; Figure 10). The mean number of taxa per site was slightly higher in 2016 (Table 2) but there was no significant difference in species richness between the two sampling years (Figure 10; $p = 0.295$).

The overall abundance (raw count) was similar between 2016 and 2008 with 1,996 individual organisms counted in 2016 vs. 1,745 individual organisms in 2008. Annelids were the most abundant phylum in both years, accounting for approximately 63% of the total abundance in 2016 and 50% in 2008. The top three most abundant taxa accounted for a third of the overall abundance in both 2016 and 2008. The most abundant species in 2016 was the polychaete *Laeonereis culveri* which accounted for 16% of the total abundance and was found at 70% of the sites. The bivalve *Parastarte triquetra* (Brown Gem clam) was the second most abundant species in 2016 making up 10% of the total abundance and was found at 80% of the sites, and unidentified Oligochaetes (Tubificinae) ranked third making up 6% of the total abundance and were present at 70% of the sites. Unidentified Oligochaetes were the dominate taxon in 2008 accounting for 13% of the abundance and were found at 100% of the sites, while *Laeonereis culveri* and an unidentified gastropod (Rissooidea) each accounted for 10% of the overall abundance. Sample abundances (*N*) ranged from 125/m^2 at site 16CLB03 to 11,325/m^2 at site 16CLB07 (Table 2; Figure 11). The same site (CLB03) also had the lowest abundance in 2008 with 225/m^2 while the maximum abundance of 9,625/m^2 was at site 08CLB04 (Table 2). There was no significant difference in the mean abundance between 2008 and 2016 ($p = 0.564$) with decreases in abundance observed at sites CLB04 and CLB05 and notable increases at sites CLB06 and CLB07 (Table 2; Figure 11).

The Shannon diversity index (H'_{ln}) was not significantly different between 2008 and 2016 (Figure 12; $p = 0.703$). Several sites did show decreases in the Shannon diversity, notably at sites CLB01 and CLB12 which mirrored similar decreases in species richness (Figures 10 & 12). There was a relatively large increase in Shannon diversity at site CLB02, however the species richness and abundance at this site was much lower than most of the other sites (with the exception of CLB03) in both 2008 and 2016. The mean evenness index (*J'*) was similar between 2008 and 2016 and was not significantly different (Table 2; $p = 0.344$). Site CLB02 had a large increase in *J'* in 2016, which was due to the low abundance at this site distributed across only 5 taxa (Table 2).

The mean Tampa Bay Benthic Index (TBBI) scores were not significantly different between 2008 and 2016, however 60% of the sites did show an increase in their TBBI scores (Table 2; Figure 13). The TBBI scores in 2008 were generally near or below the “Degraded” threshold value of 73 and none were above the “Healthy” threshold value of 87 while in 2016 two sites had “Healthy” TBBI scores (CLB07 & CLB08) and two sites (CLB06 and CLB 10) were just below the “Healthy” threshold (Table 2; Figure 13).

Table 2. Clam Bayou benthic community summary metrics.

TBBI: Red= "Degraded" (<73); Yellow="Marginal" (73-87); Green="Healthy" (>87)

Site	Spp. Richness (S = # of taxa)		Abundance (N = #/m^2)		Shannon Diversity (H'_{ln})		Evenness ($J' = H'_{ln}/\ln S$)		TBBI	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	24	18	3750	5000	2.82	1.87	0.89	0.65	76.61	53.87
CLB02	2	5	650	175	0.16	1.55	0.24	0.96	64.69	68.39
CLB03	5	3	225	125	1.30	0.95	0.81	0.86	72.38	67.15
CLB04	30	23	9625	4850	2.38	2.12	0.70	0.68	72.24	45.65
CLB05	14	11	9425	6900	1.92	1.80	0.73	0.75	76.38	51.84
CLB06	44	65	5601	9075	3.17	3.26	0.84	0.78	62.75	86.73
CLB07	42	62	3750	11325	2.89	3.03	0.77	0.73	84.86	91.41
CLB08	32	49	3776	4975	3.01	3.25	0.87	0.83	38.56	92.75
CLB10	22	32	1925	2875	2.70	2.70	0.87	0.78	81.51	85.75
CLB12	31	20	4900	4600	2.97	1.96	0.87	0.65	71.70	79.80
Mean	24.6	28.8	4362.7	4990.0	2.33	2.25	0.76	0.77	70.17	72.33
Median	27	21.5	3763	4912.5	2.76	2.04	0.82	0.76	72.31	74.10
Min	2	3	225	125	0.16	0.95	0.24	0.65	38.56	45.65
Max	44	65	9625	11325	3.17	3.26	0.89	0.96	84.86	92.75

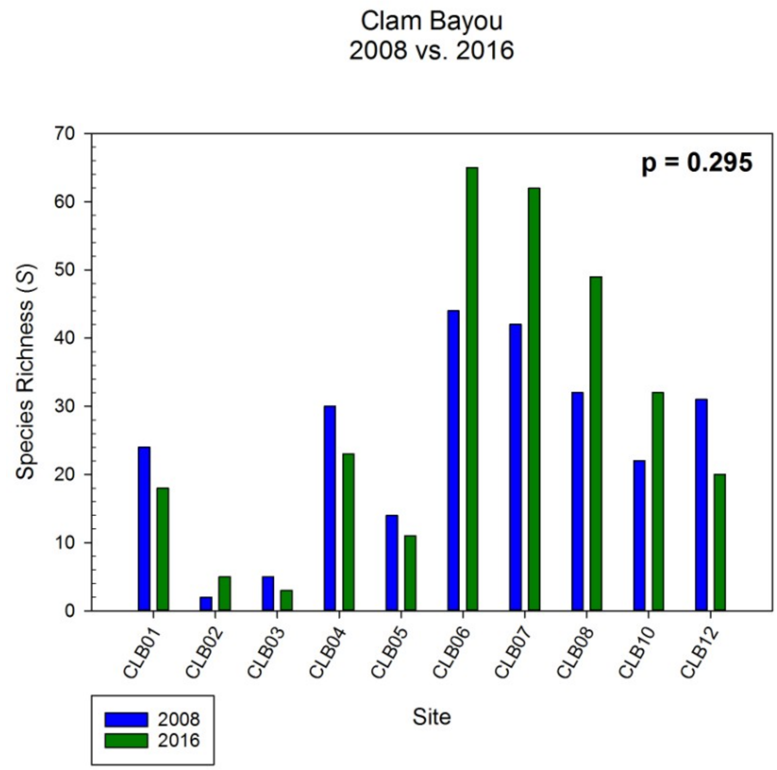

Figure 10. Clam Bayou 2008 vs. 2016 benthic species richness.

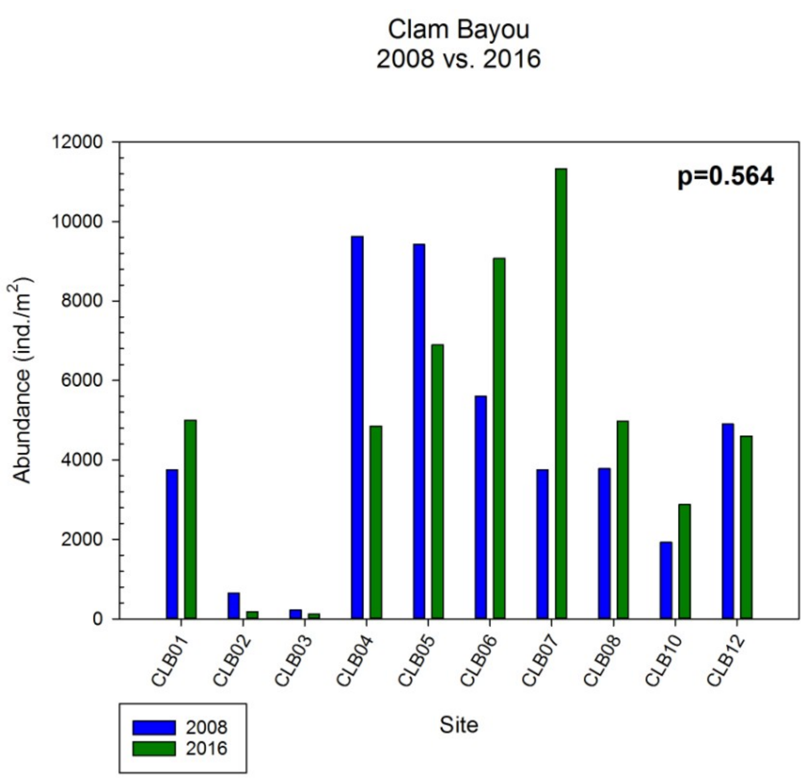

Figure 11. Clam Bayou 2008 vs. 2016 benthic abundance.

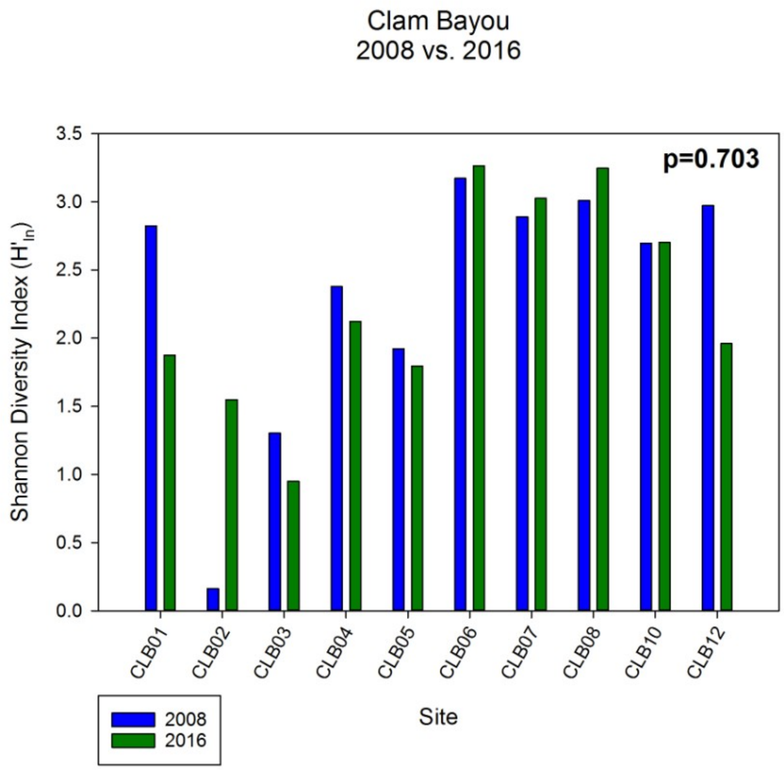

Figure 12. Clam Bayou 2008 vs. 2016 Shannon diversity index.

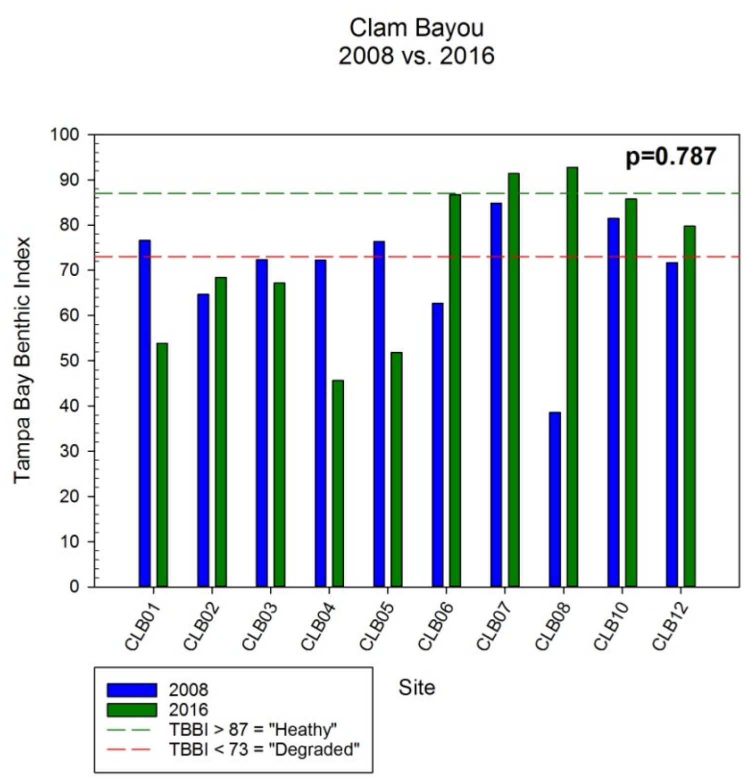

Figure 13. Clam Bayou 2008 vs 2016 Tampa Bay Benthic Index

The dominate taxa based on relative abundance at each site for 2008 and 2016 are presented in Table 3. Oligochaetes (unidentified Tubificinae and *Tubificoides wasselli*) dominated at sites CLB02 and CLB03 in 2008 and 2016. The polychaete *Laeonereis culveri*, and bivalve *Parastarte triquetra* in 2016 were among the dominant taxa at 50% and 40% of the sites respectively. Site CLB01 was dominated by aquatic insect larvae (Dolichopodidae) in 2008; however they were not present at any of the sites in 2016. The unidentified gastropod Rissooidea which was among the most abundant taxa in 2008 and dominant at site CLB05 was absent at the 2016 sites.

Table 3. Clam Bayou ranked relative abundance of benthic taxa by site and year.

CLB01		CLB02		CLB03		CLB04		CLB05	
2008	**2016**	**2008**	**2016**	**2008**	**2016**	**2008**	**2016**	**2008**	**2016**
Dolichopodidae (13.33%)	*Parastarte triquetra* (37.00%)	Tubificinae (96.15%)	*Tubificoides wasselli** (28.57%)	Tubificinae (55.56%)	*Tubificoides wasselli* (60.00%)	Tubificinae (32.31%)	*Laeonereis culveri* (38.66%)	Rissooidea (44.83%)	*Laeonereis culveri* (36.96%)
Laeonereis culveri (10.67%)	*Laeonereis culveri* (24.50%)		*Parastarte triquetra** (28.57%)			*Laeonereis culveri* (19.74%)	*Capitella capitata* spp. complex (18.56%)	Tubificinae (11.67%)	*Parastarte triquetra* (18.12%)
*Acteocina canaliculata** (9.33%)									
Eurytellina sp. A of EPC* (9.33%)									
Actiniaria (8.00%)									

Taxa represent 50% of the cumulative abundance at each site. Tied ranked abundances indicated by *.

Table 3. Continued

CLB06		CLB07		CLB08		CLB10		CLB12	
2008	**2016**	**2008**	**2016**	**2008**	**2016**	**2008**	**2016**	**2008**	**2016**
*Laeonereis culveri** (12.50%)	*Boguea enigmatica* (18.18%)	*Kirkegaardia dorsobranchialis* (24.00%)	Nereididae (23.62%)	*Capitella capitata* spp. complex (13.24%)	*Caecum pulchellum* (20.10%)	Bivalvia (16.88%)	*Kirkegaardia dorsobranchialis* (26.96%)	*Xenanthura brevitelson* (13.27%)	*Laeonereis culveri* (38.59%)
*Erichsonella attenuate** (12.50%)	*Neanthes acuminate* (12.67%)	*Eurytellina* sp. A of EPC (13.33%)	*Boguea enigmatica* (12.58%)	*Prionospio heterobranchia* (11.92%)	Tubificinae (8.04%)	*Tubificoides wasselli* (14.29%)	Tubificinae (11.30%)	*Acteocina canaliculata* (9.69%)	*Parastarte triquetra* (22.28%)
Heteromastus filiformis (10.71%)	Tubificinae (11.85%)	Tellininae (12.67%)	*Neanthes acuminate* (11.70%)	Tubificinae (8.61%)	*Costoanachis semiplicata* (7.54%)	*Mysella planulata* (10.39%)	*Laeonereis culveri* (10.43%)	*Laeonereis culveri** (9.18%)	
Prionospio heterobranchia (7.59%)	*Phascolion cryptum* (5.23%)		*Mysella planulata* (5.96%)	*Mediomastus* sp. (7.28%)	*Aricidea philbinae* (5.53%)	*Macoma cerina* (9.09%)	*Tubificoides wasselli* (9.57%)	*Parastarte triquetra** (9.18%)	
Erycina floridana (4.91%)	*Mediomastus sp*.* (3.58%)			*Tubificoides wasselli* (6.62%)	*Astyris lunata* (5.03%)			*Heteromastus filiformis* (7.14%)	
Magelona pettiboneae (4.46%)	*Tubificoides wasselli** (3.58%)			*Kirkegaardia dorsobranchialis* (5.96%)	*Polydora cornuta** (4.52%)			*Leitoscoloplos foliosus* (6.12%)	
					*Crepidula ustulatulina** (4.52%)				

Taxa represent 50% of the cumulative abundance at each site. Tied ranked abundances indicated by *.

Cluster analysis arranged the ten 2016 sites into three distinct groups (Figure 14). The red branches of the dendrogram display the results from a similarity profile (SIMPROF) test and indicate statistically significant groupings of sites (Clarke and Gorley 2006). The first group, designated as group “A”, consisted of sites 16CLB02 and 16CLB03. The remaining eight sites formed group “B” which was further divided into groups “B1” and “B2”. The “B1” group consisted of sites 16CLB01, 16CLB04, 16CLB05, and 08CLB12. Group “B2” consisted of sites 16CLB06, 16CLB07, 16CLB08 and 16CLB10 with 16CLB06 and 16CLB07 showing greater similarity in their species composition relative to the other “B2” sites (Figure 14). The 2016 benthic community structure was very similar to 2008 with the same sites generally grouping together (Figure 15). Cluster analysis on the combined 2008 and 2016 data (Figure 16) shows the benthic community at sites CLB02 and CLB03 grouping together within the same years (designated at Groups “A1” and “A2” for the 2008 and 2016 samples respectively). The remaining sites cluster together under group “B” with subgroups “B1” and “B2” and individual samples within these subgroups generally grouping together by year.

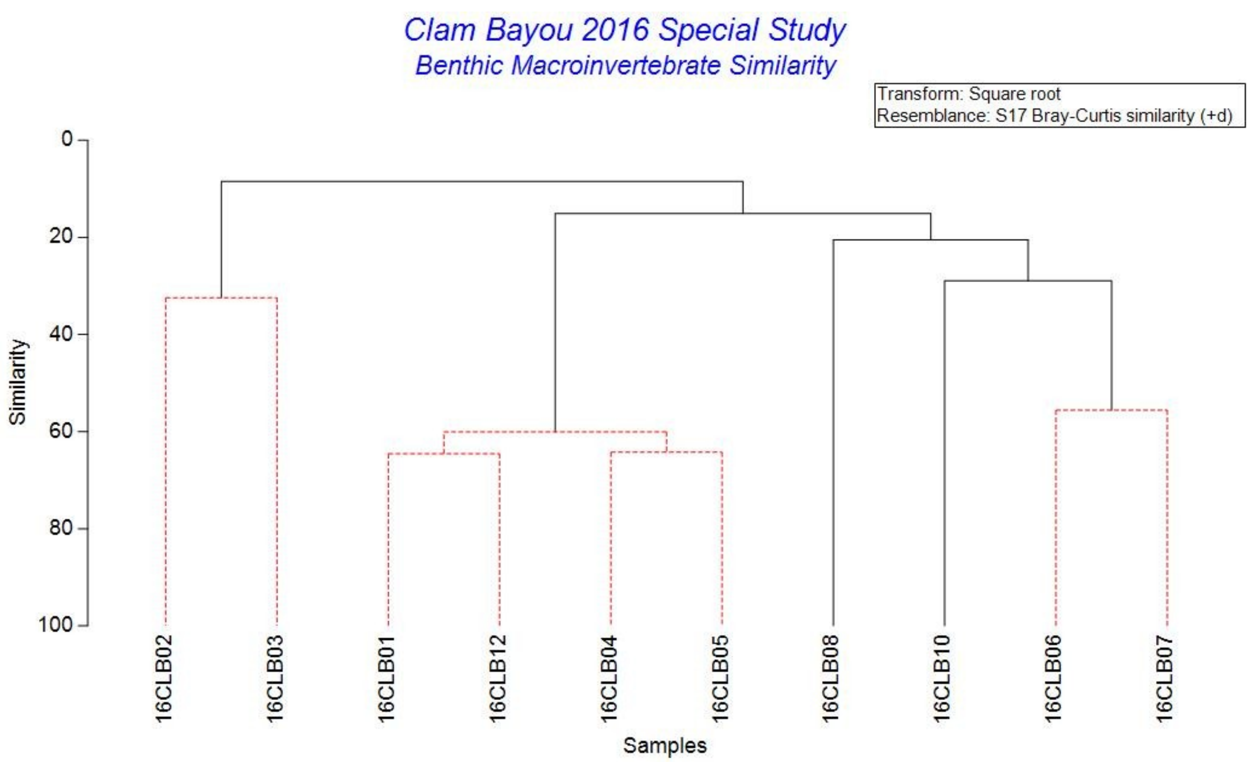

Figure 14. Bray-Curtis Similarity dendrogram of 2016 TBEP Clam Bayou sampling sites.

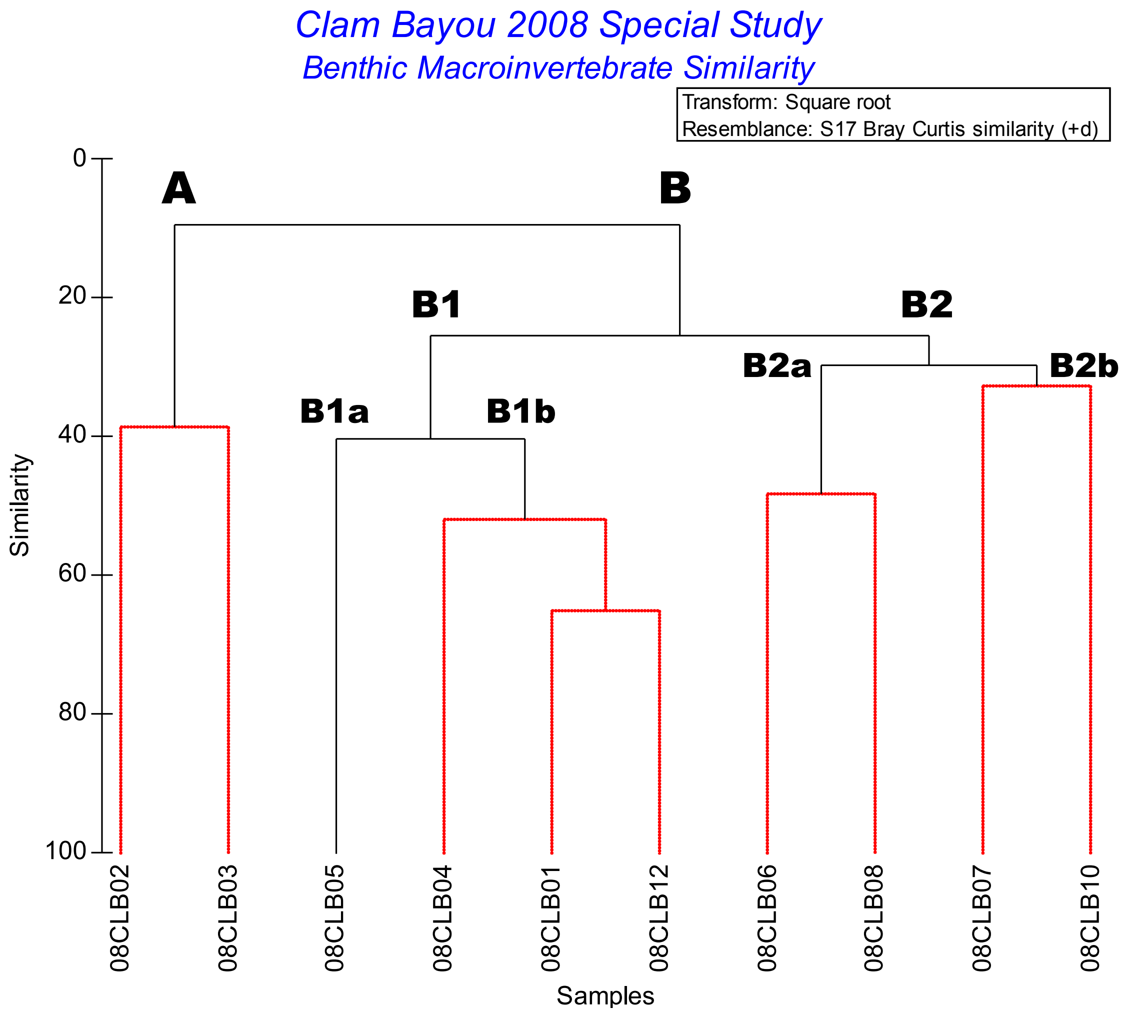

Figure 15. Bray-Curtis Similarity dendrogram of 2008 TBEP Clam Bayou sampling sites.

(from Karlen et al. 2009)

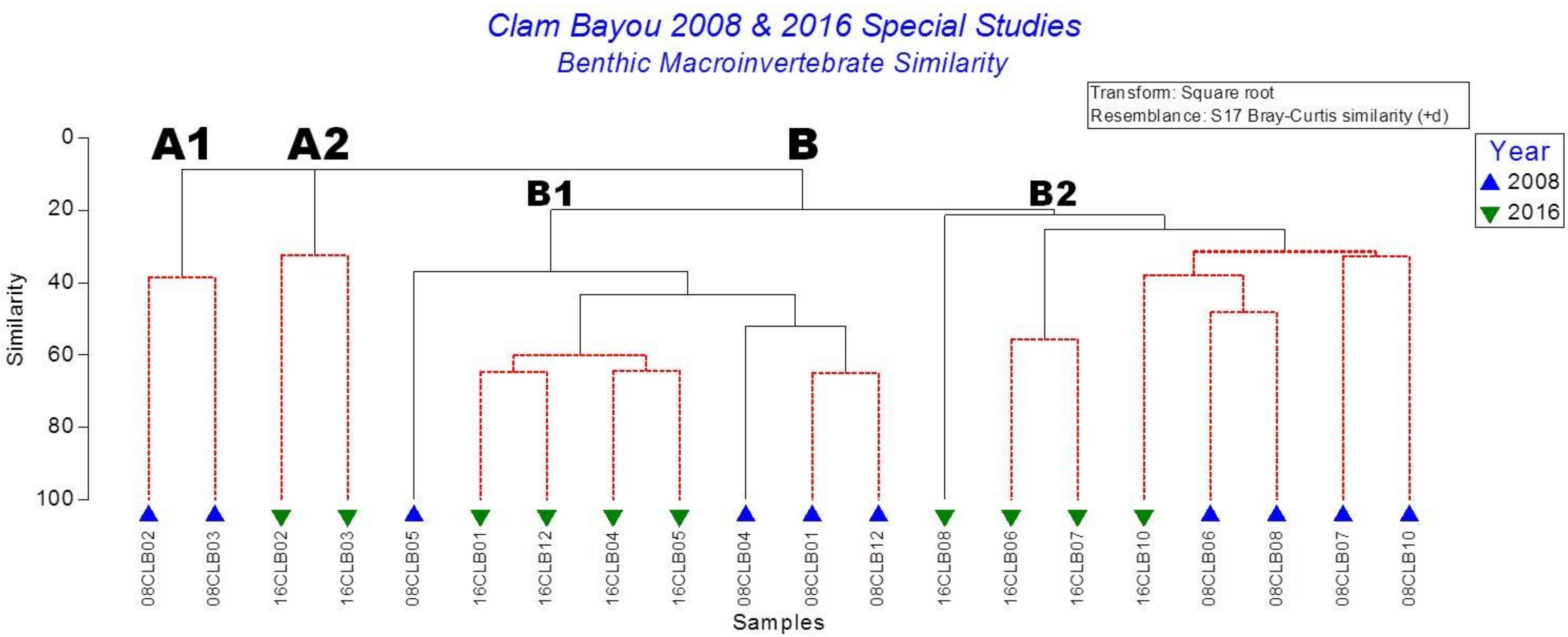

Figure 16. Bray-Curtis Similarity dendrogram of combined 2008 and 2016 Clam Bayou sampling sites.

Comparison on Biological and Physical Variables.

A BIO-ENV analysis was run on the water quality + silt/clay dataset to look for correlations between these various physical parameters and structure of the benthic community seen in the similarity analysis. The highest correlation ($\rho = 0.515$) was due to a combination the percent silt+clay and bottom temperature. The percent silt+clay had the strongest single variable correlation ($\rho = 0.336$) of the measured parameters followed by bottom temperature ($\rho = 0.282$).

Sediment Contaminants

The metals analysis is presented in Table 4. The metal:aluminum regressions shown in Figure 17 suggest that the metals concentrations in Clam Bayou were not elevated above natural levels. Several metals (antimony, arsenic, cadmium, selenium, silver and tin) were below the method detection limit (<MDL) at all sites in 2016 (Table 4). Chromium (Cr) was above its TEL at site CLB03 in 2016 but there was no significant difference in the sediment Cr concentrations between years (Figure 18; p=0.703). Copper exceeded its TEL at the same three sites in 2008 and 2016, but was not significantly different between the two years (Figure 19; p=0.970). Lead was above its TEL at three sites and exceeded its PEL at site CLB03 in 2016 (Table 4; Figure 20), however there was no significant difference (p=0.297) between years. Zinc exceeded its PEL at site CLB03 in 2016 and was above its TEL at CLB02 in 2016 (Table 4; Figure 21). Several sites showed a decrease in zinc concentrations from 2008 to 2016, but there was no significant difference between years (p=0.344; Figure 21).

Chlorinated pesticides and total polychlorinated biphenyls (PCBs) concentrations are shown in Table 5., Only two of 23 compounds showed significant changes between 2008 and 2016: β-BHC which increased (p=0.002), and Endrin which decreased (p=0.017)(Table 5). Seven of the measured pesticides have established sediment quality guidelines and seven of the ten sites showed elevated levels for at least one of these pesticides in 2016. There were three sites that did not have high pesticide levels in 2016; site CLB04 also did not have high pesticides in 2008 while sites CLB06 and CLB07 showed large decreases in Lindane, DDT, total Chlordane and PCBs (Table 5). Lindane exceeded its PEL at four sites in 2016 (versus two sites in 2008) and was above the TEL at 16CLB01 (Table 5; Figure 22). Notable increases in Lindane were observed at CLB01, CLB02, CLB08 and CLB12 (Table 5; Figure 22), however the mean difference between years was not statistically significant (p=0.131). Dieldrin concentrations were above its PEL at site CLB02 in 2016 and above the TEL at CLB05 and CLB12 (Table 5; Figure 23). DDT or one of its breakdown compounds (p,p'-DDT, p,p'-DDE, p,p'-DDD) were elevated at six of the ten sites in 2016 vs. eight sites in 2008 (Table 5). Both p,p'-DDD and p,p'-DDE exceeded their PELs at CLB02 in 2016 (Table 5; Figures 24&25) and p,p'-DDT was above its PEL at CLB08 (Figure 26). Total DDT was above its PEL at CLB02 in 2016 and exceeded its TEL at four other sites (Table 5; Figure 27). Total Chlordane exceeded its PEL at four sites and was above its TEL at two additional sites (Table 5; Figure 28). The Total PCB concentrations were above the TEL at two sites in 2016, compared to four sites in 2008 (Table 5; Figure 29).

Polycyclic aromatic hydrocarbons (PAHs) exhibited high concentrations at all sites, but most PAHs were significantly lower in 2016 compared to 2008 (Table 6, 7 & 8). The low molecular weight PAHs (LMW PAH) concentrations were generally lower than the high molecular weight PAHs (HMW PAH) (Table 6 & 7). The LMW PAH Acenaphthene was below the MDL at eight of the ten sites in 2008, with one site exceeding the PEL and one above the TEL versus no PEL exceedences in 2016, but above the TEL at seven sites (Table 6: Figure 30). Acenaphthylene was above the TEL at all sites in 2016 and was significantly higher than in 2008 ($p<0.001$) but all the sites were below the MDL (Table 6; Figure 31). There was no significant difference in sediment concentrations for Anthracene between years ($p=0.152$) although values were lower in 2016 at all sites with the exception of CLB04 which exceeded the PEL (Table 6; Figure 32). Fluorene and Naphthalene also were not significantly different between years ($p=0.740$ & 0.093 respectively). Fluorene did exceed its TEL at five sites in 2016 (versus four sites in 2008) while Naphthalene had no TEL exceedences in 2016 (Table 6: Figures 33 & 34). Sediment concentrations of Phenanthrene were significantly lower in 2016 ($p=0.022$) but it still exceeded its PEL at three sites (Table 6; Figure 35) The total LMW PAHs were significantly lower in 2016 ($p=0.034$) and showed decreases at every site since 2008 except for CLB04, which was the only site that exceeded the PEL in 2016 (Table 6; Figure 36).

The six constituent HMW PAHs all exceeded their PEL concentrations at four or more of the ten sites in 2016 (Table 7). Benzo(a) anthracene had significantly lower sediment concentrations in 2016 relative to 2008 ($p=0.024$) but still exceeded its PEL at six sites (Table 7; Figure 37). Benzo(a) pyrene also was significantly lower in 2016 ($p=0.029$) but remained above its PEL at six sites and above the TEL at the remaining four sites (Table 7; Figure 38). Sediment concentrations of Chrysene were significantly lower in 2016 ($p=0.021$) with six sites above the PEL (Table 7; Figure 39). Dibenzo(a,h) anthracene exceeded its PEL at seven sites and was above the TEL at the remaining three sites in 2016 but still was significantly lower ($p=0.026$) than in 2008 (Table 7; Figure 40). Fluoranthene and Pyrene also both had significant decreases in their sediment concentrations between 2008 and 2016 ($p=0.017$ and 0.037 respectively), with Fluoranthene exceeding its PEL at five sites and Pyrene at six sites in 2016 (Table 7; Figures 41 & 42). The total HMW PAH levels were significantly lower in 2016 ($p=0.024$) with five sites above the PEL and four sites exceeding the TEL (Table 7; Figure 43). This compares to 2008 when seven sites were above the PEL, with the remaining three sites above the TEL (Table 7). Total PAHs (sum of the LMW and HMW PAHs) was not above the PEL at any site in 2016, but did exceeded the TEL at eight sites (Table 7; Figure 44). Total PAHs were significantly lower in 2016 ($p=0.024$). Highest PAH concentrations in 2016 were found at sites CLB03 and CLB04 while sites CLB08 and CLB07 had the lowest PAH concentrations (Table 7). Six additional PAHs which do not have established sediment quality guideline were also evaluated. These are summarized in Table 8 and Figures 45-50. All six PAHs had significantly lower sediment concentrations in 2016 relative to 2008 with the exception of Retene ($p=0.300$) which was below its MDL at seven sites in 2008, but detected in at nine sites in 2016 (Table 8, Figure 49).

Table 4. Clam Bayou 2008 and 2016 sediment metals concentrations (mg/kg).

MDL = Method Detection Limit; TEL = Threshold Effects Level; PEL = Potential Effects Level.

Yellow highlighting indicates >TEL concentration. Red highlighting indicates >PEL concentration.

Site	Aluminum		Antimony		Arsenic		Cadmium		Chromium		Copper		Iron	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	2291.03	1003.33	11.89	<MDL	6.18	<MDL	1.58	<MDL	9.39	6.58	11.00	3.67	1402.91	646.81
CLB02	6174.61	5604.62	16.98	<MDL	<MDL	<MDL	2.01	<MDL	23.38	36.94	32.87	53.35	3973.00	5059.60
CLB03	8665.62	9306.55	19.45	<MDL	<MDL	<MDL	2.33	<MDL	39.58	63.61	67.05	102.11	7198.73	10651.75
CLB04	1615.29	852.48	12.95	<MDL	5.11	<MDL	1.51	<MDL	7.08	5.39	8.43	<MDL	1142.05	570.25
CLB05	1428.96	1715.43	11.29	<MDL	7.63	<MDL	1.64	<MDL	5.92	9.05	7.23	12.95	855.91	1403.84
CLB06	3226.80	471.00	14.60	<MDL	<MDL	<MDL	1.67	<MDL	10.72	4.75	11.14	<MDL	1896.53	423.34
CLB07	3043.92	409.27	13.45	<MDL	<MDL	<MDL	1.62	<MDL	10.05	4.71	14.08	<MDL	1804.81	329.06
CLB08	1448.83	84.99	15.36	<MDL	8.49	<MDL	1.77	<MDL	4.84	6.62	4.46	3.93	692.62	<MDL
CLB10	6636.23	3834.39	18.05	<MDL	<MDL	<MDL	2.75	<MDL	29.15	19.70	45.06	27.25	5588.65	4073.67
CLB12	3045.85	1195.50	15.29	<MDL	5.21	<MDL	2.13	<MDL	13.06	8.56	16.23	4.53	2112.06	814.91
Mean	3757.71	2447.76	14.93	<MDL	6.52	<MDL	1.90	<MDL	15.32	16.59	21.76	29.68	2666.73	2663.69
Median	3044.89	1099.42	14.95	<MDL	6.18	<MDL	1.72	<MDL	10.39	7.59	12.61	12.95	1850.67	814.91
Min	1428.96	84.99	11.29	<MDL	5.11	<MDL	1.51	<MDL	4.84	4.71	4.46	3.67	692.62	329.06
Max	8665.62	9306.55	19.45	<MDL	8.49	<MDL	2.75	<MDL	39.58	63.61	67.05	102.11	7198.73	10651.75

Table 4. Continued

Site	Lead		Manganese		Nickel		Selenium		Silver		Tin		Zinc	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	31.97	29.36	7.88	5.64	5.35	3.84	4.71	<MDL	<MDL	<MDL	8.17	<MDL	38.75	14.20
CLB02	66.39	93.60	16.91	19.04	6.59	8.41	8.97	<MDL	<MDL	<MDL	4.12	<MDL	103.73	147.83
CLB03	88.49	127.94	29.49	41.45	10.10	13.27	7.66	<MDL	<MDL	<MDL	4.22	<MDL	209.06	304.83
CLB04	20.84	24.84	9.86	6.82	4.24	3.43	4.72	<MDL	<MDL	<MDL	6.02	<MDL	36.42	8.33
CLB05	22.95	34.88	4.96	9.58	4.74	4.23	6.48	<MDL	<MDL	<MDL	6.65	<MDL	57.38	58.83
CLB06	17.98	21.13	9.44	5.32	4.89	2.48	6.41	<MDL	<MDL	<MDL	6.31	<MDL	49.69	<MDL
CLB07	20.86	21.62	9.38	3.92	4.86	2.96	5.74	<MDL	<MDL	<MDL	5.83	<MDL	54.72	<MDL
CLB08	15.41	26.12	6.68	5.56	4.47	3.67	5.26	<MDL	<MDL	<MDL	7.76	<MDL	31.59	8.03
CLB10	76.12	56.11	24.38	16.51	8.88	5.81	8.69	<MDL	<MDL	<MDL	4.49	<MDL	214.79	115.58
CLB12	43.27	30.18	10.04	8.52	5.74	3.73	6.07	<MDL	<MDL	<MDL	6.97	<MDL	80.03	21.47
Mean	40.43	46.58	12.90	12.24	5.99	5.18	6.47	<MDL	<MDL	<MDL	6.05	<MDL	87.62	84.89
Median	27.46	29.77	9.65	7.67	5.12	3.79	6.24	<MDL	<MDL	<MDL	6.17	<MDL	56.05	40.15
Min	15.41	21.13	4.96	3.92	4.24	2.48	4.71	<MDL	<MDL	<MDL	4.12	<MDL	31.59	8.03
Max	88.49	127.94	29.49	41.45	10.10	13.27	8.97	<MDL	<MDL	<MDL	8.17	<MDL	214.79	304.83

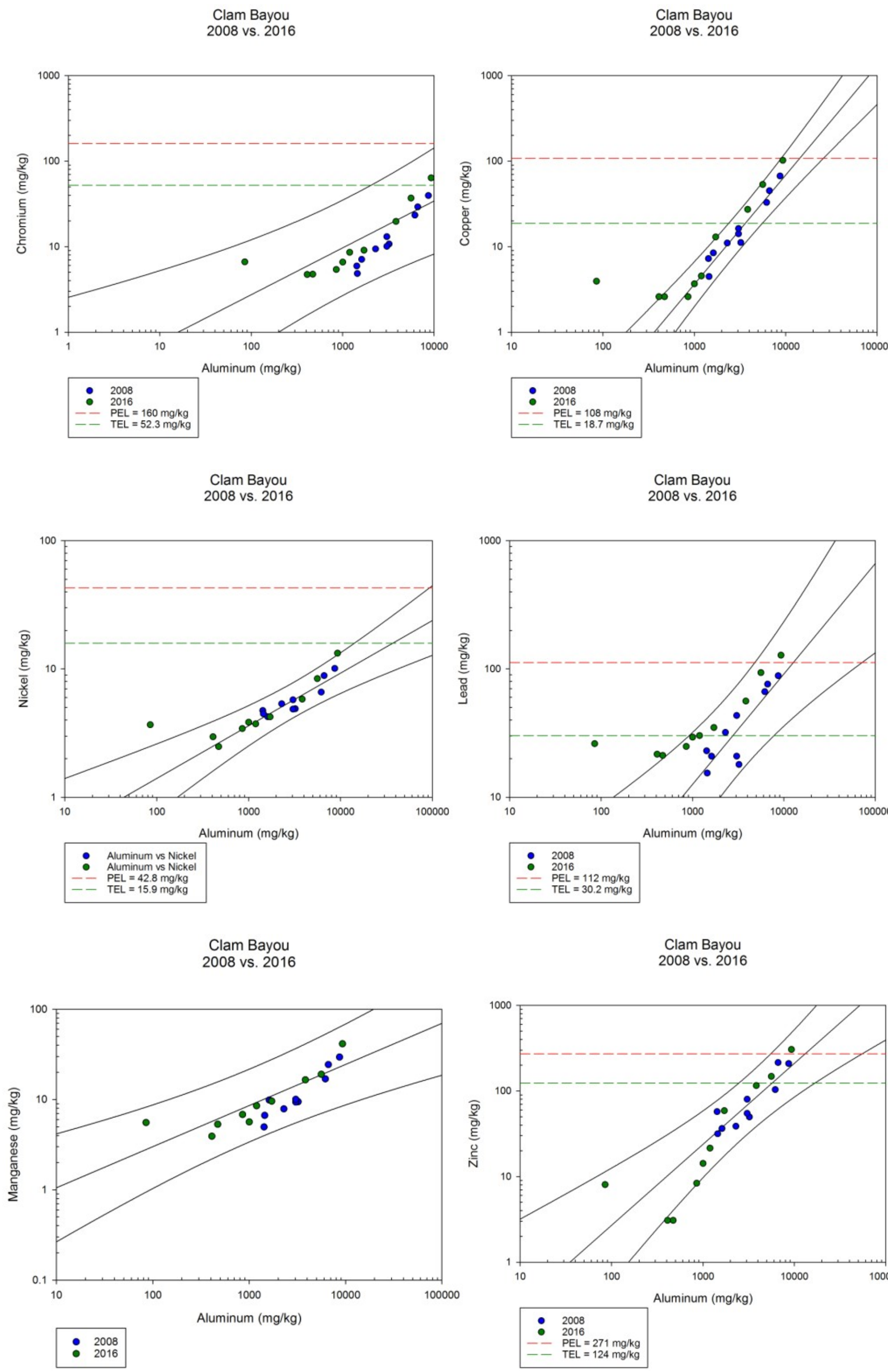

Figure 17. Clam Bayou 2008 and 2016 metals:aluminum regressions.

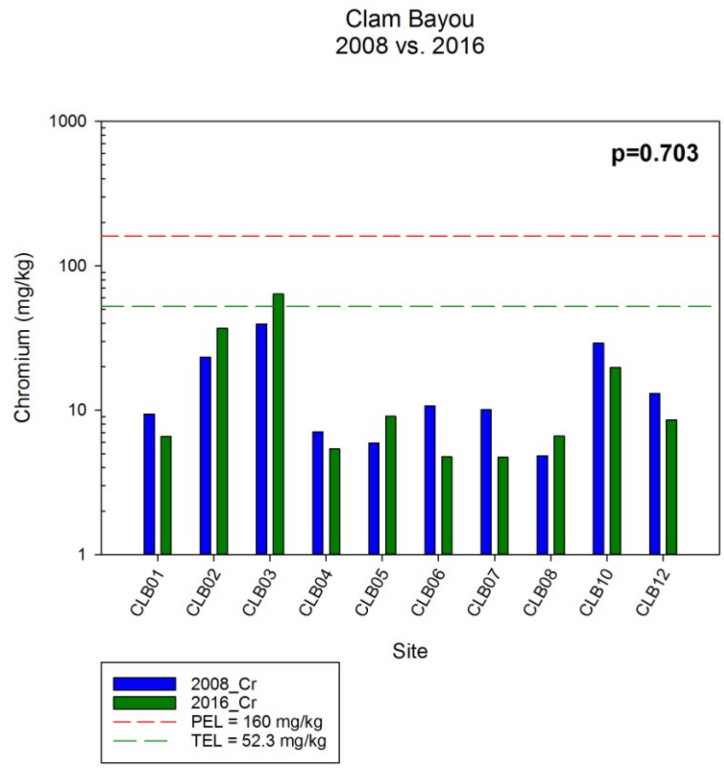

Figure 18. Clam Bayou 2008 vs. 2016 sediment chromium concentrations.

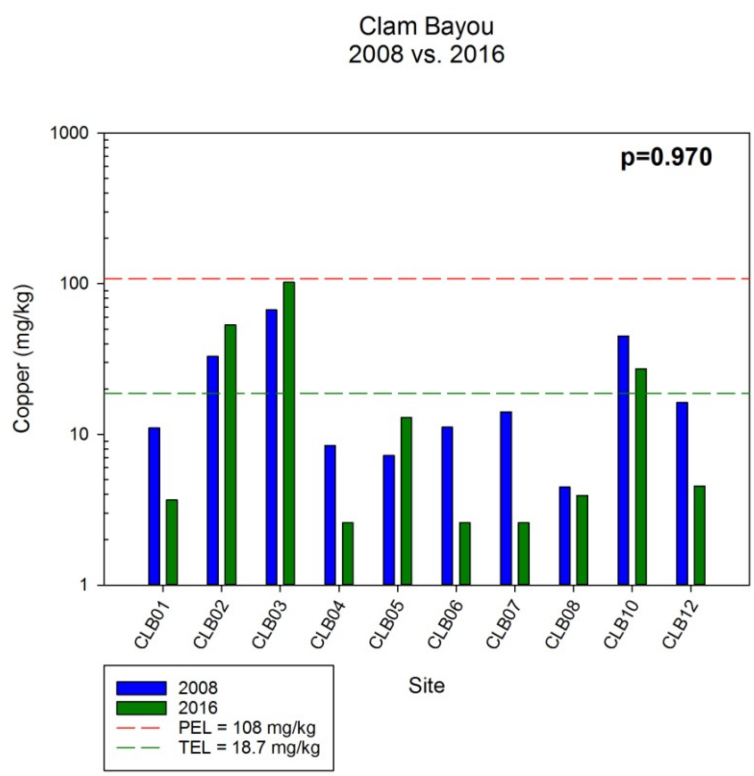

Figure 19. Clam Bayou 2008 vs. 2016 sediment copper concentrations.

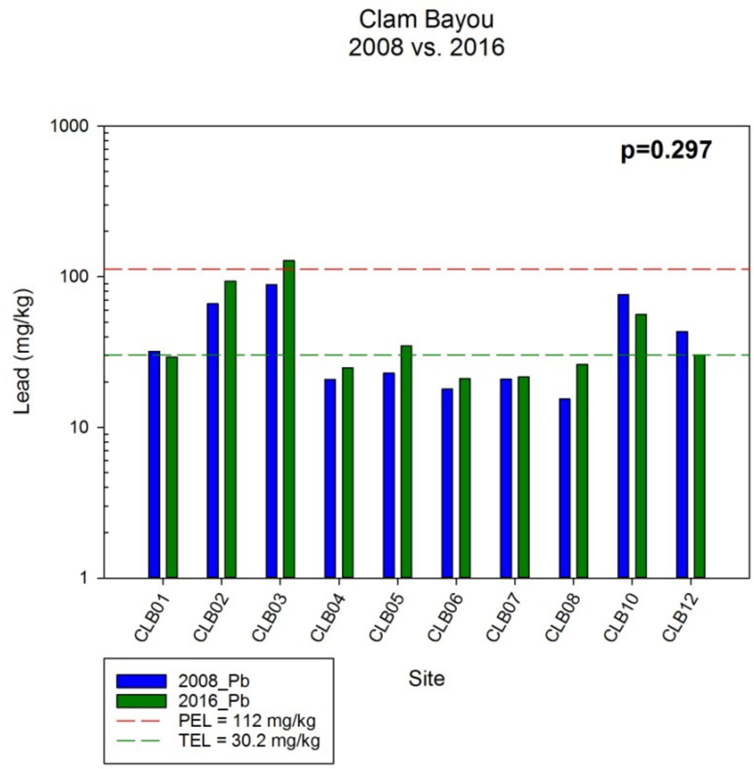

Figure 20. Clam Bayou 2008 vs. 2016 sediment lead concentrations.

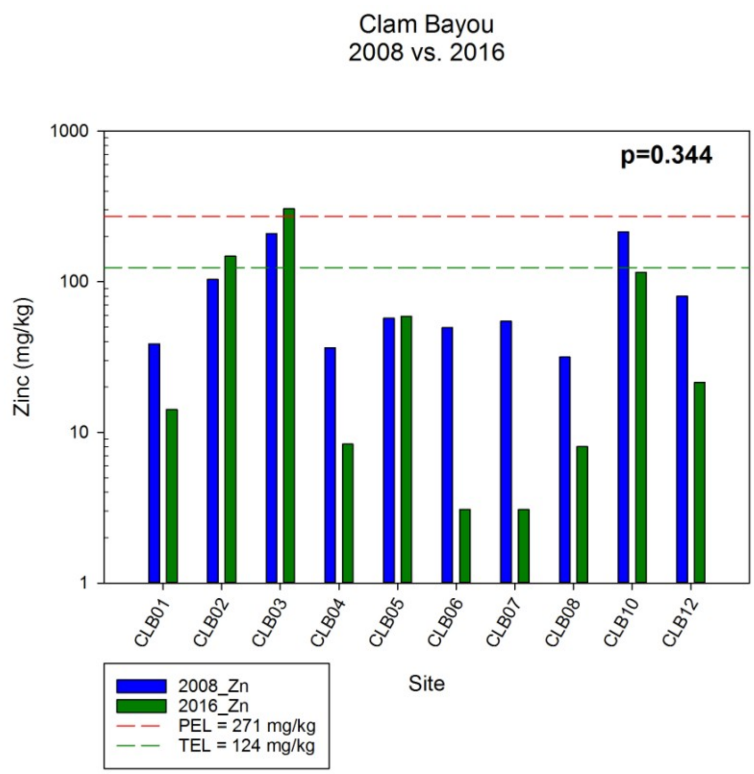

Figure 21. Clam Bayou 2008 vs. 2016 sediment zinc concentrations.

Table 5. Clam Bayou 2008 and 2016 sediment chlorinated pesticides and and total PCB concentrations (µg/kg).

MDL = Method Detection Limit; TEL = Threshold Effects Level; PEL = Potential Effects Level.

Yellow highlighting indicates >TEL concentration. Red highlighting indicates >PEL concentration.

Site	αBHC		βBHC		δBHC		Lindane (γBHC)		Aldrin		Dieldrin	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	<MDL	<MDL	<MDL	696.96	<MDL	1.26	<MDL	0.84	<MDL	0.36	<MDL	0.83
CLB02	<MDL	<MDL	<MDL	1794.65	0.55	8.07	0.83	5.00	3.09	3.78	2.88	6.40
CLB03	<MDL	0.09	<MDL	245.07	<MDL	0.11	0.22	0.07	3.26	<MDL	2.18	<MDL
CLB04	<MDL	0.68	<MDL	8.47	0.21	<MDL	<MDL	<MDL	0.94	<MDL	0.45	<MDL
CLB05	0.67	1.95	18.05	1558.59	<MDL	2.70	1.11	1.66	0.54	0.68	1.80	1.04
CLB06	1.02	<MDL	1.02	37.95	1.43	<MDL	1.52	0.10	1.35	<MDL	2.02	<MDL
CLB07	<MDL	<MDL	13.78	574.76	<MDL	0.79	0.23	0.12	0.30	0.10	1.80	<MDL
CLB08	<MDL	3.83	<MDL	882.86	0.24	5.24	0.21	3.78	0.14	1.35	0.21	<MDL
CLB10	0.20	0.35	<MDL	2006.38	0.65	0.14	0.50	0.05	0.32	<MDL	0.61	<MDL
CLB12	0.11	3.84	<MDL	743.47	<MDL	5.24	0.45	3.40	0.38	2.28	0.23	2.13
Mean	0.50	1.79	10.95	854.92	0.62	2.94	0.63	1.67	1.15	1.43	1.35	2.60
Median	0.44	1.32	13.78	720.22	0.55	1.98	0.48	0.84	0.54	1.02	1.80	1.59
Min	0.11	0.09	1.02	8.47	0.21	0.11	0.21	0.05	0.14	0.10	0.21	0.83
Max	1.02	3.84	18.05	2006.38	1.43	8.07	1.52	5.00	3.26	3.78	2.88	6.40

Table 5. continued

Site	Endosulfan_I		Endosulfan_II		Endosulfan SO4		Heptachlor		Heptachlor Epoxide		p,p'-DDD		p,p'-DDE		p,p'-DDT		Total DDT	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	<MDL	<MDL	<MDL	0.56	0.08	<MDL	<MDL	0.48	<MDL	<MDL	<MDL	1.29	<MDL	5.09	<MDL	0.78	0.11	7.16
CLB02	<MDL	0.21	0.39	<MDL	0.94	<MDL	<MDL	3.79	0.64	<MDL	<MDL	10.14	2.10	41.43	10.24	0.33	12.34	51.90
CLB03	<MDL	<MDL	<MDL	<MDL	0.30	<MDL	<MDL	0.11	<MDL	<MDL	<MDL	1.84	31.36	<MDL	28.29	0.25	59.65	2.09
CLB04	<MDL	<MDL	<MDL	0.22	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.33	1.58	<MDL	1.18	<MDL	2.76	0.35
CLB05	0.96	<MDL	3.03	<MDL	0.69	<MDL	<MDL	0.67	<MDL	<MDL	2.29	2.37	15.92	2.13	0.68	4.49	18.89	8.99
CLB06	0.55	<MDL	1.59	<MDL	0.98	<MDL	<MDL	<MDL	0.93	<MDL	4.93	<MDL	0.26	<MDL	36.30	<MDL	41.49	0.00
CLB07	<MDL	0.13	0.38	<MDL	1.22	<MDL	<MDL	0.67	0.18	0.33	5.62	<MDL	0.54	0.09	9.90	0.17	16.06	0.37
CLB08	<MDL	<MDL	0.22	<MDL	0.20	<MDL	<MDL	1.60	<MDL	<MDL	0.73	4.06	3.62	<MDL	1.73	7.94	6.08	12.00
CLB10	<MDL	<MDL	1.05	<MDL	0.63	0.86	1.18	0.09	0.79	1.13	7.80	0.91	2.84	<MDL	<MDL	<MDL	10.64	0.91
CLB12	0.58	<MDL	1.90	<MDL	0.91	<MDL	<MDL	1.53	0.21	<MDL	3.08	4.88	44.72	4.56	6.89	0.04	54.69	9.48
Mean	0.70	0.17	1.22	0.39	0.66	0.86	1.18	1.12	0.55	0.73	4.08	3.23	11.44	10.66	11.90	2.00	22.27	9.33
Median	0.58	0.17	1.05	0.39	0.69	0.86	1.18	0.67	0.64	0.73	4.01	2.11	2.84	4.56	8.40	0.33	14.20	4.63
Min	0.55	0.13	0.22	0.22	0.08	0.86	1.18	0.09	0.18	0.33	0.73	0.33	0.26	0.09	0.68	0.04	0.11	0.00
Max	0.96	0.21	3.03	0.56	1.22	0.86	1.18	3.79	0.93	1.13	7.80	10.14	44.72	41.43	36.30	7.94	59.65	51.90

Table 5. Continued

Site	Endrin		Endrin Aldehyde		Endrin Ketone		Methoxychlor		Mirex		α-Chlordane		γ-Chlordane		Total Chlordane		Total PCBs	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	<MDL	<MDL	<MDL	<MDL	<MDL	1.67	<MDL	<MDL	<MDL	<MDL	<MDL	1.79	<MDL	3.56	0.00	5.35	1.87	15.10
CLB02	0.59	1.20	2.24	1.44	<MDL	2.86	<MDL	14.25	1.32	4.26	0.66	9.04	<MDL	351.85	0.66	360.89	19.38	127.60
CLB03	<MDL	<MDL	1.64	0.27	<MDL	5.00	<MDL	2.93	1.01	6.17	10.46	0.28	13.96	3.92	24.42	4.20	15.53	2.15
CLB04	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.20	<MDL	<MDL	<MDL	0.20	0.00	2.17	2.95
CLB05	5.86	<MDL	<MDL	<MDL	1.59	0.43	3.03	16.00	0.57	<MDL	6.15	0.47	4.91	1.88	11.06	2.35	25.64	1.05
CLB06	10.61	<MDL	<MDL	<MDL	3.47	<MDL	9.52	1.84	2.91	0.47	15.49	<MDL	4.85	0.79	20.34	0.79	42.26	2.38
CLB07	2.74	<MDL	2.16	<MDL	<MDL	<MDL	<MDL	<MDL	3.69	0.25	16.03	<MDL	11.64	<MDL	27.67	0.00	44.78	14.02
CLB08	3.74	<MDL	0.81	3.94	0.88	<MDL	<MDL	<MDL	<MDL	<MDL	0.70	0.88	<MDL	0.56	0.70	1.44	2.41	<MDL
CLB10	6.94	<MDL	<MDL	<MDL	0.43	2.35	2.14	5.39	2.13	2.11	0.92	0.19	0.48	506.75	1.40	506.94	76.91	74.12
CLB12	5.40	0.47	<MDL	<MDL	<MDL	2.28	1.86	<MDL	0.71	<MDL	3.69	1.64	6.32	14.12	10.01	15.76	16.68	3.48
Mean	5.13	0.84	1.71	1.88	1.59	2.43	4.14	8.08	1.76	2.65	6.03	2.04	7.03	110.43	9.65	89.77	24.76	26.98
Median	5.40	0.84	1.90	1.44	1.24	2.32	2.59	5.39	1.32	2.11	3.69	0.88	5.62	3.74	5.71	3.28	18.03	3.48
Min	0.59	0.47	0.81	0.27	0.43	0.43	1.86	1.84	0.57	0.25	0.20	0.19	0.48	0.56	0.00	0.00	1.87	1.05
Max	10.61	1.20	2.24	3.94	3.47	5.00	9.52	16.00	3.69	6.17	16.03	9.04	13.96	506.75	27.67	506.94	76.91	127.60

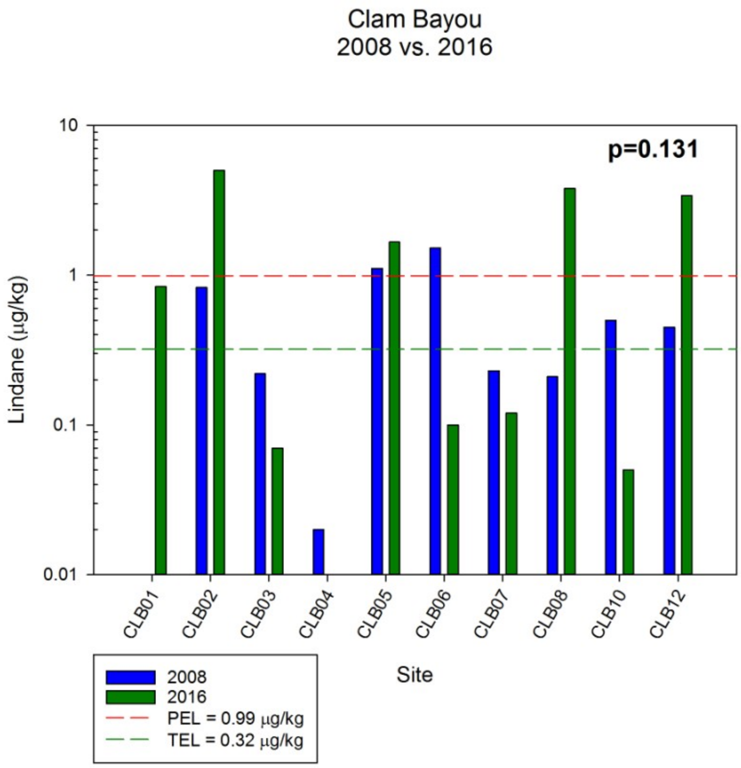

Figure 22. Clam Bayou 2008 vs. 2016 sediment Lindane concentrations.

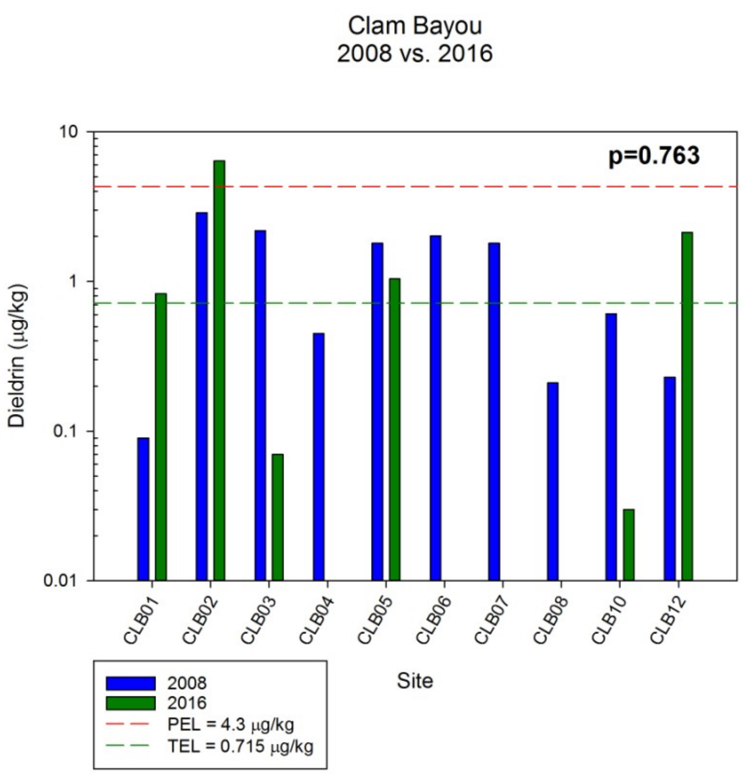

Figure 23. Clam Bayou 2008 vs. 2016 sediment Dieldrin concentrations.

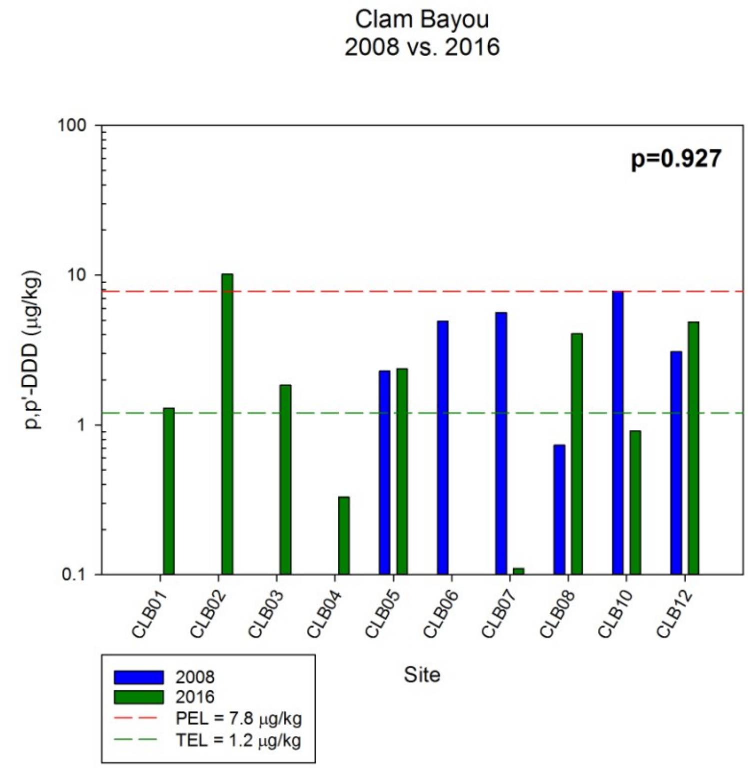

Figure 24. Clam Bayou 2008 vs. 2016 sediment p,p'-DDD concentrations.

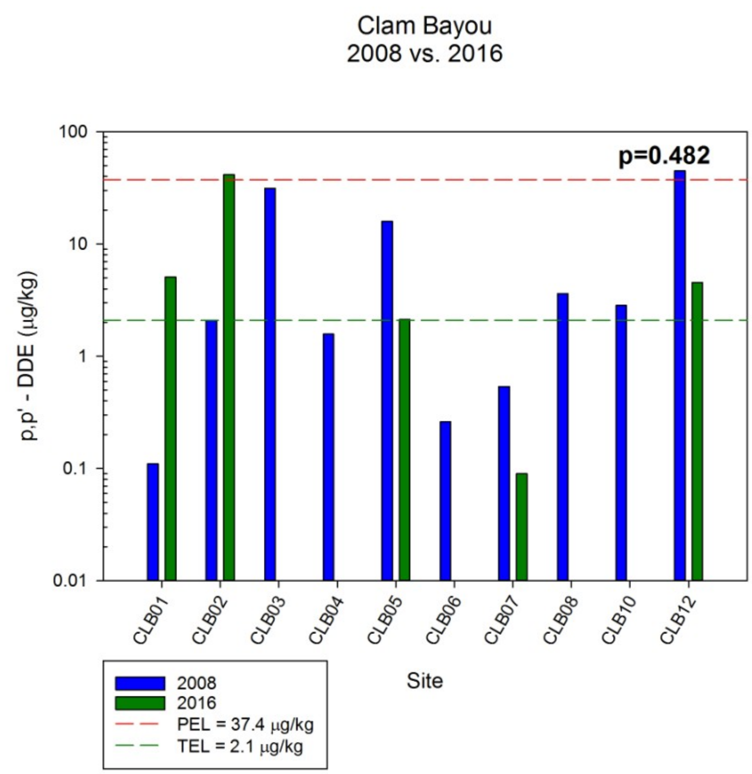

Figure 25. Clam Bayou 2008 vs. 2016 sediment p,p'-DDE concentrations.

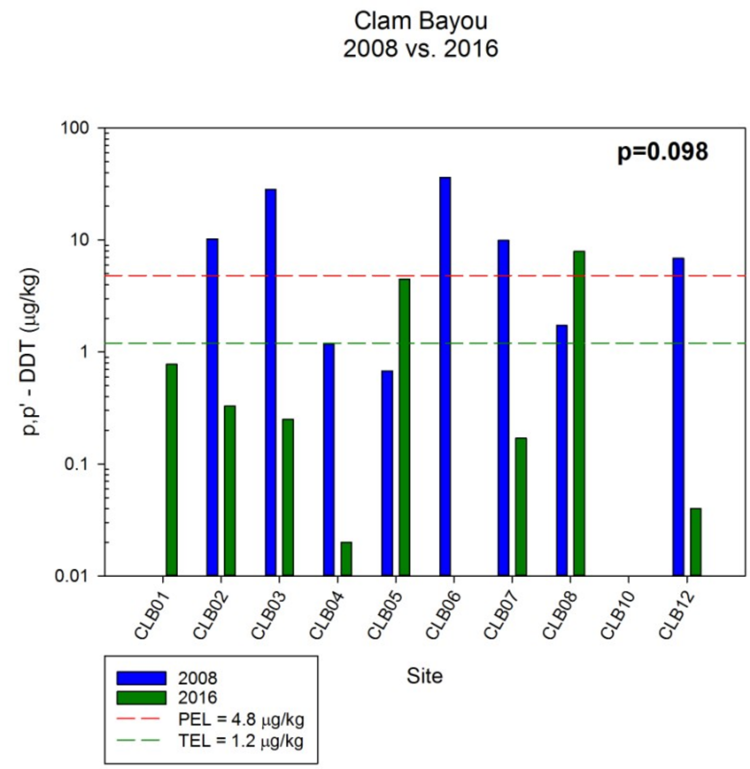

Figure 26. Clam Bayou 2008 vs. 2016 sediment p,p'-DDT concentrations.

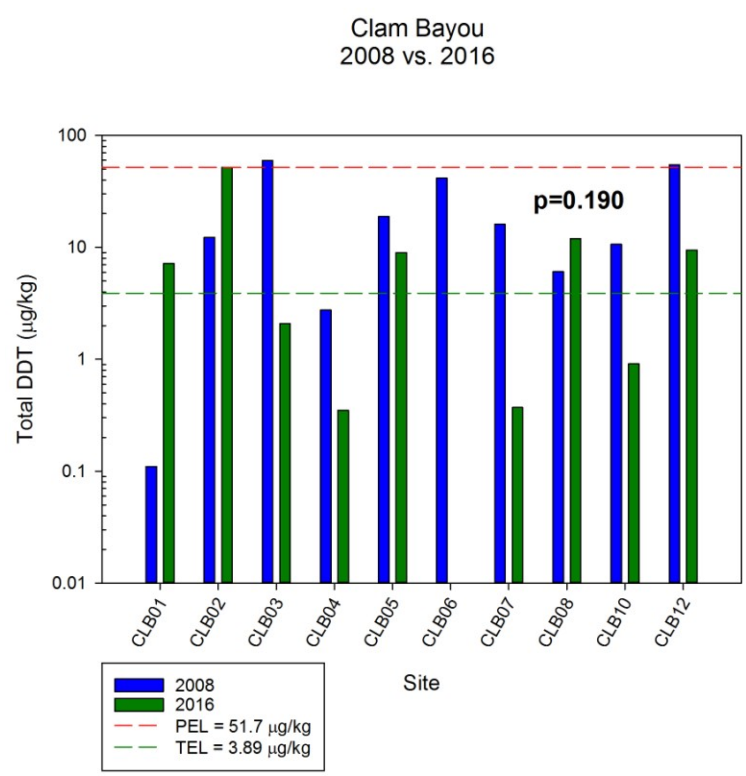

Figure 27. Clam Bayou 2008 vs. 2016 sediment total DDT concentrations.

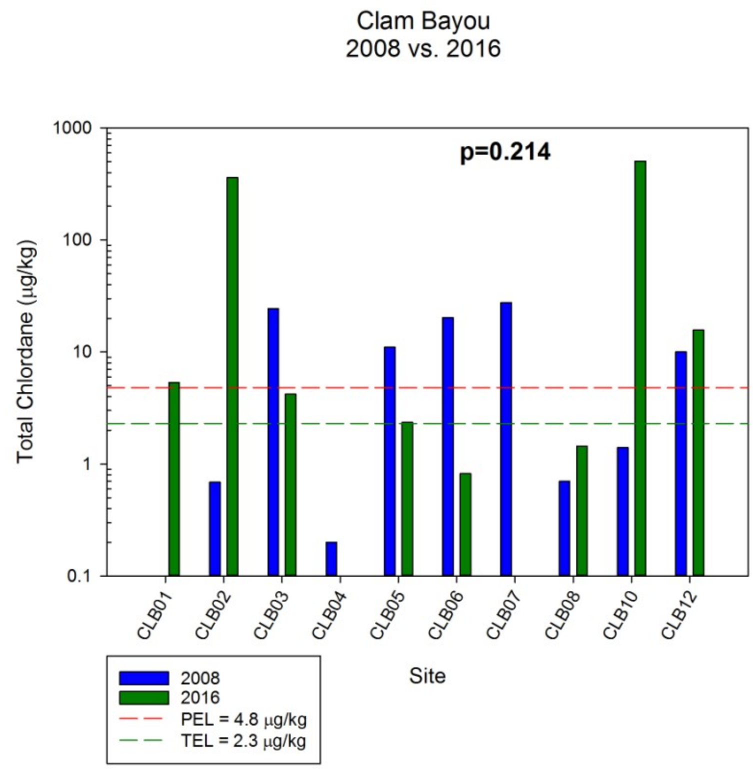

Figure 28. Clam Bayou 2008 vs. 2016 sediment total Chlordane concentrations.

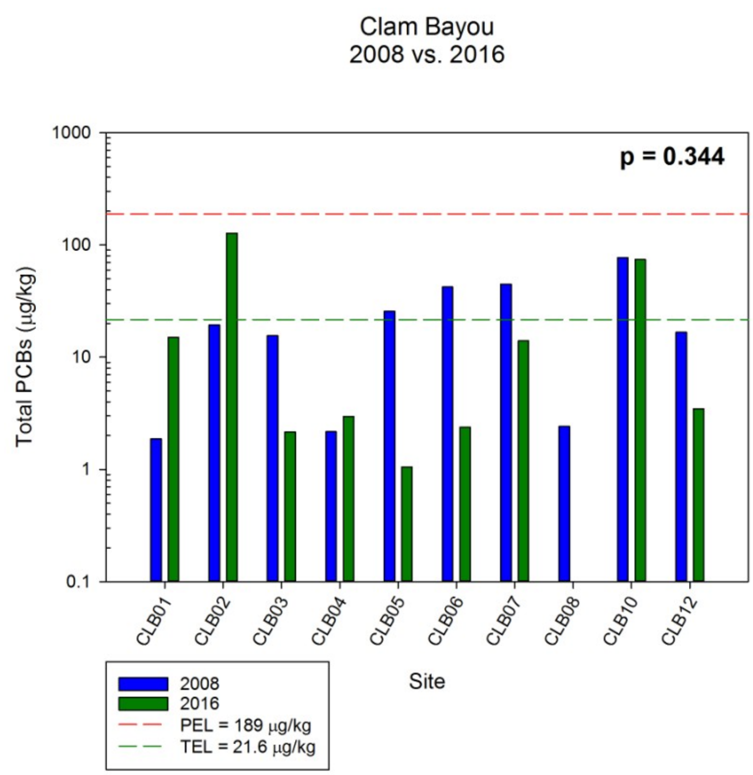

Figure 29. Clam Bayou 2008 vs. 2016 sediment total PCBs concentrations.

Table 6. Clam Bayou sediment low molecular weight polycyclic aromatic hydrocarbon (LMW PAH) concentrations (µg/kg).

Site	Acenaphthene		Acenaphthylene		Anthracene		Fluorene		Naphthalene		Phenanthrene		Total LMW PAHs	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	<MDL	7.16	<MDL	12.42	43.48	26.86	<MDL	13.43	13.59	<MDL	371.36	219.77	428.43	279.64
CLB02	<MDL	20.02	<MDL	23.31	138.65	69.19	50.42	30.19	44.12	13.13	1171.33	392.62	1404.52	548.46
CLB03	<MDL	23.42	<MDL	34.34	216.33	96.19	<MDL	34.14	81.12	18.95	2040.73	751.93	2338.18	958.97
CLB04	<MDL	21.18	<MDL	13.57	100.81	265.66	28.23	37.41	<MDL	6.65	866.02	1099.78	995.06	1444.25
CLB05	<MDL	8.97	<MDL	12.83	70.31	35.13	<MDL	15.31	<MDL	<MDL	631.51	314.38	701.82	386.62
CLB06	<MDL	<MDL	<MDL	8.60	<MDL	<MDL	<MDL	6.56	<MDL	<MDL	186.21	29.64	186.21	44.80
CLB07	<MDL	<MDL	<MDL	8.00	52.17	<MDL	<MDL	6.27	<MDL	<MDL	500.87	20.96	553.04	35.23
CLB08	<MDL	<MDL	<MDL	10.60	70.51	12.82	<MDL	9.76	<MDL	<MDL	69.22	86.97	139.73	120.15
CLB10	99.23	25.59	<MDL	28.39	258.00	100.51	79.38	33.47	78.74	20.34	2340.54	534.69	2855.89	742.99
CLB12	51.98	32.53	<MDL	18.45	178.22	114.91	44.55	39.75	21.63	12.02	1469.01	701.41	1765.39	919.07
Mean	75.61	19.84	<MDL	17.05	125.39	90.16	50.65	22.63	47.84	14.22	964.68	415.22	1136.83	548.02
Median	75.61	21.18	<MDL	13.20	100.81	82.69	47.49	22.75	44.12	13.13	748.77	353.50	848.44	467.54
Min	51.98	7.16	<MDL	8.00	43.48	12.82	28.23	6.27	13.59	6.65	69.22	20.96	139.73	35.23
Max	99.23	32.53	<MDL	34.34	258.00	265.66	79.38	39.75	81.12	20.34	2340.54	1099.78	2855.89	1444.25

MDL = Method Detection Limit; TEL = Threshold Effects Level; PEL = Potential Effects Level.

Yellow highlighting indicates >TEL concentration. Red highlighting indicates >PEL concentration.

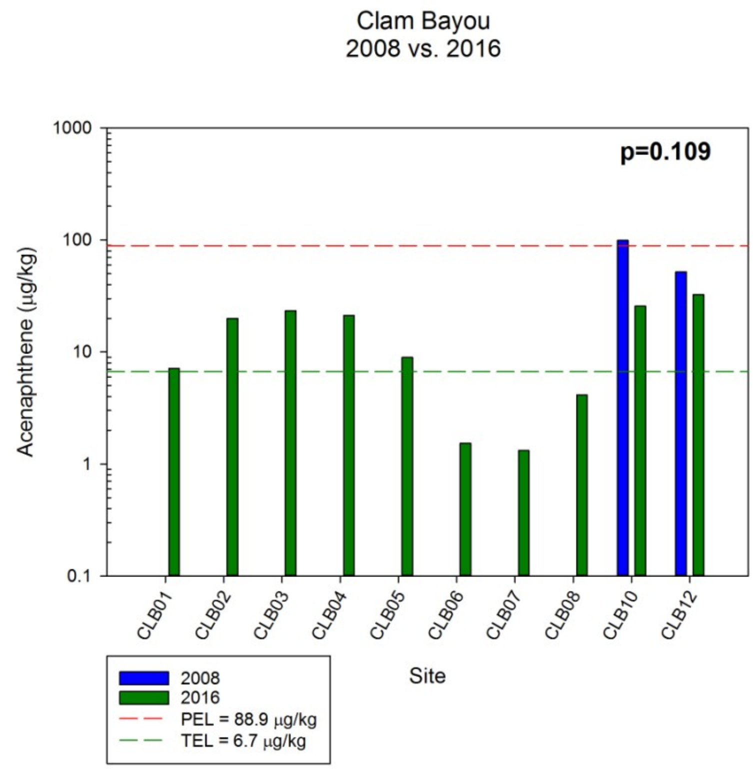

Figure 30. Clam Bayou 2008 vs. 2016 sediment Acenaphthene concentrations

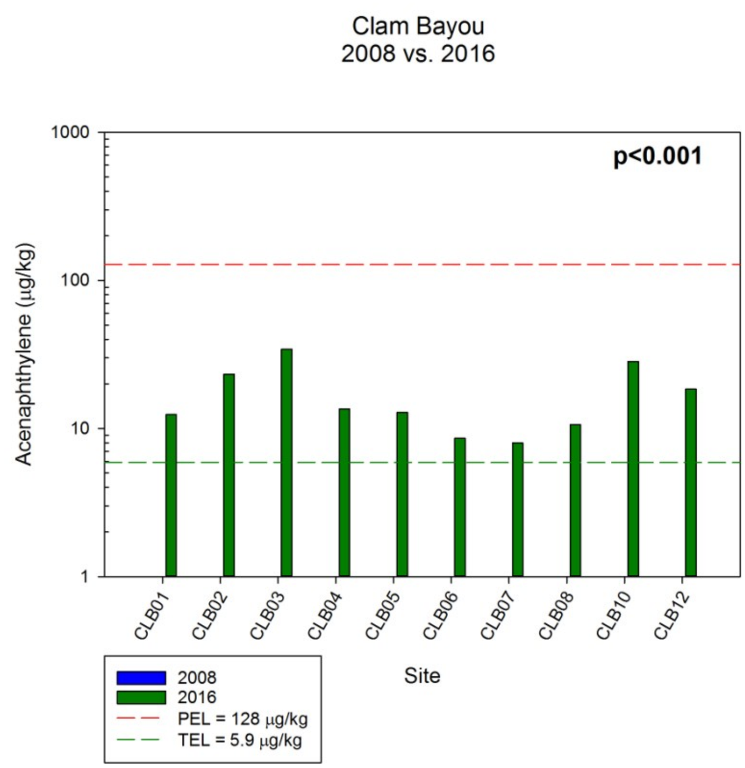

Figure 31. Clam Bayou 2008 vs. 2016 sediment Acenaphthylene concentrations.

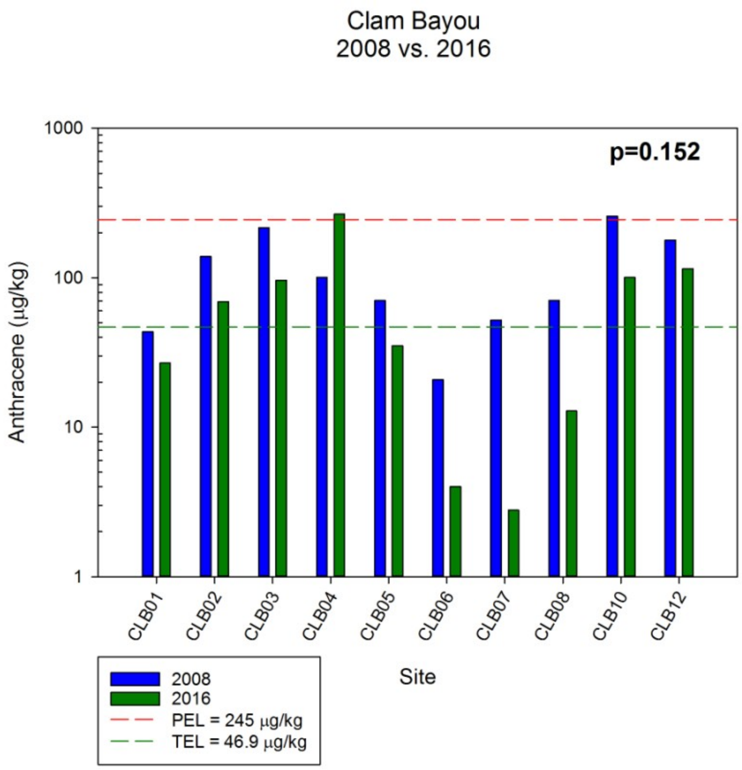

Figure 32. Clam Bayou 2008 vs. 2016 sediment Anthracene concentrations.

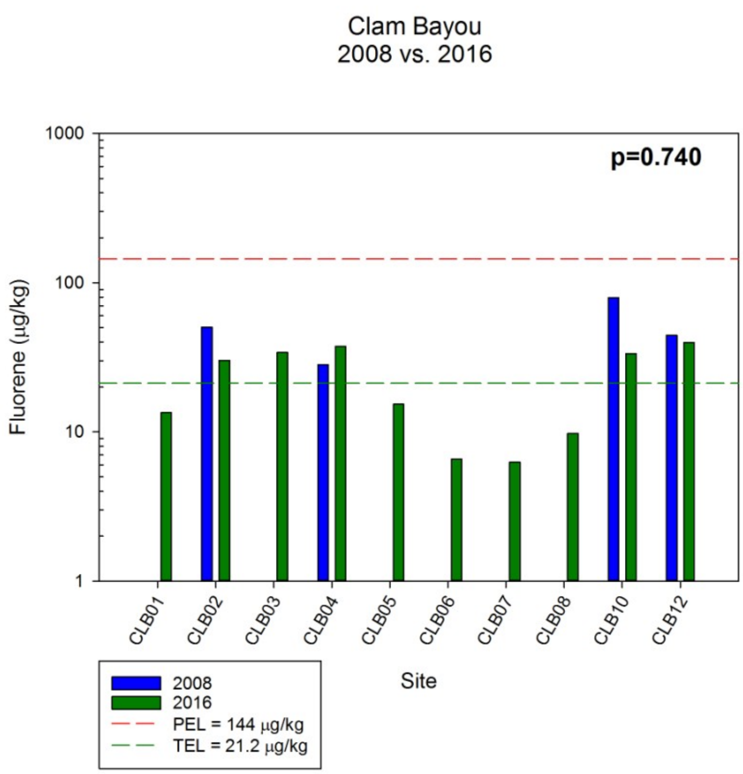

Figure 33. Clam Bayou 2008 vs. 2016 sediment Fluorene concentrations

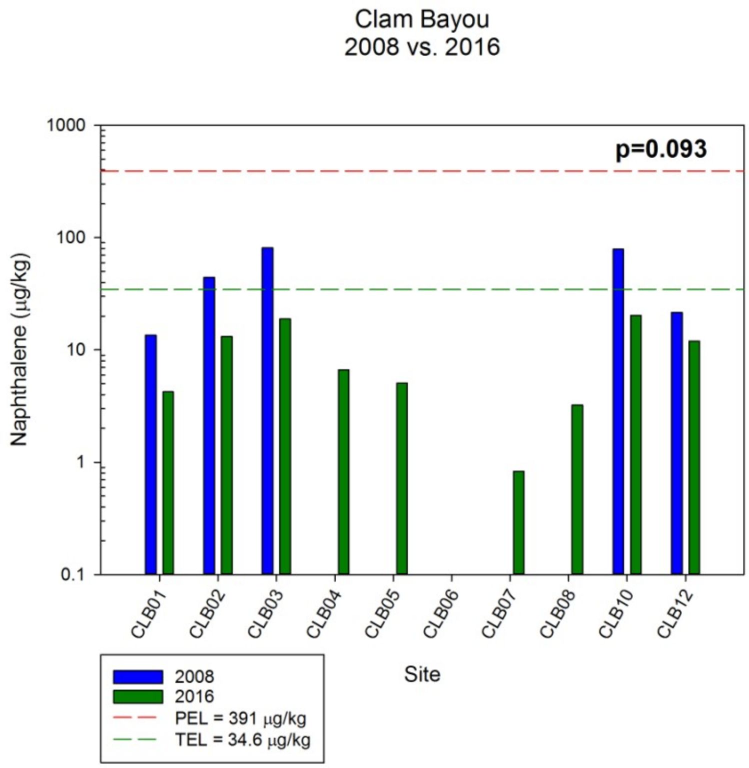

Figure 34. Clam Bayou 2008 vs. 2016 sediment Naphthalene concentrations.

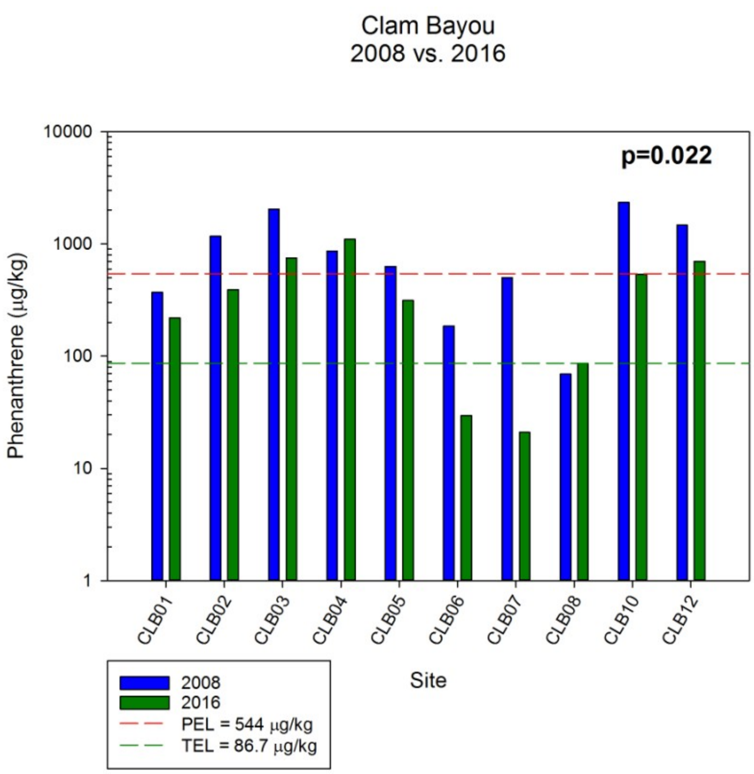

Figure 35. Clam Bayou 2008 vs. 2016 sediment Phenanthrene concentrations.

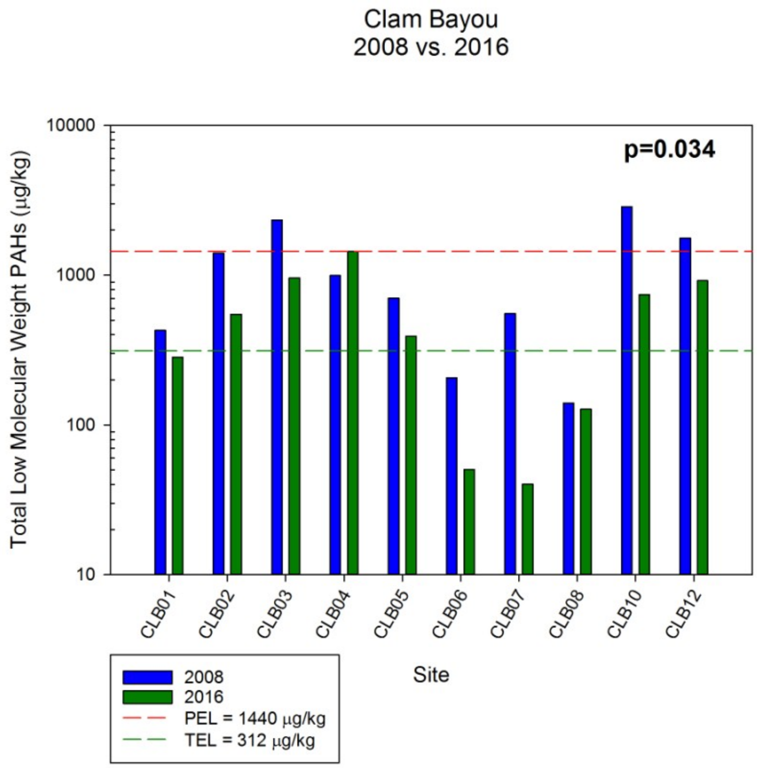

Figure 36. Clam Bayou 2008 vs. 2016 sediment low molecular weight PAH concentrations.

Table 7. Clam Bayou sediment high molecular weight polycyclic aromatic hydrocarbon (HMW PAH) concentrations (µg/kg).

Site	Benzo(a)anthracene		Benzo(a)pyrene		Chrysene		Dibenzo(a,h)anthracene		Fluoranthene		Pyrene		Total HMW PAHs		Total PAHs	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	703.8	489.6	1005.4	756.7	1135.8	686.7	304.3	196.2	1676.6	838.0	1508.1	1101.4	6334.1	4068.6	6762.5	4348.2
CLB02	2691.1	972.9	4140.7	1663.5	4002.0	1432.2	1021.0	464.6	5388.5	1611.0	5873.8	2370.8	23117.1	8514.9	24521.6	9063.3
CLB03	3948.1	1565.8	6557.6	2757.7	7071.4	2548.2	1527.9	907.8	10735.5	2716.4	10586.8	4055.9	40427.3	14551.7	42765.4	15510.7
CLB04	1254.0	1589.5	1693.6	2035.0	1915.3	1898.7	463.7	497.5	3669.4	3282.0	2971.8	3921.1	11967.7	13223.9	12962.8	14668.1
CLB05	914.0	706.5	1320.3	1389.5	1460.9	1087.6	367.2	316.5	2609.3	1299.3	2156.2	1691.7	8827.9	6491.0	9529.7	6877.7
CLB06	520.8	84.7	923.6	130.7	840.3	128.5	270.8	46.3	1076.4	149.3	1118.1	171.8	4750.0	711.4	4936.2	756.2
CLB07	984.8	53.1	1480.4	89.0	1480.4	83.0	410.9	37.1	2295.6	95.8	2256.5	90.7	8908.5	448.6	9461.5	483.8
CLB08	173.1	235.7	250.0	378.5	256.4	363.6	83.3	109.2	365.4	341.5	326.9	478.4	1455.1	1907.0	1594.9	2027.1
CLB10	4624.1	1420.0	7204.1	2263.9	6946.1	2051.7	2024.3	525.9	11272.5	2552.2	12225.1	3503.4	44296.3	12317.2	47152.2	13060.2
CLB12	2472.8	1395.7	3415.8	1880.6	3215.4	1828.2	920.8	442.1	5175.7	2598.3	5183.2	2949.2	20383.7	11094.1	22149.1	12013.2
Mean	1828.7	851.4	2799.1	1334.5	2832.4	1210.8	739.4	354.3	4426.5	1548.4	4420.6	2033.4	17046.8	7332.8	18183.6	7880.8
Median	1119.4	839.7	1587.0	1526.5	1697.9	1259.9	437.3	379.3	3139.3	1455.1	2614.1	2031.2	10438.1	7503.0	11246.3	7970.5
Min	173.1	53.1	250.0	89.0	256.4	83.0	83.3	37.1	365.4	95.8	326.9	90.7	1455.1	448.6	1594.9	483.8
Max	4624.1	1589.5	7204.1	2757.7	7071.4	2548.2	2024.3	907.8	11272.5	3282.0	12225.1	4055.9	44296.3	14551.7	47152.2	15510.7

MDL = Method Detection Limit; TEL = Threshold Effects Level; PEL = Potential Effects Level.

Yellow highlighting indicates >TEL concentration. Red highlighting indicates >PEL concentration.

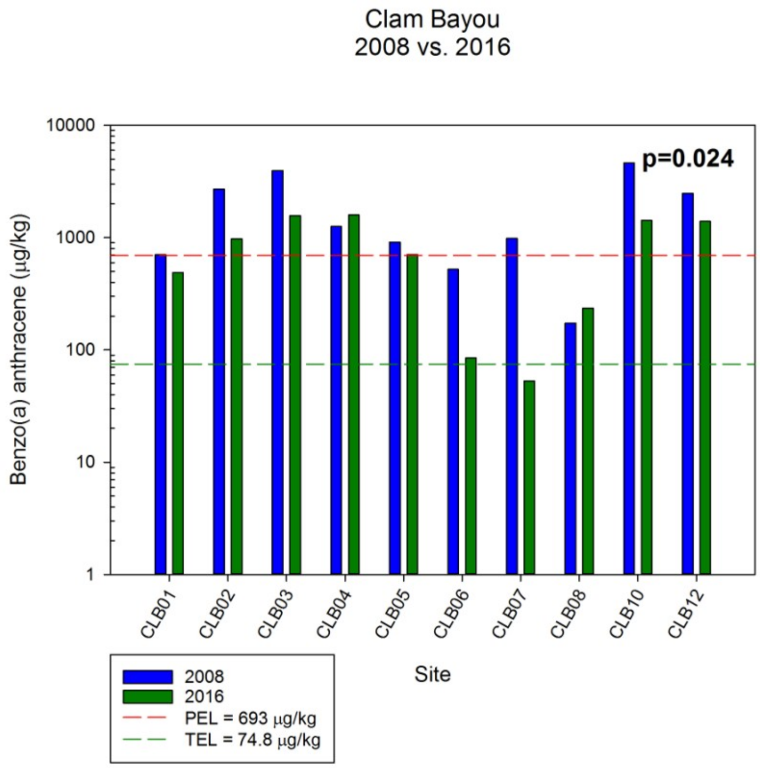

Figure 37. Clam Bayou 2008 vs. 2016 sediment Benzo(a) anthracene concentrations.

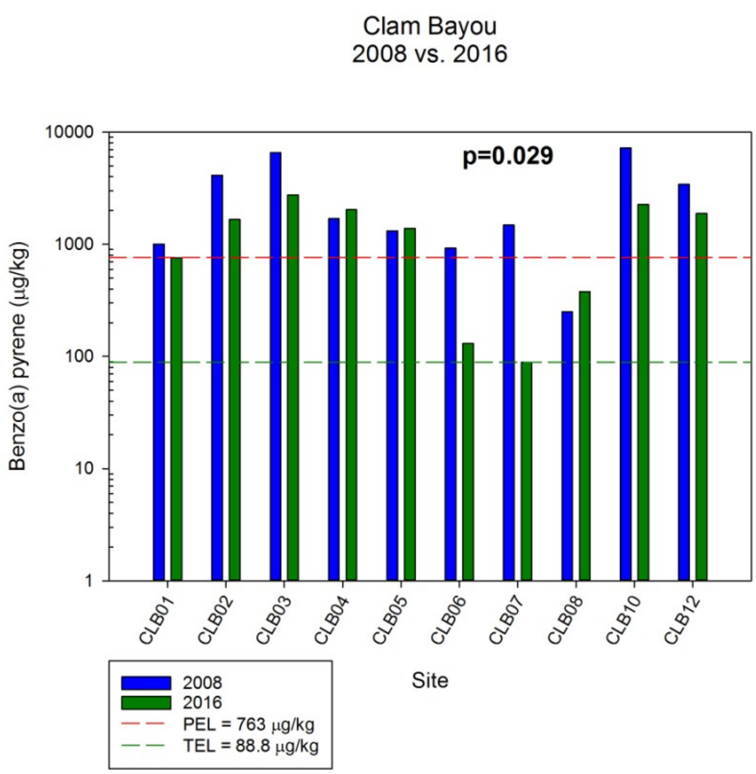

Figure 38. Clam Bayou 2008 vs. 2016 sediment Benzo(a) pyrene concentrations

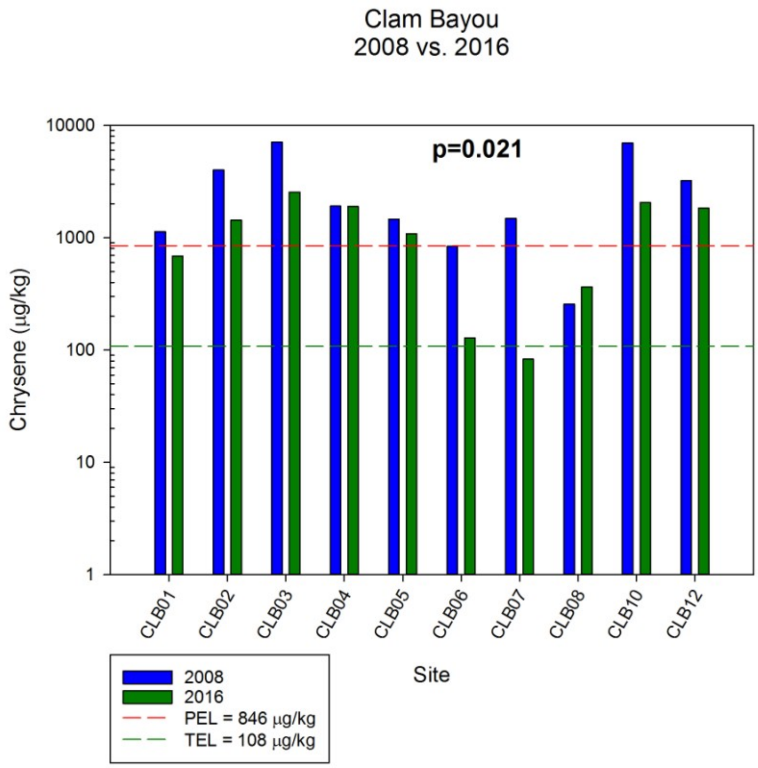

Figure 39. Clam Bayou 2008 vs. 2016 sediment Chrysene concentrations.

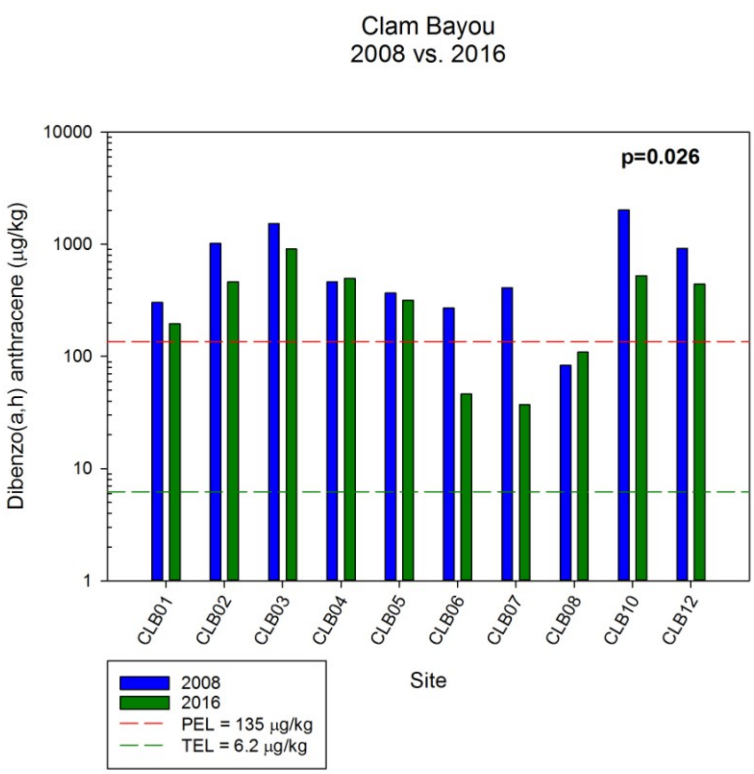

Figure 40. Clam Bayou 2008 vs. 2016 sediment Dibenzo(a,h) anthracene concentrations.

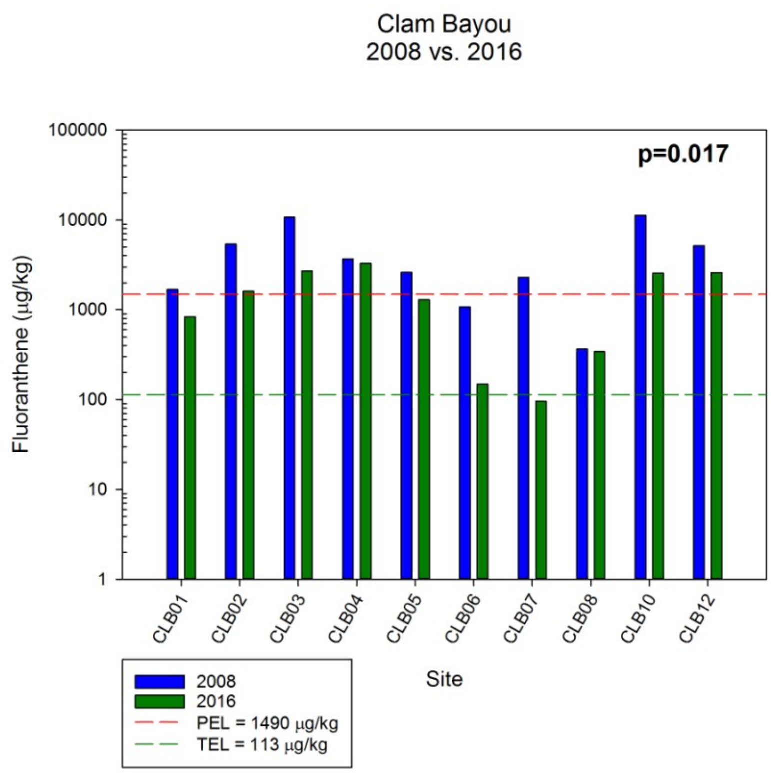

Figure 41. Clam Bayou 2008 vs. 2016 sediment Fluoranthene concentrations.

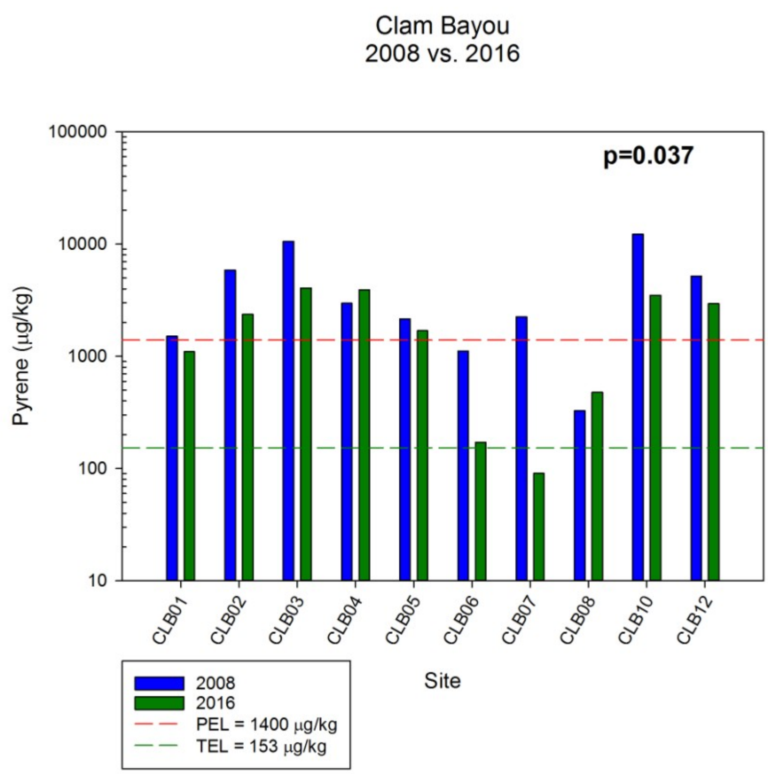

Figure 42. Clam Bayou 2008 vs. 2016 sediment Pyrene concentrations.

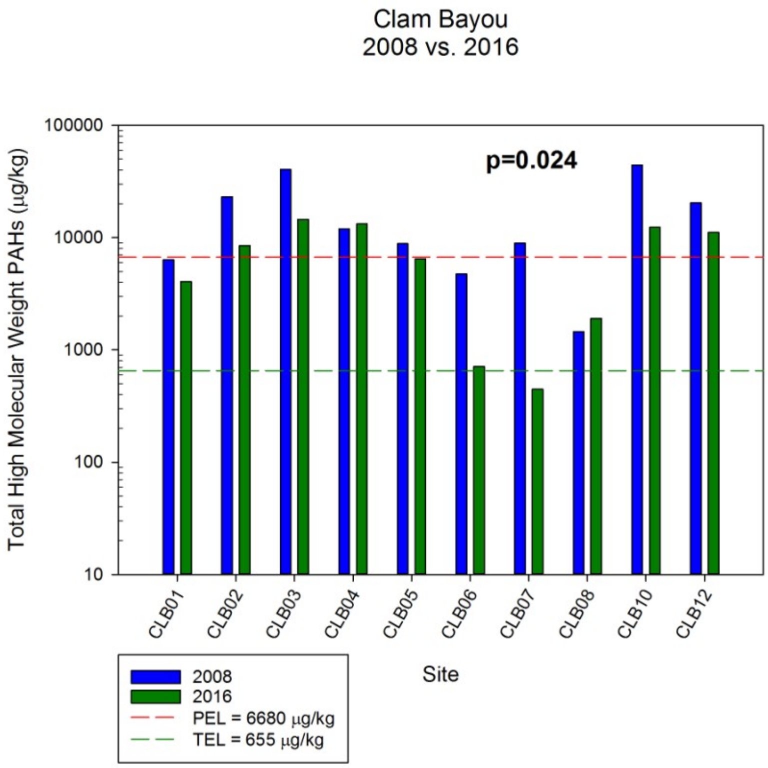

Figure 43. Clam Bayou 2008 vs. 2016 sediment total high molecular weight PAH concentrations (µg/kg).

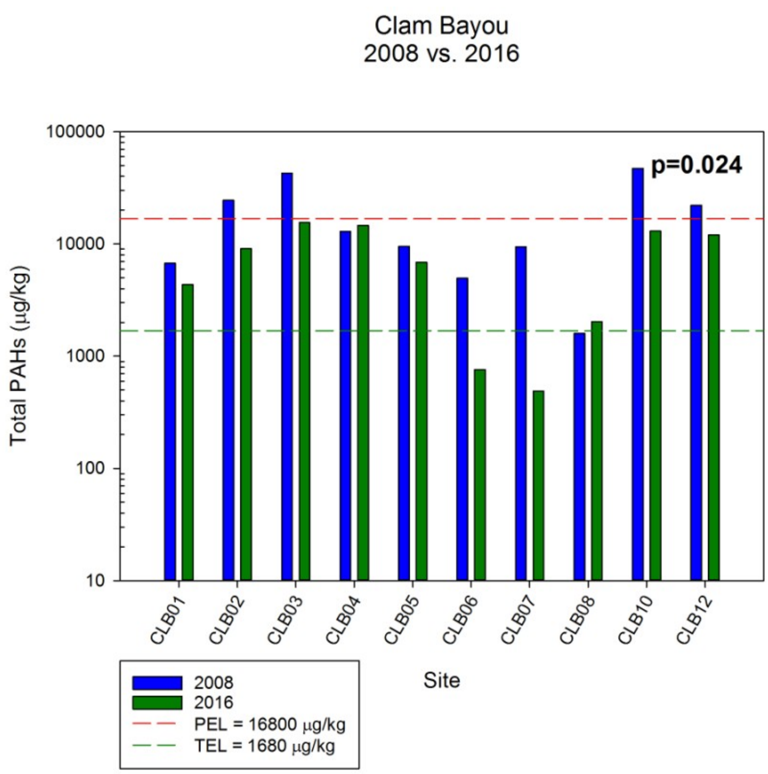

Figure 44. Clam Bayou 2008 vs. 2016 sediment total PAH concentrations.

Table 8. Clam Bayou sediment polycyclic aromatic hydrocarbons without establishes sediment quality guidelines (µg/kg).

Site	Benzo(b)fluoranthene		Benzo(k)fluoranthene		Indeno(1,2,3-c,d)pyrene		Benzo(g,h,i)perylene		Retene		Coronene	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CLB01	1339.64	1415.54	872.26	759.93	828.78	258.43	850.52	469.41	<MDL	11.38	472.81	140.16
CLB02	5319.19	2172.33	3327.65	1772.74	2842.37	573.52	2905.39	1038.28	214.28	48.21	1707.94	351.24
CLB03	7815.04	3850.78	4813.41	3018.07	4583.56	1479.70	4624.12	<MDL	<MDL	89.17	2555.44	1022.71
CLB04	2213.71	3012.13	1302.42	1959.13	1177.42	581.16	1173.39	1066.82	<MDL	<MDL	637.10	481.97
CLB05	1578.09	1552.74	1226.53	1141.40	1007.79	885.97	937.48	852.08	<MDL	19.50	546.86	239.05
CLB06	1354.17	141.45	763.89	112.53	784.72	68.20	756.94	97.01	<MDL	<MDL	340.28	45.19
CLB07	1897.78	86.99	1147.80	67.14	1154.32	59.49	1108.67	76.90	<MDL	<MDL	547.81	35.30
CLB08	320.51	475.23	256.41	334.15	237.18	294.53	250.00	319.86	<MDL	<MDL	121.79	107.12
CLB10	9744.38	3181.78	6013.34	2363.73	5457.65	762.72	5398.11	1309.32	337.38	50.74	2460.90	584.57
CLB12	3274.75	2160.64	2910.89	1790.21	2205.45	713.63	2079.21	1069.40	103.96	43.66	987.62	292.57
Mean	3485.73	1804.96	2263.46	1331.90	2027.92	567.74	2008.38	699.90	218.54	43.78	1037.86	329.99
Median	2055.75	1856.69	1264.48	1457.07	1165.87	577.34	1141.03	852.08	214.28	45.94	592.46	265.81
Min	320.51	86.99	256.41	67.14	237.18	59.49	250.00	76.90	103.96	11.38	121.79	35.30
Max	9744.38	3850.78	6013.34	3018.07	5457.65	1479.70	5398.11	1309.32	337.38	89.17	2555.44	1022.71

MDL = Method Detection Limit

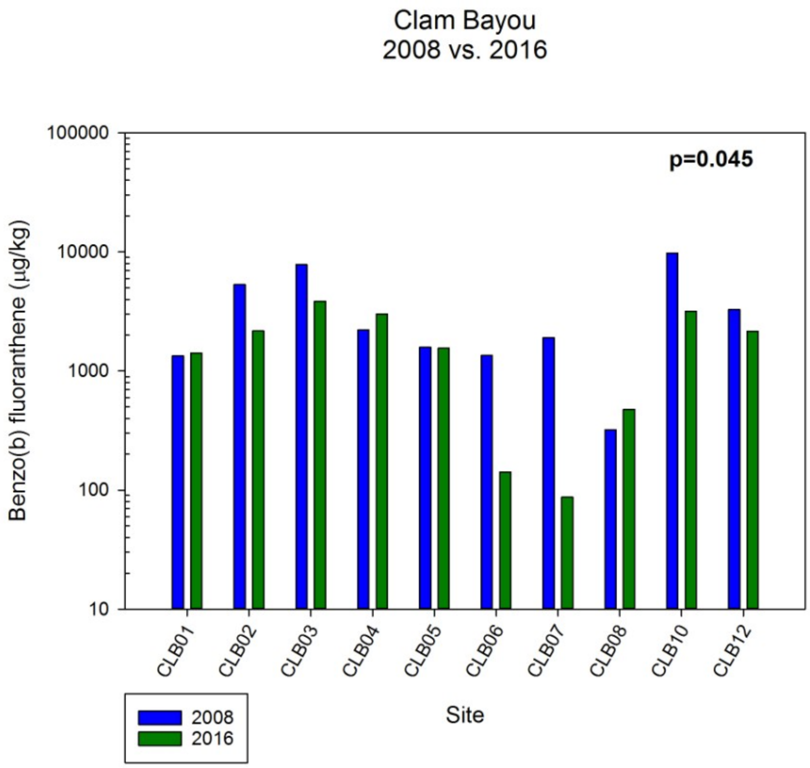

Figure 45. Clam Bayou 2008 vs. 2016 sediment Benzo(b) fluoranthene.

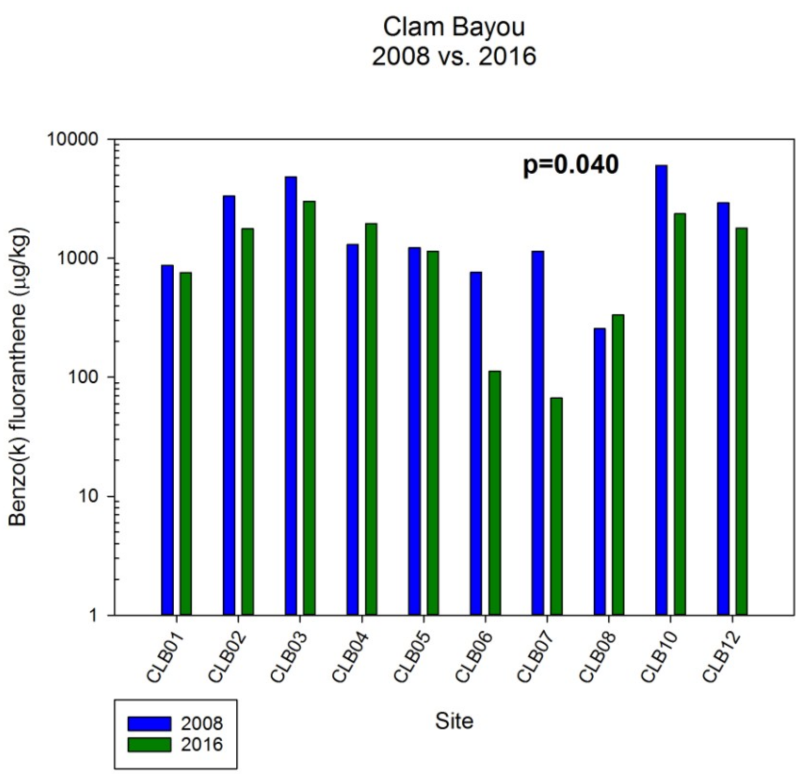

Figure 46. Clam Bayou 2008 vs. 2016 sediment Benzo(k) fluoranthene.

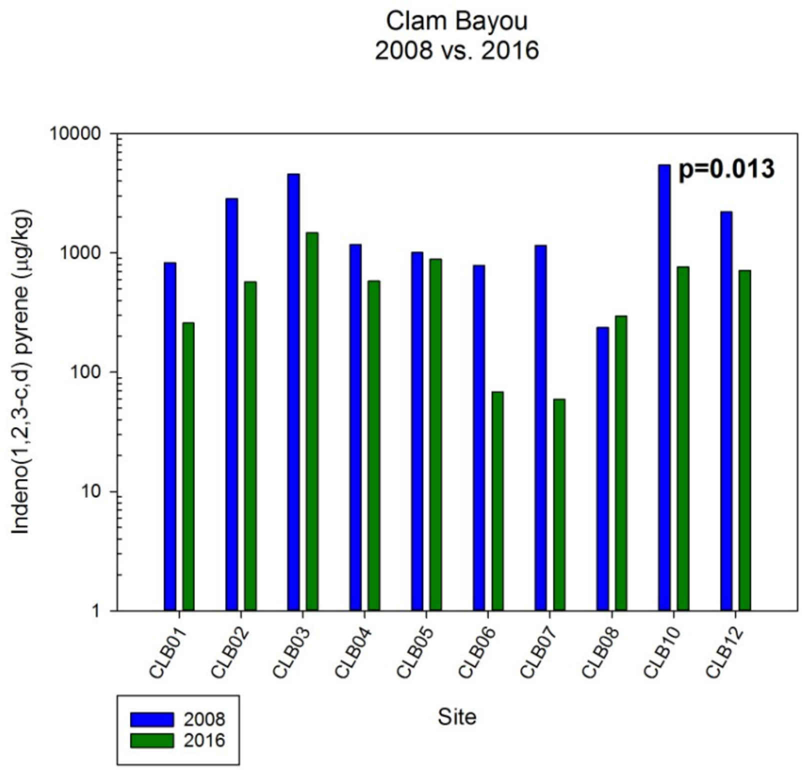

Figure 47. Clam Bayou 2008 vs. 2016 sediment Indeno(1,2,3-c,d) pyrene concentrations.

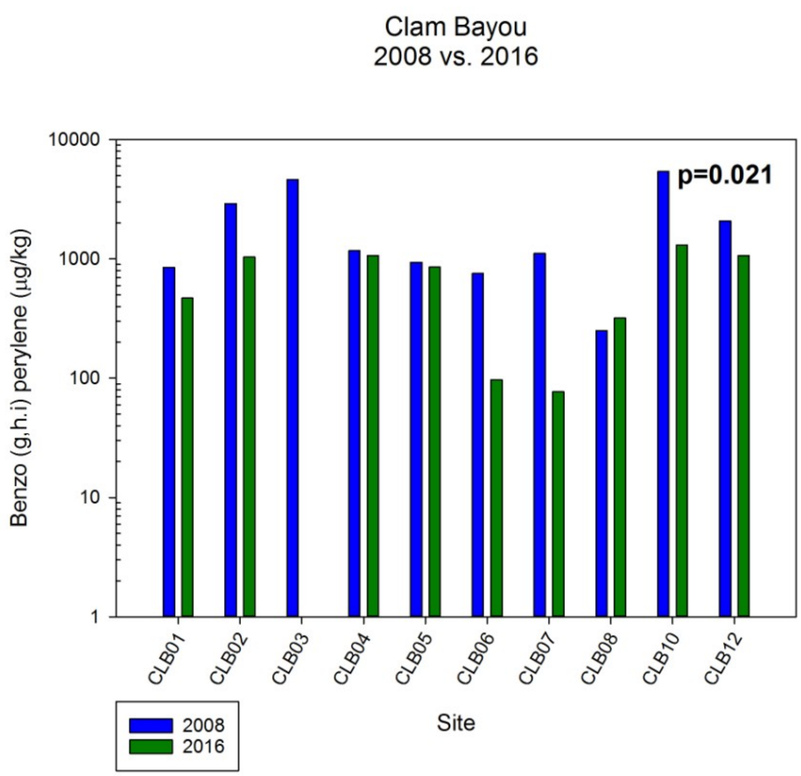

Figure 48. Clam Bayou 2008 vs. 2016 sediment Benzo(g,h,i) perylene concentrations.

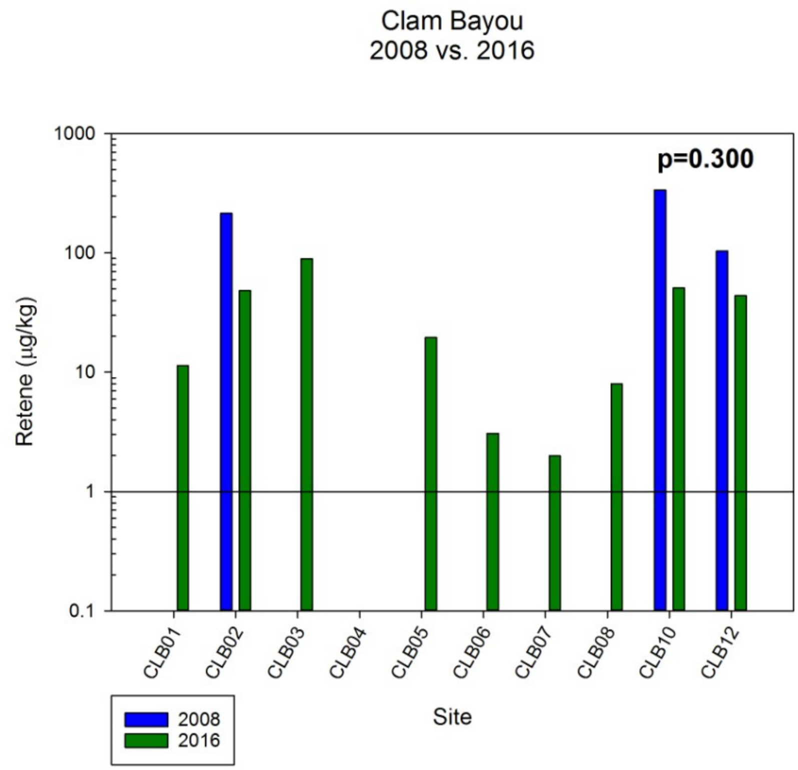

Figure 49. Clam Bayou 2008 vs. 2016 sediment Retene concentrations.

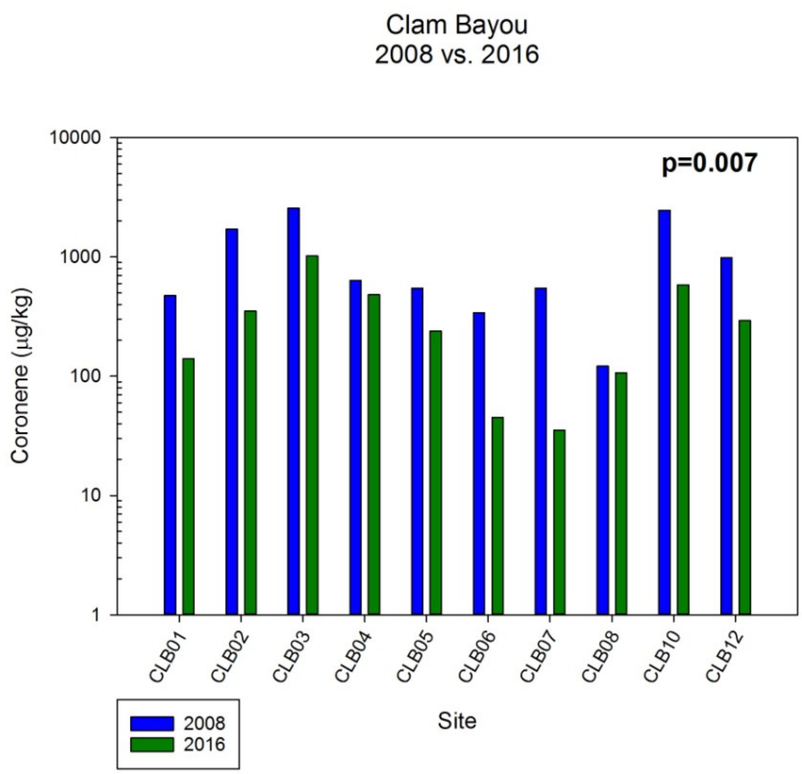

Figure 50. Clam Bayou 2008 vs. 2016 sediment Coronene concentrations.

Discussion and Conclusions

The Southwest Florida Water Management District (SWFWMD) had completed the final phase of their Clam Bayou restoration project in October 2012 (Eliopoulos, 2016), four years after the previous Clam Bayou study in 2008. This current study comparing the changes in the benthic macrofaunal community and sediment contaminants since 2008 evaluates the short term effects of the SWFWMD restoration on Clam Bayou.

The 2016 samples were characterized by higher water temperatures and lower salinities relative to 2008. This may have been due to the sample collection period (late August) and higher rainfall during the summer of 2016. The salinity was lower at all ten sites in 2016 but the overall trend was largely driven by two sites (16CLB07 and 16CLB08) which were sampled the week prior to the other eight sites and suggests the influence of a localized rain event affecting the salinity measurements. There was an apparent improvement in the bottom dissolved oxygen and percent saturation (although not statistically significant), with fewer sites falling below state water quality criteria in 2016 for dissolved oxygen and all sites meeting the state standard for percent saturation.

The benthic macrofaunal community has shown indications of improvement since 2008 with more taxa found in 2016 (149 taxa) than in 2008 (108 taxa). The mean number of taxa per site was not found to be significantly different, however he total number of species identified in 2016 represents a 38% increase since 2008 and is a strong indicator of improving water and sediment quality conditions.

The other measured benthic community indices (abundance, H', J' and TBBI) were very similar between 2016 and 2008 and were not significantly different. The TBBI however did show some overall improvements in 2016 with two sites having "Healthy" index scores. These two sites (CLB07 and CLB08) are near the mouth of Clam Bayou and are well flushed by tidal exchange with Boca Ciega Bay.

The species composition of the benthic community was generally similar between the two sampling years, with annelids and mollusks dominating in terms of species richness and abundance while crustaceans comprised a relatively minor proportion of the species richness and abundance. The polychaete *Laeonereis culveri* was the dominant species in 2016 among the sites in terms of abundance and frequency of occurrence and was also among the dominant taxa in 2008. *Laeonereis culve*ri is a common species found in estuarine habitats along the east coast and Gulf of Mexico and is a deposit feeder, consuming detritus and benthic diatoms (Mazurkiewicz, 1975; Bloom, 1983). In the historic Tampa Bay bay-wide Benthic Monitoring sampling *L. culveri* has normally been found in shallow, freshwater and lower salinity habitats, but does have a wide salinity range (Karlen et al. 2015). *Laeonereis culveri* has also been associated with contaminated sites which were above the PELs for copper and p,p'-DDD (Karlen et al. 2015).

The sites CLB02 and CLB03 were distinct having much fewer taxa and lower abundances during both sampling years. These two sites were dominated by oligochaetes, also the bivalve *Parastarte triquetra* was at CLB 02 in 2016. These sites were characterized by sediments with high silt+clay and total organic carbon content and were associated with dredged channels. Sediment composition in both years was the primary factor influencing the benthic community composition in Clam Bayou.

There was no significant change in the sediment metals concentrations between 2008 and 2016. Three sites in particular did show high metals concentrations in 2016: CLB 02, CLB03 and CLB10. These three sites also had the highest silt+clay and total organic carbon. CLB02 exceeded the TELs for copper, lead and zinc and CLB10 was above the TEL for copper. Site CLB03 was above the TELs for chromium and copper and exceeded the PELs for lead and zinc, the only two PEL exceedences for metals observed in Clam Bayou. Potential sources particularly for zinc and lead include building materials such as siding (brick, concrete, and painted wood) and galvanized metal and tile roofs from automobiles and road runoff: dust and debris from tires and brake pads and zinc additives in motor oils (Davis et al. 2001).

The levels of several pesticides including DDT products and chlordane were particularly high in both 2008 and 2016. Since these substances are currently either banned or restricted the high concentrations observed in Clam Bayou represents historical deposition.

The concentration of PAHs in Clam Bayou sediments remained high in 2016 with many TEL and PEL exceedences recorded for most of the measured compounds. Most PAHs were significantly lower in 2016 compared to the 2008 and the mean Total Low Molecular Weight PAHs decreased by 51.8%, the mean High Molecular Weight PAHs decreased by 57% and the mean Total PAHs by 56.65%. The primary source of PAHs in Clam Bayou is from stormwater runoff from the surrounding roads and urban development (Ngabe *et al*. 2000; Van Dolah *et al*. 2005).

Historically stormwater was channeled into Clam Bayou through the Clam Bayou Drain, located at the upper northeast end of the bayou (Figure 1) as well as through other smaller stormwater outfalls and surface runoff along the shoreline. The completion of the SWFWMD restoration projects in 2012 has added many improvements to help treat stormwater before it enters Clam Bayou as well as restore habitats for fish and wildlife (see map in Appendix B). These include the construction of three stormwater treatment ponds around Clam Bayou, restoring meanders to the central stormwater canal and creation of a lagoon system along the south shoreline (Eliopoulos, 2016; SWFWMD). The significant decrease observed in PAHs since 2008 is a good indication that the sediments are improving in clam Bayou although sediment contaminant levels remain above the Florida state sediment quality guidelines for many pollutants. The decreasing trend of sediment contaminant levels observed in this study along with the increase in the number of macrofaunal species is encouraging and a positive sign that the Clam Bayou ecosystem is starting to recover.

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Appendix A: Clam Bayou 2008 & 2016 Benthic Macrofaunal Data

Data presented as density ($\#/m^2$) = raw count x 25, except for colonial taxa which are presented as present = 1.

Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
CAMPANULARIIDAE															1					
ANTHOZOA																25				
Ceriantharia												125		50						
ACTINIARIA	300						50												25	
Stylochopsis ellipticus																			25	
Palaeonemertea sp. A of EPC											25				25	25				
Tubulanus pellucidus												50		75						
Paranemertes cf. biocellatus							75	50						75				25		25
Ophryotrocha sp. A of EPC					25														50	
Pettiboneia duofurca												25								
Schistomeringos cf. rudolphi				25								25	75	50			150	25		
Marphysa cf. sanguinea												25								
Lumbrineris nonatoi														50						
Scoletoma tenuis											75							25	25	
Scoletoma verrilli														25						
Drilonereis magna											25									
Diopatra cuprea																50				
Kinbergonuphis simoni											125	25	25	25	50	25				
Glycera americana													25			25				
Glycinde solitaria												25	25	25			25			
Microphthalmus sp.							25		25											
Oxydromus obscurus							25					25					25			
Parahesione luteola																	100			
Podarkeopsis levifuscina							25				75	275	50	50	50		50	25		
NEREIDIDAE														2675						
Laeonereis culveri	400	1225				25	1900	1875	600	2550	700	75			125		100	300	450	1775
Neanthes acuminata												1150		1325	25			75		
Nereis falsa																25				
Stenoninereis martini					25	25	150		925											
Cabira incerta												25								

Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
Synelmis ewingi											25		25		25					
Syllidae Genus A of EPC												25		25						
Brania nitidula																		25		
Exogone sp.														50						
Exogone dispar							25							25		50				
Exogone (Exogone) cf. breviantennata												25								
Parapionosyllis uebelackerae												50		25						
Sphaerosyllis labyrinthophila												100		50						
Syllis sp. A of EPC														25						
Syllis cornuta												225		200		25				
Phyllodoce arenae													25							
Hypereteone heteropoda	25	50					100	50						25						
Nereiphylla castanea												50								
TUBIFICINAE	50		625		125		3100	300	1100	675	100	1075	100	250	325	400	125	325	200	100
Limnodriloides sp.														25						
Limnodriloides baculatus																75				
Tubificoides brownae											100				50					
Tubificoides wasselli	25	50		50		75		175			225	325	100	325	250	200	275	275	125	75
Fabricinuda trilobata												75			25				100	
SERPULIDAE sp. A of EPC												25								
Magelona cf. rosea																50				
Magelona pettiboneae											250				200	50		25	25	
Prionospio pygmaea																		25		
Boccardiella cf. hamata												125								
Carazziella hobsonae													200							
Dipolydora socialis											25	25								
Paraprionospio pinnata													25							
Polydora cornuta							50									225				

Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
Prionospio sp.														50						
Prionospio heterobranchia											425	75		50	450	75		25		
Prionospio perkinsi				25								25								
Scolelepis (Scolelepis) texana															25					
Streblospio spp.														25				100		
Pectinaria gouldii													25	25		25		25		
CIRRATULIDAE												100		50						
Aphelochaeta sp.												75								
Caulleriella cf. alata												100		50						
Caulleriella sp. D of EPC												150								
Cirriformia sp. B of Wolf, 1984																25				
Kirkegaardia cf. dorsobranchialis	25						25		50		175	25	900	250	225		25	775	50	25
Tharyx acutus												200		250						
Ctenodrilus serratus																25				
Isolda pulchella												25				25				
Melinna maculata																	25			
Lysilla cf. alba												25								
Polycirrus sp. B of Kritzler, 1984												50								
Boguea enigmatica												1650		1425						
Clymenella mucosa											50			25						
Leitoscoloplos fragilis		25						75												
Leitoscoloplos foliosus	175	25					25	25											300	75
Leitoscoloplos robustus											25				100	100				25
Scoloplos (Scoloplos) rubra													25							
Aricidea suecica														50						
Aricidea cerrutii													25							
Aricidea philbinae											125	50		50	150	275		75		
Aricidea (Allia) bryani																		50		
Paradoneis cf. lyra												125		475						

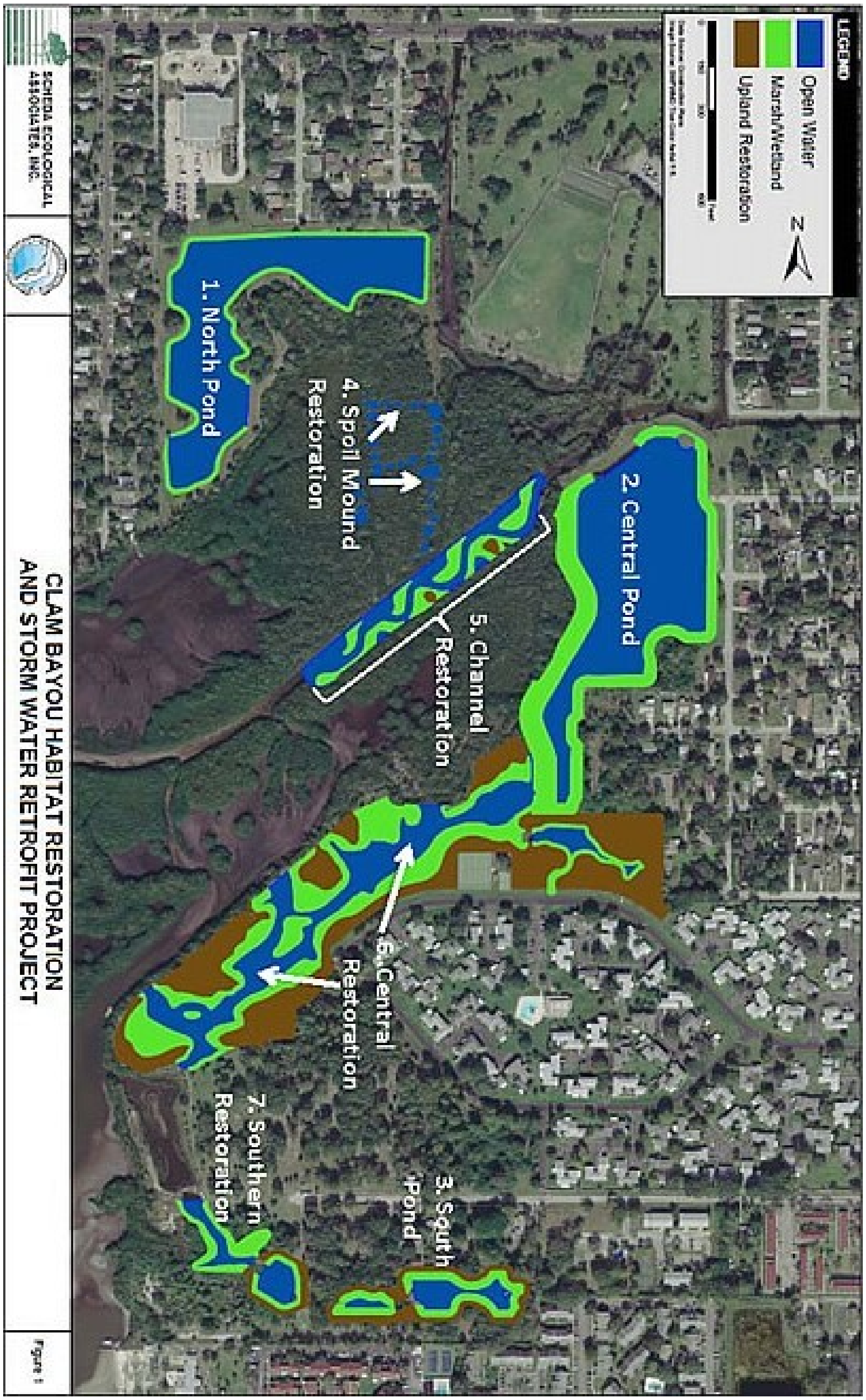
Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
Capitella capitata complex	150	500					175	900	250	850	200		50		500		50		75	100
Capitella jonesi											75	25		100	100					
Heteromastus filiformis	50	275					675	125		125	600		25		75			25	350	
Mediomastus sp.							25				25	325		100	275				25	
Mediomastus californiensis												50			50					
Notomastus cf. latericeus													50	25						
Spiochaetopterus costarum													25					25		
GASTROPODA							50		550								50		25	
RISSOOIDEA							50		4225											
Schwartziella catesbyana																75				
Teinostoma biscaynense													25							
Caecum pulchellum		25						25			25					1000				
Meioceras nitidum																125				
Batillaria minima								50												75
Cerithideopsis costata								25												
CERITHIIDAE									225											
Bittiolum varium											25					75				
Cerithium atratum												50						25		
Crepidula aculeata																				25
Crepidula ustulatulina											25					225				
Eupleura sulcidentata												25		25						
Astyris lunata																250				
Costoanachis semiplicata																375				
Melongena corona							25													
Nassarius vibex								25			25	200		100		50	25	25		
Jaspidella blanesi													250	25						
Olivella pusilla													25		25			25		
Prunum apicinum															25	50		25		
Sayella hemphilli										50	25									

Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
Odostomia laevigata								75												
Odostomia sp. C of EPC												50		25						
Odostomia sp. D of EPC		50										75								
Turbonilla hemphilli												25		25		25				
Turbonilla (Strioturbonilla) sp.											25									
Boonea impressa																75				
Acteocina canaliculata	350	350					350	50	300	950		75		275	50				475	125
Haminoea succinea													25	25						
Haminoea antillarum		25																		
BIVALVIA	100				25		175								25		325		75	
Solemya occidentalis																	25			
Musculus lateralis																25				
Brachidontes exustus																25				
Amygdalum papyrium											50			25		50	25	25		
Stewartia floridana		25						25												75
Phlyctiderma semiaspera																25				
Orobitella floridana																		100		
Mysella planulata												25	100	675		50	200			
Erycina floridana											275		25	150						
Laevicardium mortoni												150		125						
Mulinia lateralis														75						
TELLINIDAE										25										
Macoma sp.							150													
Macoma tenta													25							
Macoma cerina	100			25				25			150		25				175		50	
Macoma nr. cerina			25																	

Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
TELLININAE	200						175					225	475		150	25			250	
Angulus cf. versicolor													25					25		
Angulus texanus													75	375	50					
Angulus nr. tampaensis	25							175							125				100	
Angulus cf. tampaensis		25																		175
Angulus cf. sybariticus												175								
Angulus sp.													25							
Eurytellina sp. A of EPC	350						475				175		500		50					
Tagelus sp.																			75	
Tagelus plebeius							175							25					25	
Tagelus divisus													75							
Cyclinella tenuis																		25		
Mercenaria campechiensis													25							
Chione elevata																25				
Anomalocardia cuneimeris	75	25																	25	25
Parastarte triquetra	275	1850		50			225	550	450	1250	100	75	25	175			50	75	450	1025
Sphenia fragilis												25								
Lyonsia floridana																				25
Amphibalanus cf. amphitrite									25											
Amphibalanus improvisus					25															
Almyracuma bacescui	150	25					875	150		200									100	75
Cyclaspis varians													25							
Leptochelia/Hargeria sp.	100						150	25	425	50	50					125			225	
Leptochelia rapax												25								
Cyathura polita	200						100		275										250	
Amakusanthura magnifica											25			125						
Xenanthura brevitelson		425						50		175									650	700
Harrieta faxoni																25				
Erichsonella attenuata											700					75				
Edotia triloba												25	25	25						

Taxon	CLB01		CLB02		CLB03		CLB04		CLB05		CLB06		CLB07		CLB08		CLB10		CLB12	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
Ampelisca abdita											150					125	50			
Ampelisca holmesi												25	50	100	150			25		
Cymadusa compta																100				
Monocorophium acherusicum													25							
Americorophium ellisi	50																		200	
Grandidierella bonnieroides	50						200				50	100		25					50	
Gammarus mucronatus											25									
Melita elongata												25								
Farfantepenaeus duorarum											25									
Pagurus sp.												50				75				
Pagurus maclaughlinae												50		25						
PANOPEIDAE																25				
DOLICHOPODIDAE	500																			
Phascolion sp.																25				
Phascolion cryptum	25	25						25			100	475	50	350		25	25	200	50	50
Phascolion cf. caupo											50	25								
Phoronis sp.															25					
Aeverrillia armata											1									
Glottidia pyramidata												25								
OPHIUROIDEA												25		50		25				25
Amphiodia atra													25							
Ophiophragmus filograneus											25		25				25			
Amphioplus thrombodes											50							25		
Amphioplus (Amphioplus) sepultus														25				25		
Branchiostoma floridae														25						

Appendix B: SWFWMD Clam Bayou Restoration Project Map



https://www.swfwmd.state.fl.us/projects/clambayou/maps.php

Note: Figure rotated to orient north towards top of map.