Seasonal Colonization of Low Profile Artificial Reefs in Mississippi Coastal Waters: Invertebrates

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ABSTRACT

Artificial reefs serve as fish attractants and may increase production of some species by increasing habitat. In an effort to enhance already established recreational fisheries and to increase numbers of and access to less common structure-associated fishes, Mississippi began building new low profile artificial reefs and augmenting existing ones. Over twenty inshore low profile oyster shell reefs were developed prior to 1995. Subsequent reef development has utilized limestone gravel in conjunction with oyster shell or limestone alone. The creation of limestone gravel and/or oyster shell reefs provided an opportunity to obtain information on the colonization of these different substrates by benthic invertebrates. Colonization studies were conducted using crates of artificial substrate placed on a gravel/oyster shell reef located approximately 300 meters offshore in central Mississippi Sound. Crates contained crushed limestone gravel or oyster shells. Crates were pulled every three months and all organisms were removed. Invertebrates were identified to the lowest taxonomic level, measured to the nearest 0.1 mm and weighed to the nearest 0.001 g. Dominant invertebrate taxa included representatives of the following groups: Xanthidae (*Menippe adina, Eurypanopeus depressus, Panopeus simpsoni*), Porcellanidae (*Petrolisthes armatus*), Alpheidae (*Alpheus angulatus, A. heterochaelis*), Palaemonidae (*Palaemonetes vulgaris*), Amphipoda (*Melita, Apocorophium*), Polychaeta (*Neanthes succinea*), Bivalvia (*Ischadium recurvum*), and Gastropoda (*Stramonita haemastoma*). Observed differences in numbers of individuals and size between summer and winter collections appeared to be related to recruitment. Data are presented on species abundance and size by substrate type and season.

KEY WORDS: Estuarine, invertebrate assemblages, low profile artificial reef

INTRODUCTION

Artificial reefs serve as fish attractants and may increase production of some species by increasing habitat. In an effort to enhance already established recreational fisheries and to increase numbers of and access to less common structure-associated fishes, Mississippi began building new low profile artificial reefs and augmenting existing ones. Although over twenty low profile artificial reefs (oyster shell, concrete rubble, limestone gravel) have been constructed in Mississippi inshore waters, there are no data on reef community structure or the association of fish populations with these reefs. A study of the faunal assemblages associated with reef colonization in Mississippi Sound was begun in December 1998 as part of a larger program to assess productivity of these reefs in relation to recreational fishing opportunities. The research reported on herein is part of a long-term study addressing seasonal colonization/succession of fauna associated with limestone and oyster shell reefs in estuarine waters of Mississippi Sound. Data presented represent initial colonization studies conducted in the summer of 1998 and the winter of 1998/99.

MATERIALS AND METHODS

Colonization was studied by placing a series of crates filled with $0.025m^3$ of limestone gravel or oyster shell on a newly created, nearshore limestone/shell reef. The area adjacent the artificial reef is characterized by small patch subtidal oyster beds. Average water depth is approximately 1.5 m. Site location is shown in Figure 1. Thirty-two samplers (16 limestone, 16 oyster shell) were deployed in the summer of 1998. The crates were placed on eight plastic pallets, four trays to a pallet (Figure 2). Four pallets contained crates filled with limestone and four pallets contained crates with oyster shell. All crates and pallets were labeled. A sampling schedule was established that removed one crate from each pallet (four limestone gravel and four oyster shell) after an initial soak time of three months. At six, nine, and twelve month intervals the remaining crates were pulled (four limestone gravel and four oyster crates per sampling period). Additionally, a set of crates was replaced (four limestone gravel and four oyster) each sampling period so that a three-month set of samples was obtained for each season. Original sampling schedule called for removal of a set of three month samples and a set of three and six month samples during summer and fall of 1998, respectively. Summer samples were collected; however, Hurricane Georges in September 1998 destroyed the pallets and no fall samples were collected. Samplers were re-deployed in December 1998. Data presented in this study are from the three month summer samples (original study) and the three month winter samples that began the new sampling regime.

Crates were removed from the water, immediately placed in seawater soaked oyster sacks and returned to the Gulf Coast Research Laboratory for processing. Contents of each crate were washed over screening (winter samples) and all organisms collected. Samples were frozen prior to analysis. Each sample was sorted to species and the total number and weight recorded. When available, fifty individuals of each species were randomly selected for measurement. Individuals were measured to the nearest 0.1 mm in length or width (brachyuran crabs) using digital calipers. A Sartorius analytical balance was used to measure weight to the nearest 0.001 g.

Kruskal-Wallace ANOVA was used to test for significant differences in species abundance and size between seasons by substrate. Student's *t*-test was used to compare species abundance and size between substrates within a season. The level of significance for all tests was set at $\alpha=0.05$. Data were analyzed using the statistical packages SPSSx and Quattro Pro Version 7.

Figure 1. Location of low profile artificial reef.

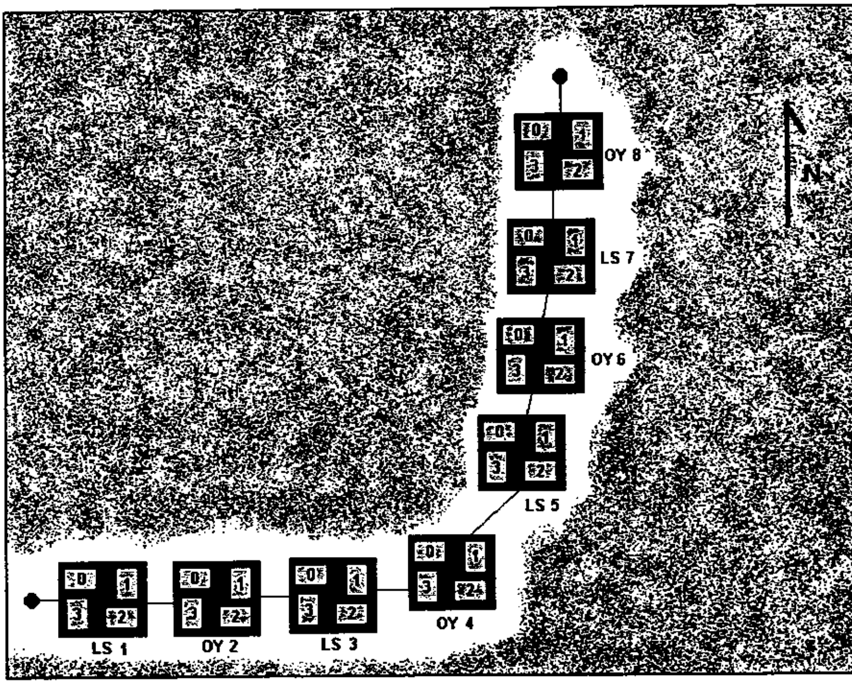

Figure 2. Sampler array

RESULTS AND DISCUSSION

Invertebrates associated with limestone gravel and oyster shell substrates for summer and winter samples are listed in Tables 1 and 2. Limestone gravel is hereafter referred to as gravel and oyster shell as shell. Because the present data are concerned with a limited number of samples that represent a small portion of the uncompleted total study, results are presented with minimal interpretation and discussion. For many species, observed differences in numbers of individuals and size between summer and winter collections appeared to be related to recruitment. Most of the species occurring in samples have been identified as oyster reef associates in Mississippi Sound (Heard 1979). The three xanthid crab species are known oyster predators and *Neanthes succinea* is one of the most commonly encountered nereids in oyster reef communities. *Melita nitida, Ischadium recurvum, Palaemonetes vulgaris, Alpheus angulatus*, and *A. heterochaelis* are known from oyster reefs in the area.

Table 1. Invertebrates associated with gravel and oyster shell substrates during the summer months (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Common Name	Total Number		*t*-test for Mean Number		Mean Size		*t*-test for Mean Size	
		LS	OY	*t*	P	LS	OY	*t*	P
Eurypanopeus depressus	Mud crab	5096	3376	N.S.D.		4.9 ± 1.3 mm	5.2 ± 2.6 mm	N.S.D.	
Neanthes succinea	Worm	2608	1146	3.89	0.008	0.029 ± 0.002 g	0.008 ± 0.005 g	7.14	0.002
Palaemonetes vulgaris	Grass shrimp	215	844	4.56	0.004	16.2 ± 4.5 mm	15.6 ± 4.4 mm	N.S.D.	
Alpheus angulatus	Snapping shrimp	442	179	7.55	0.000	14.0 ± 3.6 mm	15.9 ± 7.0 mm	3.14	0.002
Menippe adina	Stone crab	221	305	N.S.D.		7.9 ± 6.0 mm	8.5 ± 8.5 mm	N.S.D.	
Ischadium recurvum	Hooked mussel	127	155	N.S.D.		7.4 ± 2.5 mm	9.1 ± 4.1 mm	4.31	0.000
Stramonita haemastoma	Oyster drill	12	27	3.38	0.015	22.8 ± 25.4 mm	45.9 ± 31.2 mm	2.25	0.031
Turbellaria	Flatworms	30	14	N.S.D.		-	-	-	
Petrolisthes armatus	Porcelain crab	11	34	N.S.D.		-	-	-	
Panopeus simpsoni	Mud crab	10	3	2.18	0.072	16.8 ± 4.8 mm	26.0 ± 2.7 mm	2.45	0.006
Clibanarius vittatus	Striped hermit crab	3	2	N.S.D.		16.3 ± 8.6 mm	13.9 ± 5.1 mm	N.S.D.	
Nassarius vibex	Southern nassa	2	0	N.S.D.		10.6 mm	-	-	

Table 2. Invertebrates associated with gravel and oyster shell substrates during the winter months (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Common Name	Total Number		*t*-test for Mean #		Mean Size		*t*-test for Mean Size	
		LS	OY	*t*	P	LS	OY	*t*	P
Eurypanopeus depressus	Flat mud crab	65	42	N.S.D.		9.4 ± 3.2 mm	11.4 ± 3.5 mm	2.88	0.005
Neanthes succinea	Worm	1,382	562	N.S.D.		0.021 ± 0.010 g	0.018 ± 0.015 g	N.S.D.	
Palaemonetes vulgaris	Grass shrimp	1	9	4.37	0.022	24.5 mm	21.6 ± 2.7 mm	N.S.D.	
Alpheus heterochaelis	Snapping shrimp	1	0	N.S.D.		23.7 mm	-	-	
Menippe adina	Stone crab	1	0	N.S.D.		19.7 mm	-	-	
Ischadium recurvum	Hooked mussel	0	4	N.S.D.		-	6.8 ± 4.3 mm	-	
Panopeus simpsoni	Mud crab	3	3	N.S.D.		19.2 ± 3.5 mm	25.4 ± 2.4 mm	N.S.D.	
Callinectes sapidus	Blue crab	14	2	N.S.D.		7.6 ± 2.6 mm	34.2 ± 9.9 mm	10.31	0.000
Callinectes similis	Lesser blue crab	2	0	N.S.D.		4.8 ± 0.4 mm	-	-	
Melita nitida	Amphipod	10,947	3170	N.S.D.		-	-	-	
Melita longisetosa	Amphipod	1,101	447	N.S.D.		-	-	-	
Apocorophium louisianum	Amphipod	204	323	N.S.D.		-	-	-	
Monocorophium acherusicum	Amphipod	0	9	N.S.D.		-	-	-	

Crustaceans

Amphipods were the most abundant macro-crustaceans associated with the reef materials. Because the size of these organisms allowed for escapement through the small holes in the crates during sampler retrieval and use of netting to retain these organisms wasn't begun until the winter samples, numerical estimates of relative abundance are available only for the latter collections. Amphipods were identified using the keys of Sheridan (1979) and Bousfield and Hoover (1997).

Two genera of free-living gammarideans dominated the amphipod fauna on both gravel and shell substrates: *Melita* and *Apocorophium* (Table 2). Species of both genera are associated with oyster reefs and shell material in Mississippi waters (Heard 1979). *Melita nitida* was extremely abundant; *Melita longisetosa* and *Apocorophium louisianum* (= *Corophium louisianum*) were common in samples. There was no significant difference in species composition between the two substrates in winter samples. *Monocorophium acherusicum (=Corophium acherusicum)* was found only in oyster shell material and in limited numbers.

Eurypanopeus depressus was the most the most abundant brachyuran crab collected. This species is associated with oyster reefs throughout much of its range and it is often present in large numbers (Ryan 1956, Tabb and Manning 1961, Rouse 1970). It is a known predator of oyster spat (McDermott 1960). Ovigerous females were numerous in summer samples in both substrate types. Thirty-one percent of the females collected in gravel and 25% of the females taken in shell were egg-bearing. Size of ovigerous females ranged from 3.8 to 13.4 mm in carapace width (CW). Width frequency distributions for summer and winter samples by substrate are shown in Figure 3. Recruitment was evident in summer samples and newly recruited crabs were abundant on both substrates. There was no significant difference in abundance or size of crabs in either substrate (Table 1). As in summer samples, winter densities in the two substrates were not significantly different; however, there was a significant difference in size of crabs occupying gravel and shell during the winter with mean carapace width greater in shell (Table 2). Comparing seasons, there were significant differences in crab densities and size between summer and winter in both gravel and shell with crabs more numerous in summer samples on both substrates (Tables 3 and 4). Crabs were significantly larger on both substrates in winter samples. Increase in size in winter samples is, in part, related to decreased recruitment and growth of summer recruits. Variables responsible for reduction in crab densities in winter samples may include emigration in response to environmental conditions and/or mortalities related to predation and competition for food. Greater abundance of crabs in oyster substrate in winter may be related to their increased size and larger niche availability in shell habitats.

Table 3. Seasonal comparison of numerical abundance and size for *E. depressus* and *N. succinea* (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Substrate	Mean Number		ANOVA for Mean Number	
		Summer	Winter	χ^2	P
Eurypanopeus depressus	LS	1274 ± 413	16 ± 10	5.333	0.021
	OY	844 ± 321	14 ± 1	4.500	0.034
Neanthes succinea	LS	652 ± 123	346 ± 222	N.S.D.	
	OY	286 ± 142	187 ± 227	N.S.D.	

Table 4. Seasonal comparison of mean size for *E. depressus* and *N. succinea* (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Substrate	Mean Size		ANOVA for Mean Size	
		Summer	Winter	χ^2	P
Eurypanopeus depressus	LS	4.9 ± 1.3 mm	9.4 ± 3.2 mm	92.02	0.000
	OY	5.2 ± 2.6 mm	11.4 ± 3.5 mm	70.48	0.000
Neanthes succinea	LS	0.029 ± 0.002 g	0.021 ± 0.010 g	N.S.D.	
	OY	0.008 ± 0.005 g	0.018 ± 0.015 g	N.S.D.	

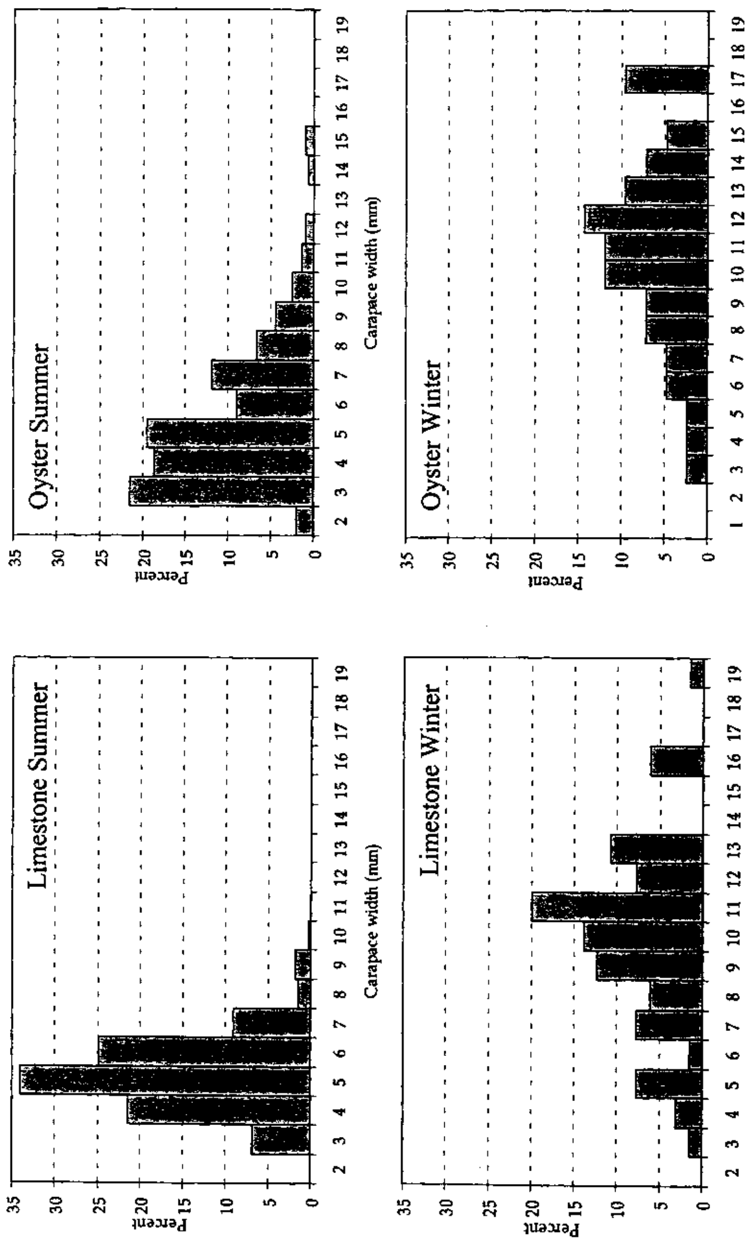

Figure 3. Width frequency distributions of *Eurypanopeus depressus*

Stone crabs, *Menippe adina*, were common only in summer samples; a single specimen was identified from winter collections. Stone crabs were numerous in both substrate types and there was no significant difference in abundance or size between gravel and shell (Table 1). The majority of the crabs collected were under 10.0 mm CW (Figure 4). Stone crabs spawn in the summer and recruits and early juveniles are common on oyster reefs and stone rubble breakwaters in Mississippi Sound (Stuck and Perry 1992). Lack of stone crabs in winter samples may reflect seasonal emigration from shallow reef areas and/or increased predation associated with decreased niche availability for larger juveniles. Size-specific shelter limitation has been implicated as a factor in determining population levels of large juveniles in northern GOM estuaries (Beck 1995, 1997).

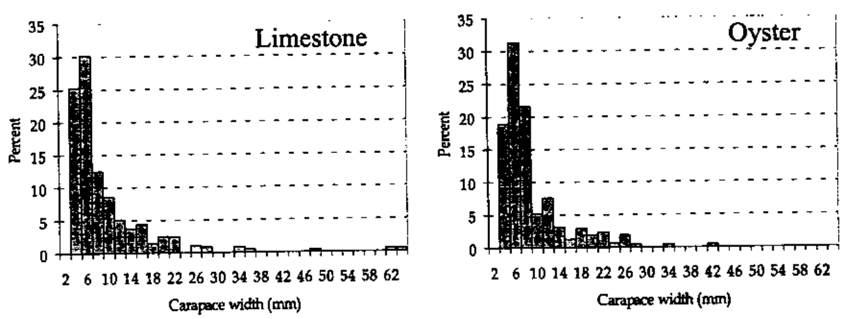

Figure 4. Width frequency distributions of *Menippe adina* in summer samples

Other crab species occurring in samples included Simpson's mud crab, *Panopeus simpsoni*, the porcellanid crab, *Petrolisthes armatus* and the striped hermit crab, *Clibanarius vittatus*. Porcelain crabs and the striped hermit were collected only in summer samples and there was no significant difference in density between the two substrate types (Table 1). *Petrolisthes armatus* is a filter feeder but this species will also scrape algae from rock and shell (Fotheringham and Brunenmeister 1989). The striped hermit is an omnivorous scavenger common in tidal marsh habitats, on rock jetties, and around mud flats (Heard 1979). Adults often utilize shells of the oyster drill. Simpson's mud crabs were collected in both seasons in small numbers. In summer samples, they were significantly more abundant in gravel, but were significantly larger in shell (Table 1). In winter collections, there was no significant difference in numbers or size between the substrate types, but larger individuals were associated with shell (Table 2). *Panopeus simpsoni* is an oyster associate that occurs subtidally and intertidally in Mississippi Sound and it often co-occurs with *E. depressus* (Heard 1979).

Callinectes sapidus, the blue crab, and *C. similis*, the lesser blue crab, were found only in winter samples in small numbers. There was no significant difference in the numbers of blue crabs between the two substrates, but crabs in shell samples were significantly larger (Table 2). Blue crabs in winter gravel samples were summer/fall recruits (mean size was <10.0 mm CW) that move to deeper waters with decreasing water temperatures (Steele and Perry 1990). Peak settlement of blue crab megalopae occurs in the late summer/early fall (Perry *et al.* 1995, Johnson and Perry 1999). Both megalopae and early crab stages are associated with shallow nearshore waters.

The snapping shrimp, *Alpheus angulatus,* was found only in the summer. Densities were significantly higher in gravel, but size was significantly larger in shell (Table 1). A single specimen of *Alpheus heterochaelis,* occurred in winter samples in gravel (Table 2). Both species of *Alpheus* are associated with oyster reef communities in the northern GOM (McClure 1995). The grass shrimp, *Palaemonetes vulgaris*, was common in summer samples. There were significant differences in summer catch of grass shrimp between substrates, but no significant difference in size (Table 1). Grass shrimp were more abundant in shell than in gravel. Heard (1979) noted that this species of grass shrimp was often associated with fouling communities and shell bottoms and may occur with *P. pugio* around oyster reefs.

Polychaetes/platyhelminths

The polychaete, *Neanthes succinea*, was the only other species abundant enough during both sampling periods to allow for comparative testing between seasonality and abundance and size and to test for seasonal differences in abundance and size between substrates. There were no significant differences in polychaete densities or size between winter and summer samples for either substrate type (Tables 3 and 4). In comparing gravel and shell substrates in summer samples, there was a significant difference in density and size of polychaetes. Polychaetes were more abundant in gravel and were larger (Table 1). In winter samples there was no significant difference in density or size (Table 2). Flatworms (turbellarians) occurred in summer samples with no significant difference in numbers between the two substrate types.

Molluscs

Molluscs associated with samples included the hooked mussel, *Ischadium recurvum*, the oyster drill, *Stramonita haemastoma*, and the southern nassa, *Nassarius vibex*. Only hooked mussels occurred in both summer and winter samples. Mussels in summer samples occurred in both substrates with larger individuals found in shell samples (Table 1). Small size of specimens in summer samples and much reduced numbers of individuals in winter suggests recruitment and settlement occurs in the warmer months. Oyster drills were significantly more abundant and larger in shell samples than in gravel (Table 1).

CONCLUSIONS

High abundance indices for many of the invertebrates appearing in summer samples were related to recruitment. Reduced numbers of individuals in winter samples occurred as organisms migrated from the reef area with falling water temperatures in the winter or were subject to increased predation rates associated with a larger suite of predators in warmer months. Early juvenile stages of brachyuran crabs suffer high mortality rates with both intra- and inter-specific predation influential in controlling population size. Present data represent a small portion of the overall study. Completion of the seasonal sampling regime will provide a more comprehensive data set from which to evaluate the effect of season and substrate on invertebrate assemblages associated with low profile reefs in estuarine waters. This study also provides the baseline data on species composition and abundance necessary to evaluate utilization of these reefs by recreational fish species. Concurrent studies include a fishery independent finfish sampling program near reef areas and an analysis of the stomach contents of selected fish species in those collections. Creel surveys are also ongoing.

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