January 2002

Spatial and Temporal Variability in Zooplankton Community Dynamics in Three Urbanized Bayous of the Pensacola Bay System, Florida, USA

Emile M. Lores
U.S. Environmental Protection Agency

Michael A. Lewis
U.S. Environmental Protection Agency

Ziad A. Malaeb

SPATIAL AND TEMPORAL VARIABILITY IN ZOOPLANKTON COMMUNITY DYNAMICS IN THREE URBANIZED BAYOUS OF THE PENSACOLA BAY SYSTEM, FLORIDA, USA

Emile M. Lores[1], Michael A. Lewis[1], and Ziad A. Malaeb[2]

[1]*US Environmental Protection Agency, 1 Sabine Island Drive, Gulf Breeze, Florida 32561,USA, Email: lores.emile@epa.gov*
[2]*4800 Rucker Boulevard #241, Enterprise, Alabama 36336, USA*

ABSTRACT Spatial and temporal patterns in zooplankton community composition and abundance in coastal areas of the Gulf of Mexico are not well understood. Spatial and temporal differences in zooplankton community composition and abundance from 10 stations located in four sites are presented (Pensacola Bay and Bayou Texar, Bayou Chico, and Bayou Grande, three adjacent mesohaline-tidal bayous affected by urban and industrial development). Statistically significant differences ($P < 0.05$) were found in log-biovolume among sites. The mean biovolume of zooplankton was highest in Pensacola Bay (0.38 ml m^{-3}) followed by Bayou Grande (0.21 ml m^{-3}), Bayou Chico (0.14 ml m^{-3}), and Bayou Texar (0.06 ml m^{-3}). Mean zooplankton abundances (organisms m^{-3}) in Pensacola Bay (3,100 m^{-3}) and Bayou Grande (3,000 m^{-3}) were more than double the abundances in Bayou Texar (1,400 m^{-3}) and Bayou Chico (1,100 m^{-3}). The calanoid copepod *Acartia tonsa* Dana was the dominant species in the study area. The observed differences in the zooplankton community may be attributable to either one or a combination of factors such as water quality (toxicity), predation, and nutrient availability. Zooplankton abundance increased following two hurricanes that impacted the study area.

INTRODUCTION

The Gulf of Mexico (Gulf) is a valuable economic and ecological resource that receives contaminants from a variety of sources (USEPA 1994a). These include the effluents from 3,700 permitted outfalls, drainage of 33 rivers, oil/chemical spills, deposition of dredged spoils, and nonpoint runoff from urban and agricultural areas. As a consequence, the ecological condition of the Gulf is thought to be declining as evidenced by decreases in fisheries, wetlands, and seagrasses (USEPA 1994a).

Little information exists on spatial and temporal response of zooplankton to anthropogenic activity in Gulf coastal areas. This is surprising since the meso-zooplankton community (> 200 µm, Sieburth et al. 1978) is an important biological component of coastal food webs. Copepods are often the major constituents of the meso-zooplankton and an important herbivore in the plankton community (Landry 1977). Due to the density of their fecal pellets, the meso-zooplankton play a critical role in the sinking flux or exportation of primary production to the sediments (McCave 1984, Michaels and Silver 1988). Copepods are important grazers of phytoplankton, particularly during phytoplankton blooms, and they reproduce rapidly when food is abundant (Durbin et al. 1990, White and Roman 1992, Buskey 1993, Dam et al. 1994, Mallin and Pearl 1994, Dagg 1995). In addition, they serve as food for larval fish, both through direct predation (Motta et al. 1995) and the production of eggs and larvae which may provide critically-sized nutritious food for larval fish (Runge 1988).

The sources, causes, extent, and biological consequences of chemical contamination in Gulf coastal rivers, bays, and estuaries are not well understood (USEPA 1994b). Of the research needs that exist for the Gulf, a high priority has been placed on defining spatial and temporal patterns of the community structure of the various biota inhabiting impacted and unimpacted coastal areas. The current study was conducted in three urbanized bayous which are typical of those near populated coastal areas of the Gulf. Previous environmental surveys, during which chemical and biological analyses were performed, have been conducted in these bayous and Pensacola Bay (Jones et al. 1990, Stone and Morgan 1990, NWFMD 1997). No published information exists, however, that compares the condition of the zooplankton community between areas of different environmental quality. This research provides information on the seasonal and spatial distribution of the zooplankton and compares that information with what is known about the chemical quality of the water and sediments in these bayous.

In addition to contaminant inputs from anthropogenic sources, areas of the Gulf are impacted by frequent episodic weather events. Understanding the effects of episodic events like hurricanes is important (Wiens and Parker 1995, Boero 1996). The few reported storm-related studies conducted in the Gulf region have examined the effects of storms on biota other than zooplankton (Isphording et al. 1987, Boero 1996, Posey et al. 1996, Rakocinski et al. 2000). A rare opportunity to provide some perspective on the effects of two consecutive hurricanes on zooplankton occurred during this study.

Materials and Methods

Study area

This one year study was conducted in conjunction with a multi-year fish abundance and diversity study in Pensacola Bay and three adjacent bayous near Pensacola, Florida (Figure 1)(Larry Goodman, personal communication, US EPA, Gulf Breeze, FL). This study was conducted from March 1995 through March 1996. Hurricanes Erin (Category 1) and Opal (Category 4) directly impacted the study area during August and October 1995. Detailed physical and chemical descriptions of the water bodies have been previously reported (Lewis et al. 2001). Three sampling stations each were located in Pensacola Bay and Bayou Grande and two each in Bayou Chico and Bayou Texar. Physical and chemical measurements were taken in-situ at each station during the field collections. Salinity, pH, temperature (°C), and dissolved oxygen (DO, mg/L) were measured using a Hydrolab H_2O Sonde® (Hydrolab, Inc., Austin, TX) at 1 m depth intervals. Salinity was measured using Practical Salinity Units (psu, Unesco 1981).

Zooplankton collection and analysis

Duplicate zooplankton samples were collected in all months except April, December, and February from each of the 10 sampling stations (only Pensacola Bay was sampled in July). Procedures for collection and analysis of the zooplankton followed the guidelines of Jacobs and Grant (1978), except that zooplankton were collected using a 0.3 m diameter plankton net (0.07 m²). The 153 μm mesh net was equipped with a flow meter (General Oceanic, Inc., Miami, FL) and a 2.5 kg weight attached to the bottom of the net ring. The length of the tow line was adjusted each minute during sampling to simulate an oblique tow (actually sampling at five discreet depths over the depth range at each station). Flow meter counts were used to calculate the volume of water sampled. Tow speed was about 1 m s⁻¹. Duplicate 5 min tows were conducted in opposite directions at each collection station. The zooplankton samples were preserved with 10% formalin.

The total settled biovolume was recorded for each sample. For most samples, the biovolume was measured using the graduations on 50 ml centrifuge tubes, but a graduated cylinder was used for larger samples. The presence of numerous ctenophores inhibited accurate
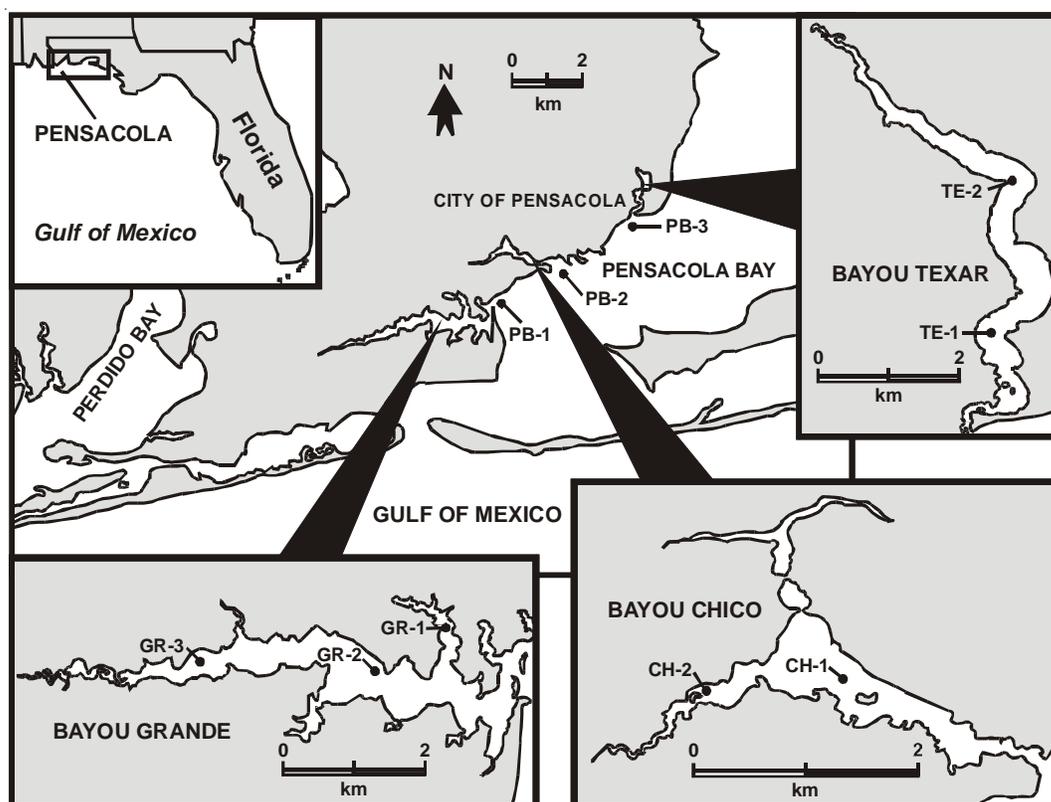

Figure 1. Map of study area showing sampling sites and stations. The four sampling sites are Pensacola Bay (PB), three stations; Bayou Grande (GR), three stations; Bayou Chico (CH), two stations; Bayou Texar (TE), two stations.

determination of the true meso-zooplankton biovolume in about 40 of the 180 samples collected. Consequently, those biovolume measurements were excluded from statistical analysis. In addition to biovolume, 110 samples were selected for taxonomic identification and abundance measurements.

To measure abundance, zooplankton samples were stained with rose-bengal and larger organisms removed (>1 mm). Samples were then diluted with water until a density of about 200–400 organisms ml^{-1} was achieved, then the sample was shaken to obtain a homogenous mixture and a 1 ml sub-sample was immediately removed and placed in a counting chamber. A minimum of 200 organisms was counted. In addition to enumeration, the zooplankton were identified to the lowest possible taxon using regional taxonomic keys (e.g., Owre and Foyo 1967, Gosner 1971, Smith 1977). The Shannon-Weiner diversity index (Shannon and Weaver 1949) was also calculated for each sample. This index is the most widely used of its type, and its strengths and weaknesses have been previously described (Washington 1984).

Statistical Analysis

Samples for taxonomic analysis were not randomly selected; therefore, comparisons of means based on numerical abundances and diversity could be biased. As a result, statistical analyses to determine significant differences among sites were performed on the biovolume data only. Means and standard deviation for abundance and diversity data are provided to allow the reader to visualize spatial and temporal trends. All biovolume and abundance measurements were divided by the volume

(m^3) of water sampled. Initial examination of the data suggested that the empirical distributions of biovolume were log-normal. Biovolume data were log-transformed to achieve normality, and correlation, regression, and analysis of covariance (ANCOVA) were conducted on the logarithmic scale. Correlation analysis was used to examine the parametric relationship between log-biovolume and independent variables (i.e., salinity). We then used regression analysis to define further significant correlation between log-biovolume and salinity. Because differences in sites may in part be due to differences in salinity, salinity was treated as a covariate in the ANCOVA to test for differences in log-biovolume among sites. All tests of statistical significance were based on the 95% confidence level ($P < 0.05$).

RESULTS

The physical and chemical measurements were more variable between sampling periods than they were spatially within a single time period. For example, mean surface salinity (Figure 2) usually differed by <10 psu across stations during sampling periods, but within each station salinity generally differed by >10 psu across all sampling periods. Temperature ranged from a winter minimum of 10°C to a summer maximum of 32°C, but differed by <2°C across stations during any sampling period. Dissolved oxygen was higher in winter than summer, ranging from 6.1–11.8 mg L^{-1} and pH ranged from 6.8–8.2.
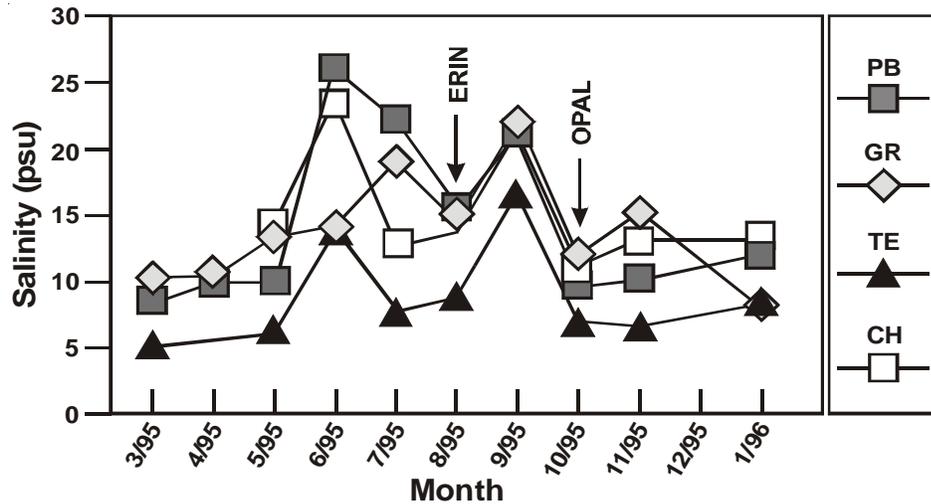
Figure 2. Mean surface salinity at the four study sites Pensacola Bay (PB), Bayou Grande (GR), Bayou Chico (CH), and Bayou Texar (TE) recorded during collection of zooplankton samples. Approximate dates when hurricanes Erin and Opal impacted the study sites are indicated.
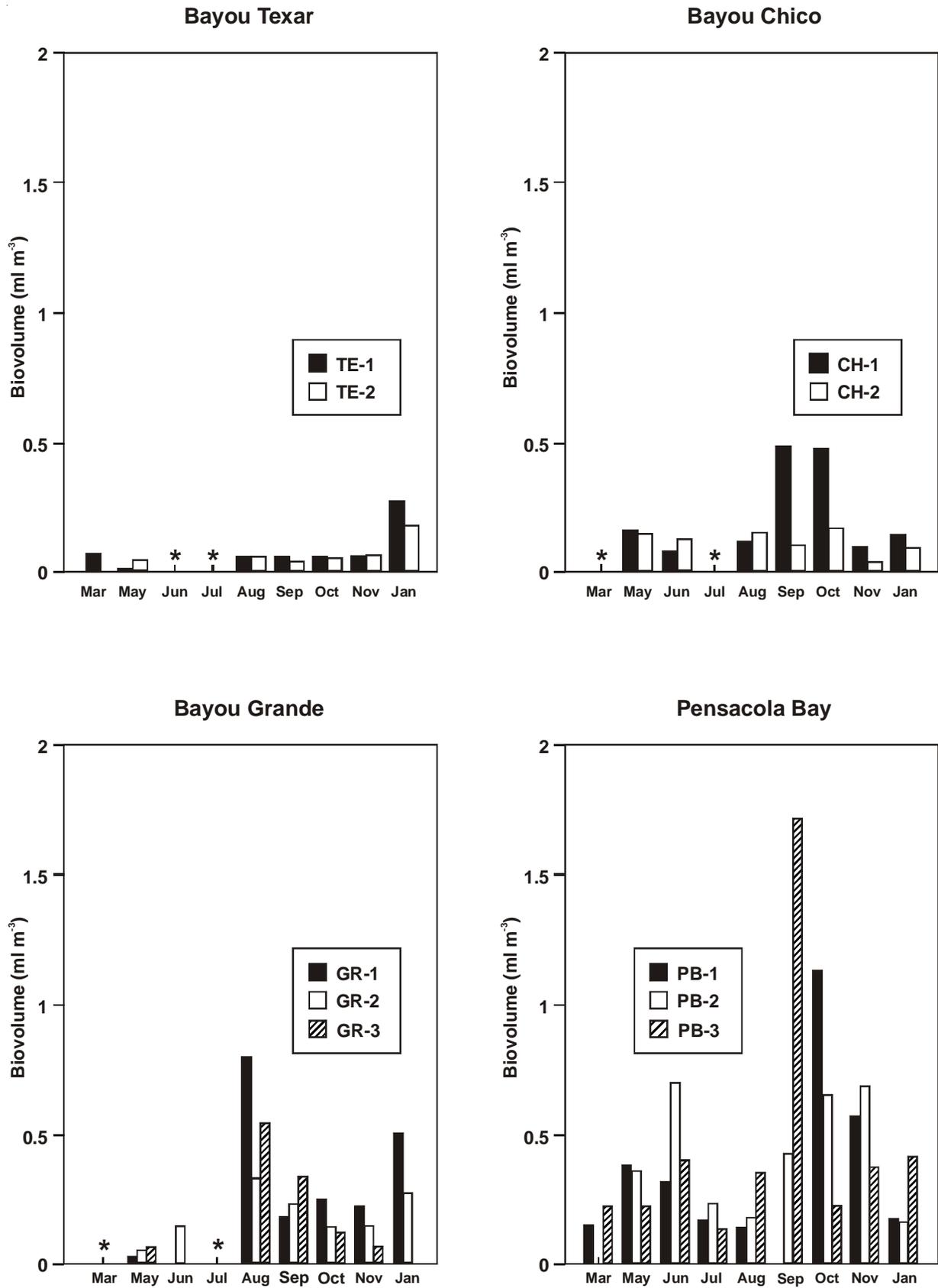
Figure 3. Biovolume (ml m^{-3}) of zooplankton samples collected in 1995–1996 for 10 stations in the four study sites. Legends correspond to stations in Figure 1. Asterisks indicate no data.

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Biovolume

Monthly zooplankton biovolume (ml m^{-3}) for the 10 stations is shown in Figure 3. Peak biovolumes occurred during August at all stations in Bayou Grande, during October in Bayou Chico, and during January in Bayou Texar. In contrast, Pensacola Bay peak biovolumes occurred at different times at different stations. The mean biovolume was 0.38 ml m^{-3} ($\pm$ 0.31) in Pensacola Bay, 0.21 ml m^{-3} ($\pm$ 0.25) in Bayou Grande, 0.14 ml m^{-3} ($\pm$ 0.11) in Bayou Chico, and 0.06 ml m^{-3} ($\pm$ 0.06) in Bayou Texar. Using data from all months, log-biovolume was moderately correlated with surface salinity (r = 0.41, P < 0.0001). An ANCOVA with salinity as covariate indicated that log-biovolume was significantly different among sites (ANCOVA, R^2 = 0.49; P < 0.0001). Duncan's Multiple Range Test, conducted on the adjusted means, indicated that the mean log-biovolume was highest in Pensacola Bay and lowest in Bayou Texar. The means in Bayou Grande and Bayou Chico were not significantly different from one another but were significantly lower than that of Pensacola Bay and higher than that of Bayou Texar. The ranks of the adjusted and unadjusted means were the same, indicating that the effects of salinity were the same within each of the sites.

Abundance

The relative abundance of zooplankton taxa is summarized in Figure 4. Where overall abundances of individual taxa were low, they were combined into groups (i.e., other calanoida, total branchiopoda). The mean abundance (organisms ml^{-1}) was highest in Pensacola Bay at 3,100 m^{-3} ($\pm$ 2500) compared to 3,000 m^{-3} ($\pm$ 3100) in Bayou Grande, 1,400 m^{-3} ($\pm$ 1800) in Bayou Texar, and 1,100 m^{-3} ($\pm$ 1600) in Bayou Chico. The peak numerical abundance values for each bayou in decreasing order were: 12,500 m^{-3} for Bayou Grande (January); 11,600 m^{-3} for Pensacola Bay (October); 6,100 m^{-3} for Bayou Chico (October); and 5,700 m^{-3} in Bayou Texar (January).

Community Composition

Overall, 80 taxa were identified in this study; 20 were identified to species and 17 to genera. The 10 most abundant taxa for each of the bayous and Pensacola Bay appear in Table 1. See Appendix for a complete taxonomic list of organisms found in this study. Zooplankton community composition in Pensacola Bay and the bayous was similar. The zoo-plankton in the bayous was dominated by copepods and crustacean nauplii (Figure 4); the copepod *Acartia tonsa* Dana, 1852 was the dominant taxa in most samples. However, in Pensacola Bay a cyclopoid copepod (*Oithona* sp.) was dominant during July and August at several stations and a branchiopod (*Podon* sp.) dominated most bay samples in May.

The mean diversity index for the 10 stations ranged from 0.79–1.19 (Table 2). The values were greatest in Pensacola Bay and seasonal variation was evident with the highest diversity occurring in May (1.60) and July (1.99). The diversity index peaked in Bayou Grande in September (1.18) and October (1.75) and in Bayou Texar during August (1.59) and September (1.82). Diversity was low during November in Pensacola Bay, Bayou Grande, and Bayou Texar. In Bayou Chico, the diversity peaked in June (1.41, 1.74) and January (1.44, 1.49). Species diversity was lowest during March in Bayou Chico but also low during September for one station.

Two hurricanes directly impacted the study area within a three-month period, and salinity was affected dramatically. The salinity range decreased from 20–24 psu in July (pre-hurricane) to 14–17 psu in late August (post-hurricane) in the top 2 m of the water column in Pensacola Bay almost a month after the first hurricane (Erin). Bottom water salinity (>2 m depth) was similar to pre-hurricane conditions. After hurricane Opal (October 3), hydrographic measurements were made on October 12. Salinity decreased to <6 psu in the top 3 m of Pensacola Bay and at one station, PB-2; the salinity at 4 m dropped from 32 psu in July to 6 psu (post hurricane). The reduction in salinity was less in the bayous than in Pensacola Bay, especially at depths greater than 1 m. Since there is no comparable data from the same periods without hurricanes, meaningful statistical analyses cannot be conducted. However, zooplankton biovolume and abundance in Pensacola Bay increased for 1–2 months following each hurricane. Similar effects in the bayous were less obvious.

DISCUSSION

The most significant finding in this study is the spatial difference in biovolume of zooplankton. Overall, mean biovolume was significantly greater in Pensacola Bay as compared to the bayous, especially as compared to Bayou Texar (P < 0.05). Bayou Texar had significantly lower biovolume than all other sites, but Bayou Chico and Bayou Grande were not significantly different. The zooplankton community can be impacted by multiple and interacting physical, chemical, and biological factors. Surface salinity, DO, pH, and temperature were not dramatically different among sites in the study area during the individual sampling periods. None of these parameters were, thus, likely to cause the biovolume
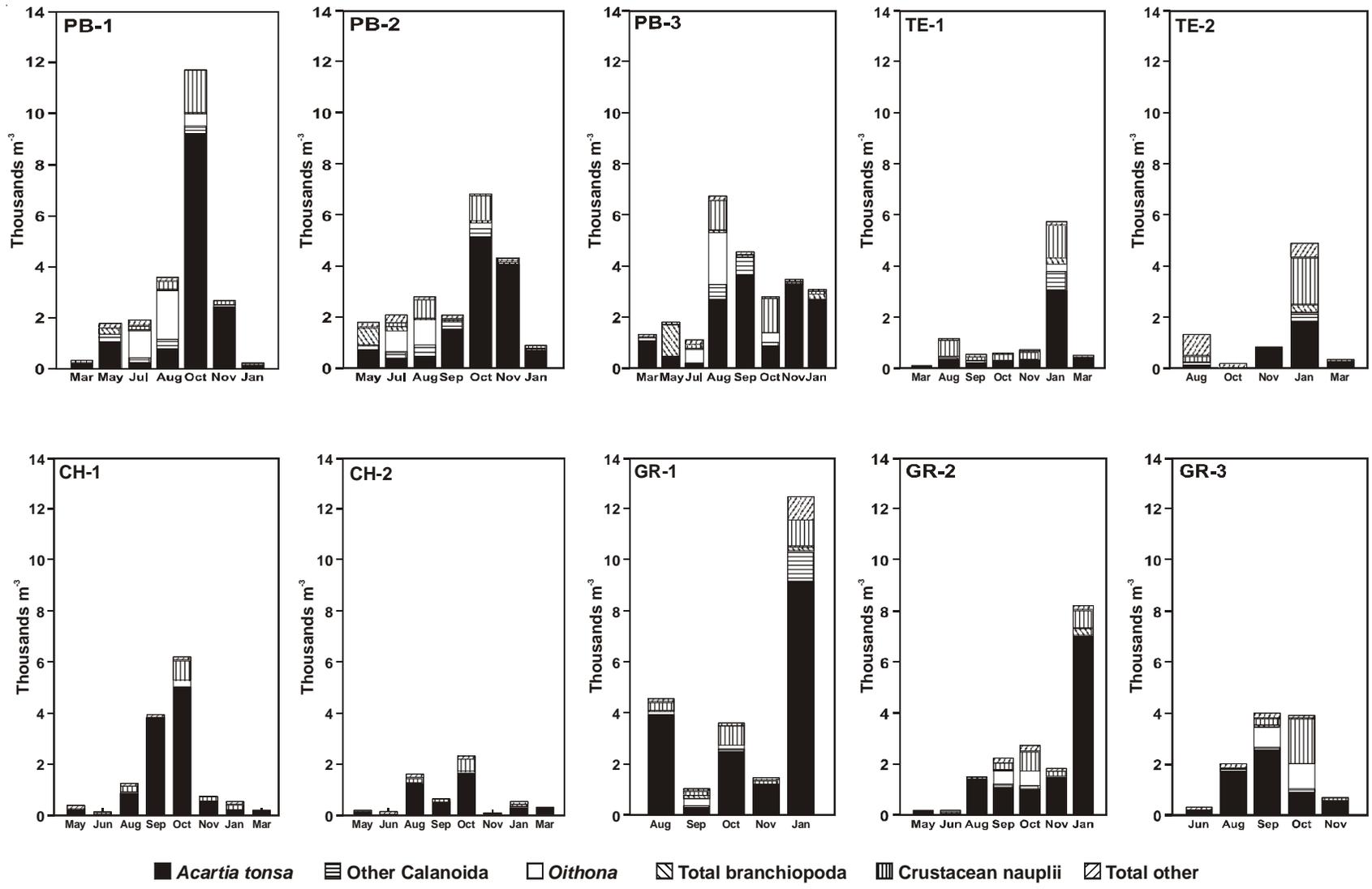
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Figure 4. Relative abundance (thousands m⁻³) of major components from selected zooplankton samples collected in 1995–1996 at the 10 stations in this study. Legends correspond to stations shown in Figure 1.

TABLE 1

Ten dominant taxa from each of the four study sites. LPIL = lowest possible identification level.

Pensacola Bay	Bayou Grande	Bayou Texar	Bayou Chico
Acartia tonsa	*Acartia tonsa*	*Acartia tonsa*	*Acartia tonsa*
Oithona (LPIL)	*Oithona* (LPIL)	*Oithona* (LPIL)	*Oithona* (LPIL)
Podon (LPIL)	*Balanus* (LPIL)	*Podon* (LPIL)	*Balanus* (LPIL)
Labidocera aestiva	*Podon* (LPIL)	*Labidocera aestiva*	*Rhithropanopeus harrisii*
Oikopleura (LPIL)	*Evadne* (LPIL)	*Evadne* (LPIL)	*Podon* (LPIL)
Evadne (LPIL)	*Oikopleura* (LPIL)	*Oikopleura* (LPIL)	*Polydora* (LPIL)
Balanus (LPIL)	*Polydora* (LPIL)	*Balanus* (LPIL)	*Evadne* (LPIL)
Lucifer faxoni	*Rhithropanopeus harrisii*	*Lucifer faxoni*	*Sagitta* (Includes LPIL and *S. friderici*)
Sagitta (Includes LPIL and *S. friderici*)	*Lucifer faxoni*	*Sagitta* (Includes LPIL and *S. friderici*)	*Oikopleura* (LPIL)
Penilia (LPIL)	*Labidocera aestiva*	*Penilia* (LPIL)	*Eurypanopeus depressus*

differences among sites. However, because salinity was moderately correlated with log-biovolume ($P < 0.05$, $r = 0.41$), the differences in log-biovolume among sites were tested using ANCOVA with salinity as the covariate. The results indicated that sites accounted for 48% of the variability when salinity effects were taken into consideration. We speculate that various combinations of factors, such as predation, toxicity, and food web dynamics are affecting this community.

Differences in water and sediment quality between sites may account for differences in zooplankton biovolume, since zooplankton biovolume and abundance were lowest in the two bayous which are impacted most by anthropogenic activity in their watersheds. Both Bayou Texar and Bayou Chico are considered to be eutrophic, experience seasonal hypoxia, and have degraded water and sediment quality (Collard 1991, Lewis et al. 1999). Copper concentrations in these waters exceeded Florida water quality criteria (2.9 µg/L) continuously during a two-year study while other metals intermittently exceeded the criteria (Lewis et al. 1999). Furthermore, 15 compounds in the sediments exceeded proposed sediment quality assessment guidelines, indicating a high level of degradation and risk to biota. Copper is highly toxic to copepods and can cause reproductive effects at concentrations as low as 1–5 µg/L (Beers et al. 1977, Reeve et al. 1977, Sosnowski and Gentile 1978, Sunda et al. 1990). Studies determining the in-situ toxicity of the bayou waters would provide needed insight on this issue.

In addition to water quality, a trophic cascade effect (Carpenter et al. 1985) may explain the lower densities in the bayous through increased predation on zooplankton.

There is some evidence that fish densities are higher in the bayous than in Pensacola Bay (Larry Goodman, personal communication). Other predators such as ctenophores may also be important and were more common in the bayous than in Pensacola Bay. However, Bayou Grande had more ctenophores than the other two bayous where zooplankton abundance was lower. Consequently, the role of predation by ctenophores or fish and its significance in explaining our observations is uncertain and needs further study.

Other studies describing the zooplankton community in the study area were not available in the scientific literature. However, data were available for areas adjacent to Pensacola Bay. Zooplankton abundances in Escambia and East Bay, Florida, reported by Olinger (1975) showed mean values of 36,674 m^{-3} in Escambia Bay and 32,253 m^{-3} in East Bay (a 74 µm mesh net was used in that study and would be expected to result in higher abundance values). Using a 154 µm mesh net, Hopkins (1966) reported 40,100 m^{-3} as the annual mean in St. Andrew Bay, Florida, and Buskey (1993) reported a mean of 6,100 m^{-3} in Nueces Estuary, Texas. These values were considerably greater than the mean abundance reported here for Pensacola Bay (3,059 m^{-3}). In contrast, McIlwain (1968) reported a mean copepod density in Mississippi Sound of 115 copepods m^{-3} which is much lower than the copepod densities reported here where the abundance of *Acartia* alone frequently exceeded 1,000 m^{-3}. Peak zooplankton densities of 11,600 m^{-3} reported for Pensacola Bay and 12,500 m^{-3} for Bayou Grande were also lower than those found in St. Andrew Bay (97,471 m^{-3}, Hopkins 1966) and Nueces

TABLE 2

Zooplankton diversity (Shannon-Weiner) in 10 stations sampled during 1995–1996. Values in parentheses are SD ($n = 2$). See Figure 1 for station identification.

Month	PB1	PB2	PB3	GR1	GR2	GR3	CH1	CH2	TE1	TE2
						Stations				
Mar 95	1.02 (0.36)		0.70 (0.07)						0.74 (0.19)	
May 95	1.60 (0.32)	1.57 (0.00)	0.96 (0.05)		1.06	0.98 (0.09)	1.08 (0.06)	1.64 (0.09)		
Jun 95					1.05		1.41 (0.15)	1.74		
Jul 95	1.46 (0.04)	1.99 (0.15)	1.76 (0.13)							
Aug 95	1.32 (0.1)	1.60 (0.15)	1.50 (0.09)	0.66 (0.30)	0.45 (0.00)	0.65 (0.17)	0.85 (0.02)	0.69 (0.09)	1.23	1.59
Sep 95		1.07	0.75	1.75	1.41	1.13	0.17	0.69	1.82	
Oct 95	0.69 (0.13)	0.86 (0.05)	1.15	0.78 (0.08)	1.26 (0.01)	1.18 (0.03)	0.64 (0.05)	0.86 (0.12)	1.07 (0.03)	1.45
Nov 95	0.42	0.51 (0.15)	0.40 (0.07)	0.55	0.60	0.49	.61	1.17	1.01	0.13
Jan 96	1.16 (0.08)	0.92 (0.14)		0.91 (0.19)	0.63		1.44 (0.03)	1.49 (0.09)	1.45 (0.00)	1.06 (0.01)
Mar 96							0.14 (0.01)	0.13 (0.05)	0.83 (0.18)	0.45 (0.05)
Station Mean	1.10	1.19	1.00	0.93	0.92	0.89	0.79	1.05	1.16	0.94
Bay Bayou Mean			1.09			0.91		0.92		1.05

Bay and Corpus Christi Bay (40,000 m^{-3}, Buskey 1993). Causes of the lower zooplankton density observed in Pensacola Bay relative to values reported for other Gulf estuaries are unknown; however, one possibility is that in summer Escambia/Pensacola Bay phytoplankton is dominated by cyanobacteria which produce food too small to support most meso-zooplankton organisms (Lores et al. 2001).

In this study, 20 organisms were identified to species and an additional 17 to genera. Overall, there were more than 80 taxa identified. Hopkins (1966) reported a total of 37 organisms identified to species in Tampa Bay and a range of 16–37 identified in samples from St. Andrew Bay. Dye (1987) reported 54 taxa (identified to at least the genus level) in Escambia Bay and 49 in East Bay, with a peak taxa richness in October in Escambia Bay and in December for East Bay. The minimum richness for Escambia and East Bay occurred in March and June. In contrast, the highest diversity values in Pensacola Bay occurred in early summer and the lowest in fall. A similar pattern was reported by Hopkins (1966) for St. Andrew Bay, with higher diversity in summer and lower diversity in winter. However, the diversity patterns seen in the bayous seem to correspond more closely to the patterns seen by Dye (1987) in Escambia and East Bays. Diversity values in the bayous (Table 2) were often high in the summer and early fall (0.45–2.0 from June–September) and low in early spring (0.13–1.0 during March). Two bayous did have a sharp drop in diversity at one site during the fall (Bayou Chico in September and Bayou Texar in November) that may have been related to seasonal DO problems or possibly delayed effects from the hurricanes. Hopkins (1966) reported a trend toward higher diversity (types of plankton) with increasing salinity and a similar trend was seen in this study.

Acartia tonsa was the most abundant species in this study, as in several other studies in Gulf estuaries (Gillespie 1971, Dye 1987, Buskey 1995). McIlwain

(1968) reported *A. tonsa* as the overall dominant species, but found *Labidocera aestiva* Wheeler,1901, *Labidocera* sp., *Paracalanus parvus* (Claus, 1863), *Euterpina acutifrons* (Dana, 1848), and *Temora longicornis* (Müller, 1792) to be dominant at times. However, Hopkins (1977) found *Oithona colcarva* Bowman, 1975 to be dominant in most samples from Tampa Bay with *A. tonsa* the dominant during winter. In St. Andrew Bay, Hopkins (1966) found high variability in dominants at the station nearest the Gulf, while *Oithona simplex* Farran, 1913 or *Centropages hamatus* (Lilljeborg, 1853) dominated the middle stations and East Bay and *A. tonsa, Parvocalanus crassirostris* (Dahl, 1894) and *Pseudodiaptomus coronatus* Williams, 1906 were dominant in the upper reaches of West Bay.

Mallin and Pearl (1994) reported a positive correlation between river flow, phytoplankton growth, and zooplankton grazing. Hurricanes certainly increased river flow and appeared to increase biovolume and abundance in Pensacola Bay during the period following the hurricanes from September–November. This trend of stimulating zooplankton production may have been due to the increase in freshwater supply and the associated allochthonous inputs.

In summary, the results reported here indicate that the abundance of zooplankton in Pensacola Bay and associated bayous was low relative to historical data from other estuaries within the Gulf. Considerable spatial and temporal variations in zooplankton community structure were evident in this study, indicating that data generalizations and extrapolations should be made with caution when applied to characterizing this biota in coastal areas. A variety of chemical and biological factors, such as water quality, and to a lesser extent, predation pressure may have been the cause of the observed differences. Two hurricanes impacted the study area causing a short-term decrease in salinity with a concomitant increase in zooplankton. The zooplankton community is an important component of estuarine ecosystems and trophic disruptions in this community due to imbalanced predation, toxicity, or unsuitable environmental parameters may have significant effects on the function of these ecosystems.

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APPENDIX

Taxonomic list for Pensacola Bay-Bayou Study
Cnidaria
  Hydrozoa
    Hydroida
      Bouganvillidae
        Nemopsis bachei Agassiz, 1862
  Scyphozoa
    Semaeostomae
      Pelagiidae
        Chrysaora quinquecirrha (Desor, 1848)
      Ulmaridae
        Aurelia sp.
  Siphonophora
    Diphyidae
      Lensia sp.
Rotifera
Annelida,
  Oligocheta
  Polychaeta
    Spionidae
      Polydora sp.
    Syllidae
Arthropoda
    Crustacean nauplii
  Crustacea
  Branchiopoda
    Diplostraca
      Polypheniidae
        Evadne sp.
  Cladocarasa
  (cladoderan)
    Podon
      Sididae
        Penilia sp.
  Branchuria
    Argulidae
      Argulus sp.
  Cirripedia
    Thoracica
      Balanidae
        Balanus sp.
  Copepoda
    Calanoida
      Acartiidae
        Acartia tonsa Dana,1852
      Eucalanidae
        Eucalanus monachus Giesbrecht, 1892
      Centropagidae
        Centropages sp.
        Centropages furcatus Brady, 1883
      Pontellidae
        Labidocera aestiva Wheeler, 1901
    Caligoida
    Cyclopoida
      Clausidiidae
        Saphirella sp.
      Corycaedidae
        Corycaeus sp.
        Corycaeus catus F. Dahl, 1894
        Corycaeus clausi F. Dahl, 1894

        Corycaeus limbatus Brady, 1883
        Corycaeus speciosus Dana, 1852
      Cyclopodidae
      Oithonidae
        Oithona sp.
      Oncaeidae
        Oncaea venusta Philippi, 1843
    Harpacticoida
  Malacostraca
    Cumacea
    Decapoda
      Dentrobranchiata
        Luciferidae
          Lucifer faxoni Borradaile, 1915
        Palaemonidae
          Palaemonetes sp.
        Sergestidae
          Acetes americanus carolinae Hansen, 1933
      Pleocyemata
      Anomura
        Callianassidae
          Unid. Callianassidae
        Diogeneiidae
          Clibanarius vittatus (Bosc, 1802)
        Porcellanidae
          Euceramus praelongus Stimpson, 1860
      Brachyura
        Grapsidae
          Sesarma sp.
          Armases cinereum (Bosc, 1802)
        Portunidae
          Callinectes sapidus Rathbun, 1896
        Xanthidae
          Eurypanopeus depressus (Smith, 1869)
          Rithropanopeus harrisii (Gould, 1841)
    Ostracoda
    Podocopa
      Cypridinidae
        Cypridina sp.
Insecta
  Diptera
    Chironomidae
      Dicrotendipes sp.
      Polypedilum sp.

Chaetognatha
  Sagittoidea
    Aphragmophora
      Sagittidae
        Sagitta sp.
        Sagitta friderici Ritter-Zahony, 1911
Chordata
  Larvacea
    Oikopleuidae
      Oikopleura sp.
Mollusca
  Gastropoda
  Plecypoda
Platyhelminthes
  Turbellaria