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Comparison of Macrobenthic Assemblages in Shallow Coastal Lagoons (Northwest Florida) with Different Level of Anthropogenic Effect

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SHORT PAPERS AND NOTES

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COMPARISON OF MACROBENTHIC ASSEMBLAGES IN SHALLOW COASTAL LAGOONS (NORTHWEST FLORIDA) WITH DIFFERENT LEVEL OF ANTHROPOGENIC IMPACT.—Eutrophication of coastal waters is a widespread environmental problem commonly linked to increases in population density in coastal drainage basins or expanded agricultural activities (Howarth, 1998). Eutrophication is frequently associated with algal blooms, accumulation of organic matter, and development of anoxia (Paerl, 2006; McQuatters-Gollop et al., 2009). These processes often decrease benthic species richness and lead to dominance by opportunistic species (Weston, 1990; Hillebrand and Sommer, 2000; Cardoso et al., 2004). We studied the effects of anthropogenic pressure on the composition of the benthic community in three shallow coastal lagoons located in Perdido Bay (northwest Florida): State Park (30.308°N, 87.403°W), Kees Bayou (30.313°N, 87.469°W), and Gongora (30.305°N, 87.424°W). These lagoons are shallow, relatively small in size, connect to the same body of water, and experience similar tidal cycles, salinities, and temperatures (Stutes et al., 2007). However, they are differently affected by human activities and contain different coverage of seagrasses (*Halodule wrightii* and *Ruppia maritima*) (Table 1), ranging from a total absence of coverage in Gongora to 4.2% ± 0.4% [mean ± standard error (SE)] in Kees Bayou and 64.5% ± 1.0% in State Park (Stutes et al., 2007). The absence of seagrass in Gongora and the low seagrass in Kees Bayou appear to be an indirect consequence of eutrophication and dredging (Stutes et al., 2007). Gongora and Kees Bayou receive higher nitrogen (N) loads than does State Park, which is likely due to greater nearby development (Gongora: 27.7 kg N ha^{-1} yr^{-1}; Kees Bayou: 25.7 kg N ha^{-1} yr^{-1}; and State Park: 4.2 kg N ha^{-1} yr^{-1}) (Stutes et al., 2007). Both Gongora and Kees Bayou are occasionally dredged. Additional information about the lagoons and their characteristics can be found in Stutes et al. (2007).

The goals of our study were to compare the macrobenthic assemblages between these lagoons and to evaluate seagrass coverage as a variable both within and between lagoons. We also attempt to identify possible indicator taxa using nonparametric multivariate classification techniques.

Materials and methods.—Samples were taken on 13 Oct. 2009 using a cylindrical core that covered a surface area of 181 cm^2 (Ø = 15.2 cm) and penetrated to a depth of 13 cm. We took five replicates in each habitat type (Gongora bare sediment, Kees Bayou bare sediment, State Park bare sediment, Kees Bayou seagrass, and State Park seagrass) at the three lagoons, for a total of 25 samples (no seagrass in Gongora). Samples were sieved on a 0.5-mm mesh screen in the field, and the fauna retained were brought to the laboratory for sorting and identification to the family level.

To characterize the sediment three additional cores were taken in each of the habitats at the three lagoons. We dried these samples for 48 hr at 60°C and sorted them into the following six categories: gravel, coarse sand, medium sand, fine sand, and silt and clays (Buchanan, 1984). Organic matter was determined in subsamples of approximately 10 g dry weight as loss on ignition after 4 hr at 500°C. Data analyses were carried out using the PRIMER statistical package (Clarke and Warwick, 1994). We used the abundances [individuals (ind.) m^{-2}] without transformation, and we chose the Bray–Curtis coefficient to calculate the similarity matrix. From this similarity matrix, nonmetric multidimensional scaling techniques (nMDS) were applied. To determine the percentage contribution of each family to the dissimilarity and to detect possible indicator families, the SIMPER (similarity percentages) procedure was used. Finally, a two-way analysis of variance with factors of location and habitat type was used to test if the total number of individuals, taxa richness, and values of the Shannon–Wiener diversity index were significantly different among the different sampling locations and habitats. (Gongora samples were not used for this analysis because there is no seagrass at this site.)

Results.—The granulometric analysis did not show large differences between the three lagoons (Table 2). The lagoons had similar granulometric characteristics, with sediment dominated by fine and medium sands (83–89%). Gongora presents higher values of medium sand, while sites within seagrass patches (State Park/seagrass and Kees Bayou/seagrass) had slightly higher values of silt and clay. The amount of organic matter was also greater within seagrass beds than in bare sediment.

We collected a total of 1,249 individuals belonging to 50 different families (Table 3).

TABLE 1. Percentage of the different species of seagrasses, shoot density, temperature, and salinity from Christiaen et al. (unpubl. data).[a]

	Date	Gongora (mean ± SE)	Kees Bayou (mean ± SE)		State Park (mean ± SE)	
		Unvegetated	Unvegetated	Seagrass	Unvegetated	Seagrass
% *Halodule wrightii*	30 Sep. 09–14 Nov. 09	0.00 ± 0.00	0.00 ± 0.00	44.97 ± 12.40	0.00 ± 0.00	100.00 ± 0.00
% *Ruppia maritima*	30 Sep. 09–14 Nov. 09	0.00 ± 0.00	0.00 ± 0.00	55.03 ± 12.41	0.00 ± 0.00	0.00 ± 0.00
Shoot density (shoots m^{-2})	30 Sep. 09–18 Nov. 09	0.00 ± 0.00	0.00 ± 0.00	3,526 ± 634	0.00 ± 0.00	4,459 ± 466
Temperature (°C)	30 Sep. 09–18 Nov. 09	23.51 ± 1.19	21.07 ± 1.37		22.61 ± 1.50	
Salinity (PPT)	30 Sep. 09–18 Nov. 09	20.35 ± 0.06	17.16 ± 0.58		20.06 ± 1.54	

[a] PPT = parts per thousand.

The greatest number of families was found at State Park/seagrass, with 31 different families (10 of them exclusive for this lagoon and habitat), whereas the lowest number of different families was found at Kees Bayou/unvegetated, with 10 families (zero of which were exclusive). The total abundance of individuals was higher in State Park than in Kees Bayou, both in unvegetated areas and in seagrass beds. Total counts were also high at Gongora (2,105.2 ± 493.0 ind. m^{-2}), in part because of the elevated abundance of Nereididae and Nematoda. Total abundance of individuals, taxa richness, and Shannon–Wiener diversity index values were significantly higher in seagrass patches than in sandy sediments ($P < 0.001$, $P < 0.001$, and $P < 0.01$, respectively; Table 4), and total abundance and taxa richness were also significantly higher in State Park than in Kees Bayou ($P < 0.05$ and $P < 0.001$, respectively). nMDS (Fig. 1) split the samples into two main groups, corresponding to the habitat (sandy substrate or seagrass) and site. The families contributing most to the similarity were Spionidae (37.95%), Paratanaidae (14.45%), Nereididae (8.32%), and Neritidae (5.46%) (Table 5). The family Paratanaidae, mainly the species *Hargeria rapax* (Harger, 1879), appears abundantly in seagrass stations. On the other hand, sites without seagrass (Gongora/unvegetated, Kees Bayou/unvegetated, and State Park/unvegetated) presented an average similarity of 27.59%. The taxa that contributed most to the similarity are Nereididae (27.59%) and the bivalve families Nuculidae (22.20%) and Corbiculidae (17.99%), both being very abundant in sandy sediment, rare in State Park/seagrass, and nonexistent in Kees Bayou/seagrass. The two groups formed by the nMDS (seagrass vs sandy bottom) had an average dissimilarity of 86.95%. The main taxa that contributed to this dissimilarity were Spionidae (19.39%), Paratanaidae (10.45%), Neritidae (7.33%), and Nereididae (7.13%). It is important to note the higher abundance of all families of amphipods in State Park (Ampeliscidae, Aoridae, Gammaridae, Corophidae, Hauteridae, Amphitoidae, Liljeborgiidae, Amphilochidae, and Ischyroceridae).

Discussion.—Previous studies of benthic assemblages have demonstrated that it is possible to detect the impact of pollution without identifying taxa to the species level since there is no substantial loss of information entailed in iden-

TABLE 2. Analysis of the sediment at the sites studied, with the different percentages of grain size and amount of organic matter.

	Date	Gongora (mean ± SE)	Kees Bayou (mean ± SE)		State Park (mean ± SE)	
		Unvegetated	Unvegetated	Seagrass	Unvegetated	Seagrass
% Gravel	13 Oct. 09	0.13 ± 0.08	0.01 ± 0.00	0.04 ± 0.02	0.09 ± 0.04	0.03 ± 0.02
% Coarse sand	13 Oct. 09	17.00 ± 0.60	10.44 ± 2.25	13.58 ± 1.28	13.53 ± 2.20	14.23 ± 1.80
% Medium sand	13 Oct. 09	71.26 ± 1.30	50.99 ± 3.43	54.29 ± 0.53	58.98 ± 4.33	54.32 ± 2.15
% Fine sand	13 Oct. 09	11.43 ± 0.84	37.72 ± 5.35	29.77 ± 1.24	26.97 ± 2.65	29.72 ± 1.42
% Silt and clay	13 Oct. 09	0.18 ± 0.02	0.83 ± 0.33	2.32 ± 0.59	0.42 ± 0.08	1.70 ± 0.48
% Organic matter	13 Oct. 09	0.62 ± 0.20	0.60 ± 0.11	3.74 ± 0.56	0.79 ± 0.17	3.22 ± 0.53

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TABLE 3. Abundances (mean of ind. m^{-2} ± SE) of each family, total individuals (mean ± SE), number of different taxa, and Shannon–Wiener index values (mean ± SE) at the different sites studied.

	G/unvegetated	KB/unvegetated	SP/unvegetated	KB/seagrass	SP/seagrass
Nematoda	418.8 ± 288.8	0.0 ± 0.0	22.0 ± 13.5	33.1 ± 22.0	77.2 ± 22.0
Nemertea	132.3 ± 105.4	0.0 ± 0.0	33.1 ± 13.5	121.2 ± 86.1	66.1 ± 11.0
Gobiidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0
Ostracoda	99.2 ± 44.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Opisthobranchia	33.1 ± 33.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Branchiostoma	0.0 ± 0.0	0.0 ± 0.0	44.1 ± 20.6	0.0 ± 0.0	0.0 ± 0.0
Veneridae	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Nuculidae	154.3 ± 89.5	110.2 ± 60.4	154.3 ± 47.4	0.0 ± 0.0	11.0 ± 11.0
Corbiculidae	132.3 ± 66.6	110.2 ± 49.3	99.2 ± 32.1	0.0 ± 0.0	11.0 ± 11.0
Tellinidae	0.0 ± 0.0	22.0 ± 13.5	0.0 ± 0.0	44.1 ± 44.1	0.0 ± 0.0
Marginellidae	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0
Nassariidae	0.0 ± 0.0	0.0 ± 0.0	44.1 ± 27.0	0.0 ± 0.0	187.4 ± 125.2
Neritidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	451.9 ± 173.7	0.0 ± 0.0
Muricidae	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Columbellidae	11.0 ± 11.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0	110.2 ± 39.0
Ampeliscidae	11.0 ± 11.0	33.1 ± 13.5	0.0 ± 0.0	22.0 ± 13.5	121.2 ± 56.2
Aoridae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	352.7 ± 119.0
Gammaridae	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0	55.1 ± 17.4	143.3 ± 73.1
Bodotriidae	187.4 ± 102.5	22.0 ± 13.5	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0
Corophiidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	319.6 ± 178.9
Haustoriidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	33.1 ± 33.1
Amphitoidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	66.1 ± 53.4
Liljeborgiidae	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0
Amphilochidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0
Ischyroceridae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0
Apseudidae	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0
Sphaeromatidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0
Paratanaidae	22.0 ± 22.0	0.0 ± 0.0	22.0 ± 13.5	451.9 ± 208.7	341.7 ± 152.3
Anthuridae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	33.1 ± 13.5
Argulidae	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0
Portunidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0
Palaemonidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	44.1 ± 20.6
Penaeidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	209.4 ± 87.8
Paguridae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	22.0 ± 13.5
Xanthidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0
Ophiactidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0
Ampharetidae	0.0 ± 0.0	66.1 ± 44.1	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0
Capitellidae	99.2 ± 47.4	0.0 ± 0.0	33.1 ± 22.0	0.0 ± 0.0	407.8 ± 112.4
Cirratulidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	22.0 ± 22.0
Dorvilleidae	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	22.0 ± 22.0	0.0 ± 0.0
Magelonidae	11.0 ± 11.0	11.0 ± 11.0	33.1 ± 22.0	0.0 ± 0.0	0.0 ± 0.0
Maldanidae	11.0 ± 11.0	55.1 ± 17.4	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0
Nepthyidae	22.0 ± 13.5	0.0 ± 0.0	77.2 ± 54.0	11.0 ± 11.0	22.0 ± 13.5
Nereididae	661.3 ± 144.8	66.1 ± 20.6	99.2 ± 27.0	187.4 ± 93.2	198.4 ± 75.2
Orbiinidae	22.0 ± 22.0	22.0 ± 13.5	33.1 ± 33.1	0.0 ± 0.0	0.0 ± 0.0
Paraonidae	0.0 ± 0.0	11.0 ± 11.0	55.1 ± 24.6	165.3 ± 60.4	99.2 ± 99.2
Phyllodocidae	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	0.0 ± 0.0	33.1 ± 13.5
Sabellidae	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 11.0	66.1 ± 53.4	242.5 ± 64.3
Spionidae	33.1 ± 13.5	88.2 ± 44.8	99.2 ± 47.4	771.5 ± 326.0	1,190.4 ± 622.9
Syllidae	11.0 ± 11.0	0.0 ± 0.0	0.0 ± 0.0	110.2 ± 49.3	44.1 ± 32.1
Total individuals	2,105.2 ± 493.0	617.2 ± 197.5	947.9 ± 144.1	2,579.1 ± 563.2	4,463.8 ± 1,233.9
Total number of taxa[b]	21 (4)	12 (0)	23 (5)	20 (5)	31 (10)
Taxon richness	9.4 ± 0.68	6.0 ± 1.26	9.6 ± 1.29	9.0 ± 1.22	17.4 ± 1.44
Shannon index	1.72 ± 0.08	1.59 ± 0.22	2.06 ± 0.16	1.66 ± 0.33	2.37 ± 0.10

[a] G = Gongora; KB = Kees Bayou; SP = State Park.
[b] The total number of exclusive taxa at each location in parentheses.

TABLE 4. Analysis of variance on taxa richness and Shannon index.[a]

	Total abundance (ind.)				Taxa richness				Shannon index			
Source of variation	df	MS	*F*	*P*	df	MS	*F*	*P*	df	MS	*F*	*P*
Habitat (Ha)	1	11.2682	41.45	***	1	145.800	17.10	***	1	1.746	13.02	**
Location (Lo)	1	1.3681	5.03	*	1	180.000	21.11	***	1	0.190	1.42	ns
HaxLo	1	0.0000	0.00	ns	1	28.800	3.38	ns	1	0.072	0.54	ns
Residual	16	0.2717			16	8.525			16	0.134		
Transformation	Ln (ind.)				None				None			

[a] ns = not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. MS = mean square.

tifying only to the family level (Warwick, 1988; Dethier and Schoch, 2006). There are clear differences in the composition of the macrobenthic community between different stations in Gongora, State Park, and Kees Bayou. These differences were not directly related to the granulometric characteristics of the sediment; instead, the clearest connection was between community composition and the presence of seagrass. However, it should be noted that seagrasses can enhance the deposition of suspended sediment (Fonseca, 1989). The nMDS split the sites according to habitat and secondarily according to the degree of anthropogenic impact, with the most impacted site forming a significant cluster relative to other unvegetated samples. The presence of vegetation was the main factor controlling the distribution and the structure of the macrobenthic assemblages across the lagoons. The higher heterogeneity of the habitat formed by the rhizomes and shoots of seagrass can explain the distribution of some families. In the canopy we expect to find more herbivores and omnivores, whereas the unvegetated areas should be dominated by surface deposit and suspension feeders (Cardoso et al., 2004). This is consistent with the contrasting groupings of families found in seagrass patches and bare sediment in our study.

We can also see differences in community composition between vegetated areas in State Park and Kees Bayou. These differences could be related to the different levels of anthropogenic impact, but they could also result from differences in vegetation type, because State Park is dominated by *H. wrightii*, while Kees Bayou is dominated by *R. maritima*. Macrobenthic assemblages of Kees Bayou appear to be in an intermediate state between those in Gongora, which are already dominated by opportunistic species, and those in State Park, which features a ''good'' state of conservation. Indeed, the higher richness and elevated abundance of amphipods in State Park/seagrass is an indicator of healthy

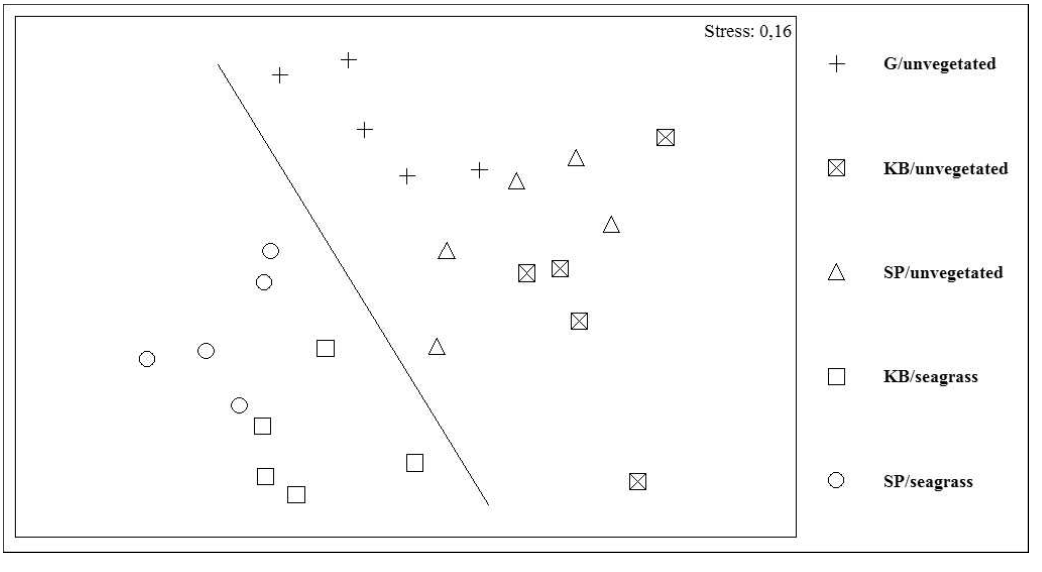

Fig. 1. nMDS showing the groups of the sites according to the abundances of the different taxa and using the Bray–Curtis similarity index. No data transform was applied.

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Table 5. Summary of the results of SIMPER analysis. Species contributing (90% cutoff) to the similarity between the sandy bottom and seagrass bed assemblages. Av. Abund = average abundance (ind. m^{-2}); Av. Sim = average similarity; Contrib. % = percentage of contribution to the similarity; Cum. % = percentage of cumulative contribution. Dissimilarities among the groups obtained by means of the MDS procedure (90% cutoff). Av. Diss = average dissimilarity; Contrib. % = percentage of contribution to the dissimilarity.

	Av. Abund				
Av. Sim = 27.59	Unvegetated	Seagrass	Av. Sim	Contrib. %	Cum. %
Nereididae	277.55		7.61	27.59	27.59
Nuculidae	139.61		6.13	22.20	49.79
Corbiculidae	113.89		4.97	17.99	67.79
Spionidae	73.48		2.76	10.01	77.79
Maldanidae	25.72		0.96	3.47	81.27
Bodotriidae	73.48		0.82	2.96	84.23
Nematoda	146.96		0.61	2.21	86.44
Capitellidae	44.09		0.54	1.97	88.40
Nemertea	55.11		0.54	1.94	90.35
Av. Sim = 33.34					
Spionidae		980.94	12.65	37.95	37.95
Paratanaidae		396.79	4.82	14.45	52.40
Nereididae		192.88	2.77	8.32	60.72
Neritidae		225.95	1.82	5.46	66.18
Sabellidae		154.31	1.66	4.97	71.16
Capitellidae		203.90	1.32	3.95	75.11
Paraonidae		132.26	1.25	3.76	78.87
Aoridae		181.86	1.11	3.33	82.20
Gammaridae		99.20	1.00	3.00	85.20
Nemertea		93.69	0.78	2.33	87.53
Nematoda		55.11	0.77	2.30	89.83
Syllidae		77.15	0.71	2.14	91.97
Av. Diss = 86.95	Unvegetated	Seagrass	Av. Diss	Contrib. %	Cum. %
Spionidae	73.48	980.94	16.86	19.39	19.39
Paratanaidae	14.70	396.79	9.09	10.45	29.84
Neritidae	0.00	225.95	6.38	7.33	37.17
Nereididae	275.55	192.88	6.20	7.13	44.30
Capitellidae	44.06	203.90	3.99	4.59	48.89
Nuculidae	139.61	5.51	3.40	3.91	52.80
Paraonidae	22.04	132.26	3.34	3.84	56.64
Aoridae	0.00	181.86	3.23	3.71	60.36
Sabellidae	3.67	154.31	3.03	3.48	63.84
Nematoda	146.96	55.11	2.94	3.38	67.21
Corbiculidae	113.89	5.51	2.64	3.04	70.25
Corophiidae	0.00	165.33	2.39	2.75	73.00
Nemertea	55.11	93.69	2.32	2.67	75.68
Nassariidae	14.70	93.69	2.32	2.67	78.35
Gammaridae	3.67	99.20	1.95	2.25	80.59
Syllidae	3.67	77.15	1.72	1.98	82.57
Penaeidae	0.00	104.71	1.70	1.95	84.52
Ampeliscidae	14.70	71.64	1.69	1.94	86.46
Bodotriidae	73.48	0.00	1.36	1.56	88.02
Columbellidae	7.35	55.11	1.33	1.53	89.56
Nepthyidae	33.07	16.53	0.99	1.14	90.70

habitat (Bellan-Santini, 1980), whereas lower values in Kees Bayou are a possible effect of reduced seagrass health due to nutrient enrichment and dredging. Families of crustaceans such Palaemonidae and Paguridae appear exclusively in State Park/seagrass. Other organisms, the presence of which usually indicates good water quality, are some species of the genus *Branchiostoma.* Individuals of these species appeared in the sandy sediment at State Park, the site that is best conserved, but were completely absent in the other two sites. An opposite trend was observed with Ostracoda and Nematoda, the abundances of which were high in Gongora/unvegetated and very low or null in the other sites. Nematodes have been used as indicators of poor water quality, with increasing abundances under conditions of high eutrophication (Essink, 2003; Ferris and Bonger, 2006). Other organisms considered as indicators of eutrophication in soft sediments are cumaceans (family Bodotriidae) (Corbera and Cardell, 1995), which were also abundant at Gongora. Our results indicate that higher nutrient input and occasional dredging at Gongora and Kees Bayou promote opportunistic species to the detriment of other species more typical of healthier systems such as State Park. These results indicate a clear association between anthropogenic disturbances and the macrobenthic community of shallow coastal lagoons, on that appears to occur through the negative impacts of the disturbances on existing seagrass beds in the lagoons.

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