Gulf and Caribbean Research

Volume 9 | Issue 4

January 1997

Spatial and Temporal Changes in Subtidal Benthic Crustaceans Along a Coastal River-Estuarine Gradient in Mississippi

Mark S. Peterson
Gulf Coast Research Laboratory, mark.peterson@usm.edu

Recommended Citation

Peterson, M. S. 1997. Spatial and Temporal Changes in Subtidal Benthic Crustaceans Along a Coastal River-Estuarine Gradient in Mississippi. Gulf Research Reports 9 (4): 321-326.
Retrieved from https://aquila.usm.edu/gcr/vol9/iss4/8
DOI: https://doi.org/10.18785/grr.0904.08

Gulf Research Reports, Vol. 9, No. 4, 321-326, 1996 Manuscript received June 5, 1995; accepted August 23,1996

SPATIAL AND TEMPORAL CHANGES IN SUBTIDAL BENTHIC CRUSTACEANS ALONG A COASTAL RIVER-ESTUARINE GRADIENT IN MISSISSIPPI

Mark S. Peterson
Gulf Coast Research Laboratory, P.O. Box 7000, Ocean Springs, MS 39566-7000, USA

ABSTRACT Benthic crustaceans were collected monthly between 24 August 1985 and 20 September 1986 from tidal freshwater (TFW), oligohaline (OH) and mesohaline (MH) sites in Old Fort Bayou, a black-water tidal river of the Biloxi Bay estuary, Mississippi. Salinity varied seasonally and spatially and was primarily related to variations in rainfall during this study. Reduced rainfall after October 1985 resulted in the upstream movement of saline water and a concommitant shift in benthic crustaceans upstream with this change in the physical-chemical environment. This shift is supported by a significant positive concordance of ranks between salinity and relative abundance of *Gammarus sp. A* (Kendall's tau-c = 0.458 and Spearman's r_s = 0.704, p<0.007) and *G. mucromatus* (Kendall's tau-c = 0.497 and Spearman's r_s = 0.701, p <0.007) at TFW indicating that when salinity became high, so did the relative abundance of these two species in TFW. No specimens of either species were collected at this site during the same months in 1985. There was no relationship between salinity and relative abundance of *G. bonnieroides* (Kendall's tau-c = 0.201 and Spearman's r_s = 0.381, p = 199) in the TFW site. At the OH site, there was a marginally significant concordance (Kendall's tau-c = 0.432 and Spearman's r_s = 0.545, p = .053) between salinity and relative abundance of *G. bonnieroides* but not for the other two species. Riverine estuarines are by nature dynamic in their physical-chemical environment. Such variation influences macrobenthic distribution which has important trophic implications because these organisms form a large portion of the food base for higher trophic levels, such as fishes.

Introduction

Numerous studies have examined spatial and temporal patterns of benthos in estuarine shallow-water habitats in the northern Gulf of Mexico (Harrel et al. 1976; McBee and Brehm 1982; Gaston et al. 1988; Gaston and Nasci 1988; LaSalle and Rozas 1991; Gaston et al. 1995). Direct examination of changes in composition or density with seasonal environmental changes (Chapman and Brinkhurst 1981; Flint and Kalke 1985; Holland et al. 1987) are common but the effect of catastrophic changes in environmental conditions has not been extensively examined in estuarine systems (Hoese 1960). This study documents the spatial and temporal dynamics of benthic crustaceans from three subtidal sites along Old Fort Bayou, Mississippi as physical-chemical factors changed during a drought, and discuss the influence of variable benthic prey availability on foraging of fish predators.

Materials and Methods

Macroinvertebrates were collected monthly, except for October 1985, between 24 August 1985 and 20 September 1986 from tidal freshwater (TFW), oligohaline (OH) and mesohaline (MH) sites (Cowardin et al. 1979) in Old Fort Bayou, a black-water tidal river of the Biloxi Bay estuary, Mississippi. The distance between TFW and OH sites was about 4 km whereas the distance between OH and MH was about 13 km. A detailed description of each site was given by Peterson and Ross (1991). Ten cores were taken haphazardly to a depth of 10 cm within each site with a 5.5 cm I.D. PVC corer (23.8 cm^2; Lewis and Stoner 1981) and were spaced about 2 meters apart. Dauer et al. (1987) indicated that > 94% of all individuals and species occurred in Cheaspeake Bay within this depth. Since the sampling area within the TFW and OH sites was determined visually to be 70% vegetated *Myriophyllum aquaticum* (Vell.) Verde. (parrot-feather), *Elodea canadensis* Michx. (waterweed), *Vallisneria americana* Michx. (wild celery), *Eleocharis* spp (spike-rush), *Juncus* spp. (rush), *Crinum americanum* L. (southern swamp lily), *Pontederia cordata* L. (pickerelweed), and *Sagittaria lancifolia* L. (lance-leaved arrowhead)) and 30% non-vegetated (Peterson and Ross 1991), I used a stratified sampling design to estimate macroinvertebrate densities (*sensu* Krebs 1989). The number of cores within the vegetated strata were 7 whereas 3 cores were used in the non-vegetated strata. No submerged vegetation was present at the MH site and all cores were taken subtidally. Samples were washed in the field on a 0.5 mm sieve, the material collected was preserved in 10% buffered formalin and stored in 45% isopropyl alcohol. Crustaceans were identified to species and presented as a total number per site and date. Prior to each collection, salinity was recorded from a littoral area of each site. Salinity were measured with a YSI Model 33 S-C-T meter. Rainfall for Biloxi, Mississippi was obtained from NOAA Climatological Data (Ashville, N.C.) between June 1951 and September 1985 and was used to construct mean ± 95% confidence intervals (CI) for this 17 year period of time. These data were used to compare to rainfall during this study.

I used the nonparametric Kendall's tau-c and Spearman's rank correlation statistic (Siegel 1956) to compare salinity within each site over the 13 months and the corresponding abundance of the more abundant crustaceans. Positive values based on ranks are considered concordant; thus high (or low) species abundance was associated with high (or low) salinity within a site. Alternatively, negative values based on ranks are discordant, indicating one variable increases while the other decreases. Ranks were considered significantly concordant or discordant if $p < 0.05$.

RESULTS

During the 13 months of this study the sites received excess rainfall from three hurricanes between August-October 1985, and markedly reduced rainfall during the remainder of the period. Rainfall in the area was markedly above and below the 17 year mean (± 95% confidence intervals; Figure 1). Salinity varied seasonally and spatially and was primarily related to variations in rainfall during this study (Figure 1). Reduced rainfall after October 1985 resulted in the upstream movement of saline water. By April 1986, salinity at the TFW site (4‰) was categorized as oligohaline (0.5-5.0‰), the OH site (10.0‰) was mesohaline (5.0-18.0‰), and the MH site (18.5‰) approached polyhaline salinities (18-30‰) (Figure 1).

Overall taxonomic composition varied among sites (Table 1) with non-amphipod abundance being low relative to the amphipods. The TFW site was dominated by *Grandidierella bonnieroides* and *Gammarus sp. A* (near *G. tigrinus*), the OH site by *G. bonnieroides* and *Gammarus* sp. (macromucronata form, Heard 1982), and the MH site was dominated by *Corophium louisianum* and *G. bonnieroides* (Table 1). Shifts of crustaceans occurred within the TFW and OH sites (Figure 2). *Gammarus sp.* A, *G. mucronatus* and *G. bonnieroides* shifted upstream (Figure 2) when salinity increased at TFW (Figure 1). This shift is supported by a significant positive concordance of ranks between salinity and relative abundance of *Gammarus sp. A* (Kendall's tau-c = 0.458 and Spearman's $r_s = 0.704$, $p < 0.007$) and *G. mucromatus* (Kendall's tau-c = 0.497 and Spearman's $r_s = 0.701$, $p < 0.007$) (Table 2) at TFW, indicating that when salinity became high, so did the relative abundance of these two species in TFW. No specimens of either species were collected at this site during the same months in 1985 (Figure 2). There was no relationship between salinity and relative abundance of *G. bonnieroides* (Kendall's tau-c = 0.201 and Spearman's $r_s = 0.381$, $p = .199$) in the TFW site. This shift began in April 1986 in the OH site and June 1986 in the TFW site (Figure 1). At the OH site, there was a marginallly significant concordance (Kendall's tau-c = 0.432 and Spearman's $r_s = 0.545$, $p = .053$) between salinity and relative abundance of *G. bonnieroides* but not for the other two species (Table 2).

DISCUSSION

Benthic crustaceans shifted upstream with seasonal changes in their physical-chemical environment in coastal Mississippi. Similar spatial and temporal macrobenthic distribution patterns also have been documented in other estuaries (McLusky 1968; Harrel *et al.* 1976; Chapman and Brinkhurst 1981; Dauer et al. 1987). Peak abundance of crustaceans occurred at different times of the year in Old Fort Bayou and was habitat specific. For example, in the MH habitat, peak abundance was between January and April and *C. louisianum* was the dominant species whereas in the OH habitat, peak abundance occurred between May and September and *G. bonnieroides* and *Gammarus* sp. "macromucronate form" were the dominant species. In the TFW habitat, peak abundance occurred between July and September and *G. bonnieroides* and to a lesser degree *Gammarus* sp. A were the dominant species. *Corophium louisianum* occurred in more saline habitats than less saline upstream habitats of Old Fort Bayou. This distribution pattern was similar in the Calcasieu estuary in Louisiana (Gaston and Nasci 1988), Neches River estuary in Texas (Harrel et al. 1976) and Wolf River estuary in Mississippi (Milligan 1979).

Abundance patterns of crustaceans may vary geographically in the northern Gulf of Mexico as well as spatially and temporally within a single system as noted in this study. For example, while *G. mucronatus* was most abundant during winter and spring in a salt marsh (0- ~29‰) in Florida (Subrahmanyam et al. 1976), in Old Fort Bayou it was abundant during summer and fall. *Corophium louisianum* peaked between March and July in a brackish marsh (0-10‰) in Mississippi, which coincides with a major reproductive period of this species

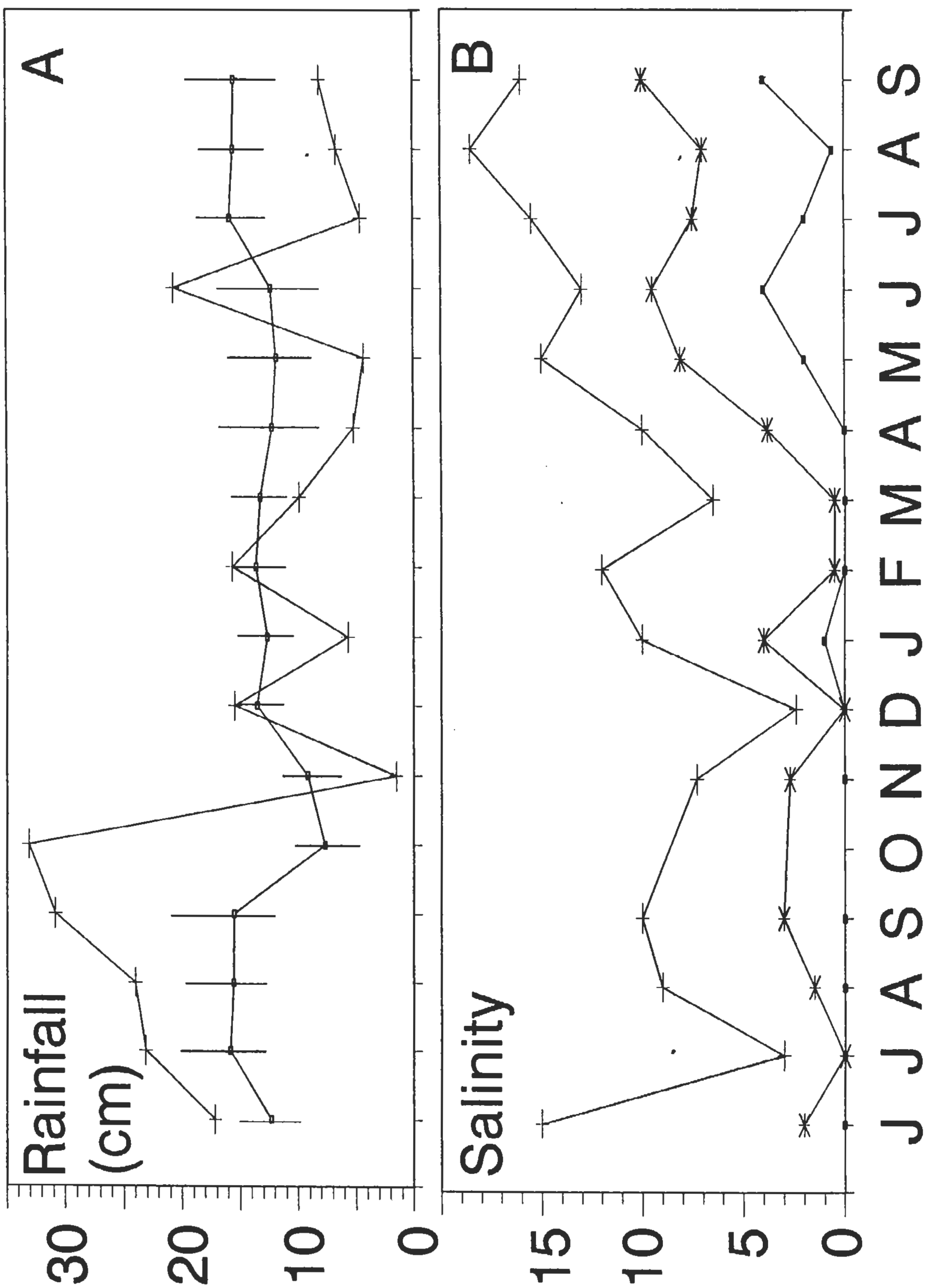

Figure 1. Rainfall data from Biloxi, Mississippi and monthly salinity data for all three sites. Rainfall between June 1951 and May 1985 (mean ± 95% CI) and rainfall during the course of this study (June 1985-September 1986) are plotted in panel A. Excessive rainfall from three tropical storms or hurricanes influenced these sites in August to October. Salinity is plotted in panel B. A square = TFW site, * = OH site, and + = MH site.

TABLE 1

Total numbers of tanaids, isopods and amphipods based on 10 cores of 23.8 cm^2 area pooled by month (n = 130 cores /site) at three sites in Old Fort Bayou, Mississippi. TFW = tidal freshwater, OH = oligohaline, MH = mesohaline.

Species	TFW	OH	MH
Tanaidacea			
Hargaria rapax	0	0	5
Isopoda			
Edotea triloba	0	4	4
Cyathura polita	0	10	0
Amphipoda			
Gammarus sp. A (near G. tigrinus)	27	4	0
G. mucronatus	15	2	1
G. sp. "macromucronate form"	2	38	0
Corophium louisianum	0	2	791
Grandidierella bonnieroides	191	140	30
Hyalella azteca	1	1	0
Melita sp.	1	6	0
Total # individuals	237	207	831
Total # species	6	9	5
Peak abundance	July-Sept	May-Sept	Jan-April

(LaSalle and Rozas 1991) but was abundant in Old Fort Bayou only during January to April at the MH site.

Riverine estuaries are by nature dynamic in their physical-chemical environment. Such variation influences macrobenthic distribution which has important trophic implications because these organisms form a large portion of the food base for higher trophic levels, such as fishes.

Darnell (1962) noted that in Lake Pontchartrain, Louisiana "the community probably never really becomes stabilized before a new set of equilibrium conditions is established and the process begins over again". In Texas, Harrel et al. (1976) indicated that "riverine estuaries are seasonally programmed and very dynamic; thus water quality and the biota constantly change."

Spatial and temporal species responses may be functionally important to fishes that use various parts of the estuarine gradient during their life-history. Nelson et al. (1982) discussed the importance of amphipods as major prey items of fishes in seagrass meadows in Florida and noted spatial and temporal variability of amphipods within a single lagoon system. Since differences in species composition and density of prey have been shown to be key factors in growth of fishes (Adams et al. 1982; Barwick and Lorenzen 1984), changes in either factor may play a role in foraging patterns of fishes that feed on benthic macroinvertebrates. For example, estuarine-dependent fishes that "pulse" up the estuary during winter and spring (i.e., *Leiostomus xanthurus,* spot and *Micropogonias undulatus,* Atlantic croaker) of dry, low-rainfall years may encounter a different suite of macrobenthic prey than those that move upriver in wet, high-rainfall years. This phenomenon would also effect freshwater fishes (i.e., *Lepomis* spp. and *Micropterus* spp.; Peterson and Ross 1991) that also use the low-salinity part of the estuary and are trophically opportunistic (Desselle et al. 1978).

ACKNOWLEDGMENTS

D. Gustafson, Jr., T. Aartila, T. Rogge, and J. Knight assisted with field work. This paper is based on a dissertation submitted to the University of Southern Mississippi in 1987 and supported by the Department of Biological Sciences, and pre-doctoral fellowships from the Slocum-Lunz Foundation, Inc., and the Mississippi-Alabama Sea Grant Consortium (NA85AA-D-SG005). S. Lecroy aided with the current taxonomy of the crustaceans. C.F. Rakocinski and N. J. Brown-Peterson reviewed an earlier version of this paper, and two reviewers made improvements to this paper.

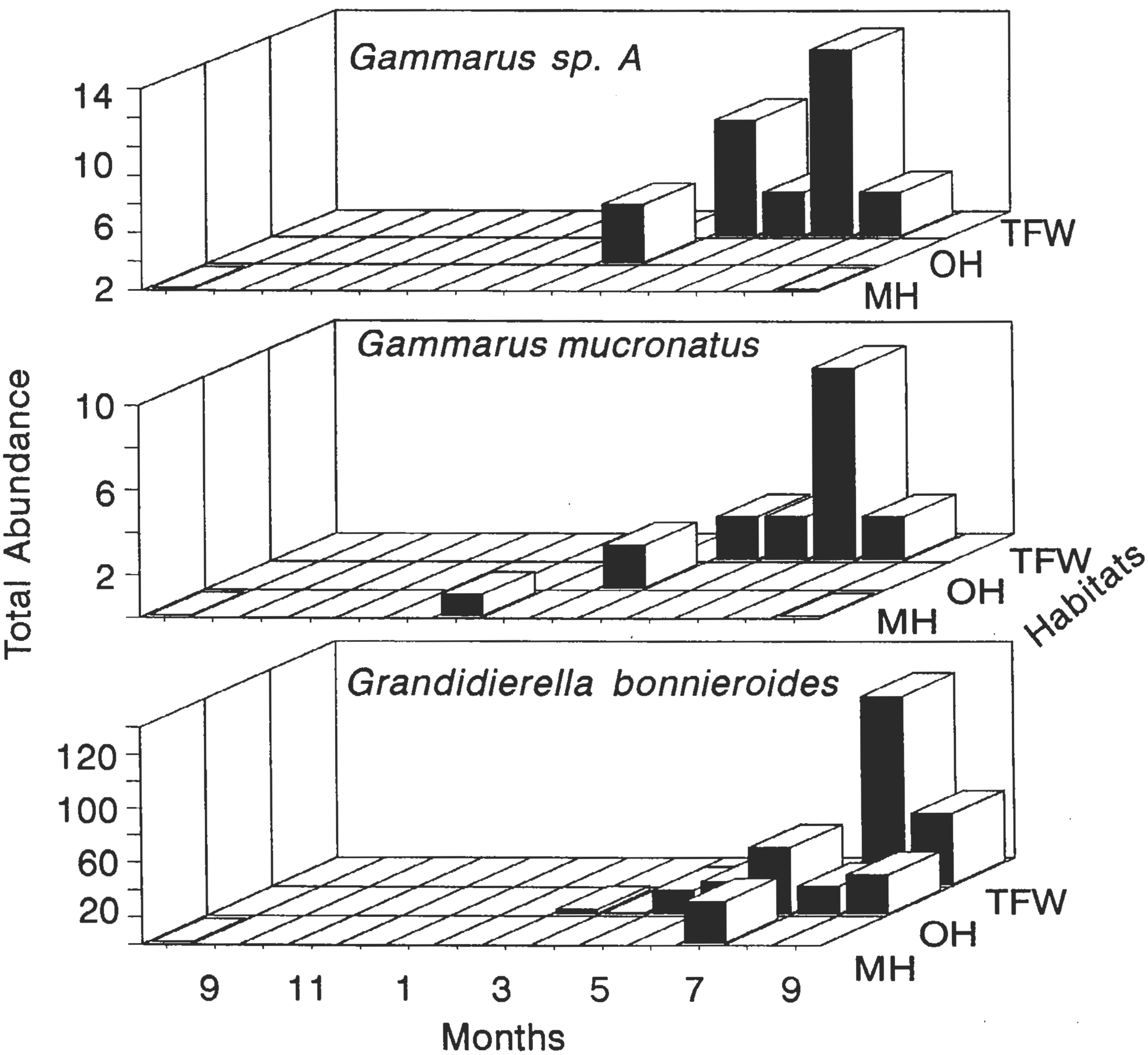

Figure 2. Plot of the total abundance and habitat distribution of *Gammarus sp. A* (near *G. tigrinus*), *Gammarus* sp. (macromucronatus form), and *G. mucronatus* from the tidal freshwater (TFW), oligohaline (OH) and mesohaline (MH) sites in Old Fort Bayou, Mississippi.

TABLE 2

Results of the Kendall's tau-c and Spearman's correlation statistics. Values presented are the p-values for the tests comparing ranks of salinity and relative abundance of each species by site. TFW = tidal freshwater, OH = oligohaline, MH = mesohaline. An * indicates insufficient number of specimens to run the analysis.

Species	TFW	OH	MH
Gammarus sp. A (near *G. tigrinus*)	.007	*	*
Gammarus mucronatus	.007	*	*
Grandidierella bonnieroides	.199	.053	*

LITERATURE CITED

Adams, S.M., R.B. McLean and M.M. Huffman. 1982. Structuring of a predator population through temperature-mediated effects on prey availability. Can J Fish Aquat Sci 39:1175-1185.

Barwick, D.H. and W.E. Lorenzen. 1984. Growth responses of fish to changing environmental conditions in a South Carolina cooling reservoir. Env Biol Fishes 10:271-279.

Chapman, P.M. and R.O. Brinkhurst. 1981. Seasonal changes in intertidal salinities and seasonal movements of subtidal benthic invertebrates in the Fraser River estuary, B.C. Estuarine, Coastal Shelf Sci 12:49-66.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish. & Wildl. Serv. FWS/OBS-79/31.

Darnell, R.M. 1962. Ecological history of Lake Pontchartrain, an estuarine community. Am Midl Nat 68:434-445.

Dauer, D.M., R. M. Ewing and A.J. Rodi, Jr. 1987. Macrobenthic distribution within the sediment along an estuarine salinity gradient. Benthic studies of the Lower Chesapeake Bay 8. Int Rev gesam de Hydrobiol 72:529-538.

Desselle, W.J., M.A. Poirrier, J.S. Rogers and R.C. Cashner. 1978. A discriminant functions analysis of sunfish (*Lepomis*) food habits and feeding niche segregation in the Lake Ponchartrain, Louisiana estuary. Trans Am Fish Soc 107:398-408.

Flint, R.W. and R.D. Kalke. 1985. Benthos structure and function in a south Texas estuary. Contrib Mar Sci 28:79-83.

Gaston, G.R., S.S. Brown, C.F. Rakocinski, R.W. Heard, aand J.K. Summers. 1995. Trophic structure of macrobenthic communities in northern Gulf of Mexico estuaries. Gulf Res Rep 9:111-116.

Gaston, G.R., D.L. Lee and J.C. Nasci. 1988. Estuarine macrobenthos in Calcasieu lake, Louisiana: community and trophic structure. Estuaries 11:192-200.

Gaston, G.R. and J.C. Nasci. 1988. Trophic structure of macrobenthic communities in the Calcasieu estuary, Louisiana. Estuaries 11:201-211.

Harrel, R.C., J. Ashcraft, R. Howard and L. Patterson. 1976. Stress and community structure of macrobenthos in a Gulf coast riverine estuary. Contrib Mar Sci 20:79-81.

Heard, R.W. 1982. Guide to common tidal marsh invertebrates of the Northeastern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium, MASGP-79-004. 82 p.

Hoese, H.D. 1960. Biotic changes in a bay associated with the end of a drought. Limnol Oceanogr 5: 326-336.

Holland, A.F., A.T. Shaughnessy, L.C. Scott, V.A. Dickens, J. Gerritsen, and J.A. Ranasinghe. 1987. Long-term variation in mesohaline Chesapeake Bay macrobenthos: spatial and temporal patterns. Estuaries 10:227-245.

Krebs, C.J. 1989. Ecological Methodology. Harper & Row Publishers, New York. 654 p.

LaSalle, M.W. and L.P. Rozas. 1991. Comparing benthic macrofaunal assemblages of creek- bank beds of the Spikerush *Eleocharis parvula* (R&S) Link and adjacent unvegetated areas in a Mississippi brackish marsh. Wetlands 11:229-244.

Lewis, F.G. and A.W. Stoner. 1981. An examination of methods for sampling macrobenthos in seagrass meadows. Bull Mar Sci 31:116-124.

McBee, J.T. and W.T. Brehm. 1982. Spatial and temporal patterns in the macrobenthos of St. Louis Bay, Mississippi. Gulf Res Rep 7:115-124.

McLusky, D.S. 1968. Some effects of salinity on the distribution and abundance of *Corophium volutator* in the Ythan estuary. J Mar Biol Assoc U K 48:443-454.

Milligan, M.R. 1979. Species composition and distribution of benthic macroinvertebrates in a Mississippi estuary. M.S. Thesis, University of Southern Mississippi, Hattiesburg, M.S. 259 p.

Nelson, W.G., K.D. Cairns and R.W. Virnstein. 1982. Seasonality and spatial patterns of seagrass-associated amphipods of the Indian River Lagoon, Florida. Bull Mar Sci 32:121-129.

Peterson, M.S. and S.T. Ross. 1991. Dynamics of littoral fishes and decapods along a coastal river-estuarine gradient. Estuarine, Coastal Shelf Sci 33:467-483.

Siegel, S. 1956. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill Book Co., Inc. New York, N.Y. 310 p.

Subrahmanyam, C.B., W.L. Kruczynski and S.H. Drake. 1976. Studies on the animalcommunities in two north Florida salt marshes. Part II. Macroinvertebrate communities. Bull Mar Sci 26:172-195.