Sport Fish Utilization of an Inshore Artificial Oyster Reef in Barataria Bay, Louisiana

KIRSTEN SIMONSEN[1] and JAMES H. COWAN JR.[2]
[1,2]*Department of Oceanography and Coastal Sciences*
Louisiana State University
Energy Coast and Environment Building
Baton Rouge, Louisiana 70803 USA

ABSTRACT

Recently we have begun to understand the importance of inshore hard-bottom substrate, including oyster reefs, to estuarine fish communities in the Gulf of Mexico, especially in the context of identifying Essential Fish Habitat (EFH). However, habitat loss, disease, overharvest, and the failure to replace shell have severely decreased the amount of high-relief oyster reefs available to finfish. The purpose of this project is to establish an artificial high-relief oyster reef in Barrataria Bay, Louisiana and monitor its use by commercially and recreationally important finfish, including spotted sea trout (*Cynoscion nebulosus*) and Atlantic croaker (*Micropogonias undulatus*). Finfish and invertebrate communities on the artificial reef were compared to a mud bottom reference site. We have also examined site-specific trophic linkages by enumerating gut contents and performing stable isotope analysis of select species. Preliminary results indicate a seasonal difference in the numbers of individuals found at both sites. Species diversity also varied by season, with highest diversity occurring in summer months. Variation in fish abundance and species diversity between sites was low. Dietary analysis indicates there are significant differences in the diets ***M. undulatus*** between sites ($p < 0.05$), but only slight differences in the diets of *C. nebulosus*. Atlantic croaker diets consisted of mud crabs (Xanthidae) and unidentified crabs on the reef, and bivalves and fish over the reference site. Spotted sea trout consumed mostly unidentified fish and anchovies by number, and penaeid shrimp by weight.

KEY WORDS: Artificial reef, fish community, dietary analysis, trophic dynamics

Utilización de un Arrecife Artificial de Ostras por Peces de Pesca Deportiva en la Bahía Barrataria en Louisiana

Recientemente hemos comenzado a comprender la importancia que presentan los sustratos de suelo duro localizados en áreas costeras, incluyendo los arrecifes de ostras, a las comunidades de peces estuarinos en el Golfo de México, especialmente en la identificación de Habitats Esenciales para Peces (HEP). Sin embargo, la desaparición de habitats, las enfermedades, la sobre pesca y la falta del reemplazo de las conchas, ha reducido el montículo de los arrecifes de ostras disponibles a peces. El propósito de este proyecto es el establecer un arrecife artificial de montículo y así monitorear la utilización que dan a la misma peces de importancia comercial y recreativa, tales como *Cynoscion nebulosus* y *Micropogonias undulatus*. Comunidades de peces e invertebrados en el arrecife artificial fueron comparados a organismos de un sitio fangoso utilizado como referencia. Se examinaron enlaces tróficos específicos a los sitios mediante el inventario de contenidos estomacales y el análisis de isótopos estables. Resultados preliminares indican una diferencia estacional en el número de individuos y la diversidad de especies en ambos sitios, encontrándose la mayor diversidad en los meses de verano. Sin embargo, la variación entre ambos sitios fue poca. El análisis alimenticio indicó que existen diferencias significativas ($p < 0.05$) en la dieta de ***M. undulatus*** entre los sitios, sin embargo estas diferencias fueron pocas en la dieta de ***C. nebulosus***. La dieta de ***M. undulatus*** en el arrecife consistió de cangrejos de fango (Xanthidae) y cangrejos no identificados, mientras que en el sitio de referencia su dieta consistió de bivalvos y peces. La dieta de *C. nebulosus* consistió en su mayoría de peces no identificados y anchoas, mientras que por peso, fue de camarones penéidos.

PALABRAS CLAVES: Arrecife artificial, comunidades de peces, análisis alimenticos

INTRODUCTION

The loss of coastal marine habitats has been described as one of the greatest threats to the viability of commercial and recreational fisheries (Caddy 2007). For this reason, the Magnuson Steven Fishery Conservation and Management Act, and its 1996 reauthorization as the Sustainable Fisheries Act (SFA) called for the identification and protection of those habitats deemed "essential" to the spawning, breeding, feeding, or growth to maturity of marine fish species (NMFS 1997). The concept of essential fish habitat (EFH) has therefore governed a great deal of the focus of fisheries research and management over the past decade.

Coastal Louisiana is dominated by three main habitat types including marshes, shallow non-vegetated or soft bottom habitats, and oyster reefs. A majority of the past work to identify EFH along the Gulf of Mexico coast documented the role of salt marsh edge as nursery habitat for juveniles of ecologically and economically important fish species (Rakocinski *et al.* 1992, Baltz *et al.* 1993, Minello 1999, Jones *et al* 2002). Numerous larval and juvenile fishes aggregate along the marsh edge to take advantage of the available prey items, as well as utilizing flooded marsh surfaces at high tide to avoid predation (Kneib 1987, Rakocinski *et al.* 1992, Baltz *et al.* 1993). The role of oyster reefs in the life history of estuarine fishes is not as well defined.

Oyster reefs, primarily the eastern oyster *Crassostrea virginica,* have always been considered important to estuarine health, primarily in the context of maintaining water quality. In the Chesapeake Bay, the decline of the oyster population is directly correlated with decreasing water quality (Rothschild *et al.* 1994). Rothschild *et al.* (1994) estimated that the oyster population in Chesapeake Bay was less than 50% of its historic acreage as of the early 1990s. Today, it may be as low as two percent of historic levels (CBF 2007). In addition to being less extensive, existing oyster reefs in the Chesapeake Bay, as well as those along the Gulf coast, are also lower in relief due to consistent harvest of oysters (Lenihan *et al.* 2001). Oyster reefs have always been considered "essential" to the oysters themselves by providing critical habitat and increasing the recruitment of oyster spat (Coen *et al*. 1999, Plunkett 2006). More recently, we have begun to realize the importance of oyster reefs as critical habitat for fish species as well.

Coen *et al.* (1999) hypothesized that three different groups of fishes use oyster reefs, including resident species, facultative residents, and transient species. Resident species are typically small benthic fishes that spend most of their lives utilizing reef habitat for foraging opportunities, protection from predators, and substrate for attachment of benthic eggs (Breitburg 1999, Coen *et al* 1999). Facultative residents are attracted to the structure of reefs, but may also opportunistically use other structured habitats such as submerged aquatic vegetation (SAV). The majority of estuarine fishes are transient species. These include schooling planktivores such as bay anchovy (*Anchoa mitchilli*) and gulf menhaden (*Brevoortia patronus*). Transient species also include top predators such as striped bass (*Morone saxatilis*) and spotted seatrout (*Cynoscion nebulosus*), a highly prized recreational species in Louisiana. Many transient species will opportunistically use different types of habitats based on their needs for prey availability, predator avoidance, or spawning. For these species, the most important function of oyster reefs may be to aggregate prey species. Breitburg *et al.* (1995) showed that the vertical structure of reefs in the Chesapeake Bay has the ability to decrease the velocity of water flow, making it easier for small, larval fishes to maintain their positions in space. Several studies have illustrated that habitat selection may be linked to the prey availability and that habitat complexity may increase the amount of available prey (Connell and Jones 1991, Burke 1995, Eklov 1997, Wells 2007). Harding and Mann (2001a) described the diets of bluefish (*Pomatomus saltatrix*) associated with oyster reefs noting that the bluefish stomachs contained more teleost prey than those over adjacent soft-bottom habitats. The authors speculated that they presence of nearly twenty-five different fish species at one oyster reef provided an attractive foraging ground for piscivorous fishes. Striped bass over oyster reefs were also found to have higher percentages of fish prey in their diets than those over soft-bottom substrates (Harding and Mann 2003).

The perceived value of oyster reefs as fish habitat has lead to an increase in the number of habitat restoration projects in areas of historically high oyster populations, including the southeast Atlantic and Gulf coasts of the United States. However, with a decrease in the amount of oyster shell available for habitat enhancement, alternative materials have been utilized to provide substrate for larval oysters and other benthic invertebrates normally associated with oysters. One such material that has been found to be cost-efficient and effective as a reef material is limestone cobble (Haywood *et al.* 1999). The purpose of this project is to establish an artificial high-relief oyster-like reef constructed of limestone cobble in Barataria Bay, Louisiana and monitor its affects on the estuarine fish community, particularly those species of commercial or recreational importance. We have examined overall community structure and fish abundance at the reef site as compared to an unaltered mud-bottom reference site. The trophic dynamics of the artificial reef site and the mud-bottom reference site were also examined to determine if there is a difference in the food-web pathways of the two sites. Two different species were chosen for dietary analysis; these are spotted sea trout, and Atlantic croaker (*Micropogonias undulatus*). Spotted sea trout were chosen for this analysis because they are a top carnivore in Barataria Bay. They are also one of the most important recreational fish species in the state of Louisiana, with a harvest of over 12 million fish in 2006 (MFRSS 2007). Atlantic croaker were chosen because they are demersal feeders that feed close to their habitat. As such, they exhibit higher site fidelity than do spotted sea trout, and therefore are hypothesized to have greater differences in diets between sites. Additionally, Atlantic croaker were once a valuable commercial and recreational species, and are still harvested in high numbers (close to one million in 2006 (MRFSS 2007)) for use as bait in the recreational fishing industry.

METHODS AND MATERIALS

Study Site and Reef Construction

The artificial reef site (reef) is located in Bay Ronquille, Plaquemines Parish, Louisiana. Bay Ronquille is located in southeastern Barataria Bay, north of Quatre Bayou Pass leading to the Gulf of Mexico (see Figure 1). The area is characterized shallow, turbid water with polyhaline salinities and small tidal ranges (less than a meter). The artificial reef site encompasses one acre of estuary bottom that was previously an oyster lease, but now contains only relic oyster shell, with few living oysters. Breitburg *et al.* (2000) commented on the necessity of determining an appropriate site for artificial reef construction. Characteristics such as availability of nutrient rich water, high phytoplankton biomass, and proximity to other favorable habitat structures (natural oyster reefs, salt marsh edge, etc.) can help ensure the survival of oyster reef communities (Breitburg *et al.* 2000). Appropriate substrate must also be considered when constructing oyster reefs as soft sediments can lead to the rapid burial of the reef material. Therefore, historic oyster reefs make suitable sites for restored reefs. The site in Bay Ronquille satisfies all the criteria necessary for a successful restoration project (Breitburg *et al.* 2000). Reef material consists of limestone cobble number 57 averaging 3.8 cm in diameter, which has been show to maintain the interstitial space that is necessary for the survival of benthic fishes and macroinvertebrates (Coen and Luckenbach 2000).

The reference site is located approximately 1km to the northwest of the artificial reef site and is characterized by a mud-bottom with no hard substrate (see Figure 1). This site was chosen due to its location with respect to the reef and to assure that both sites had a similar fish species composition. The proximity of the reference site to the reef allows for water conditions, including temperature, salinity, tidal movement, and depth to be consistent between sites. However, the reference site is far enough away from the reef as to not be included in the feeding halo surrounding the relic and new reef material.

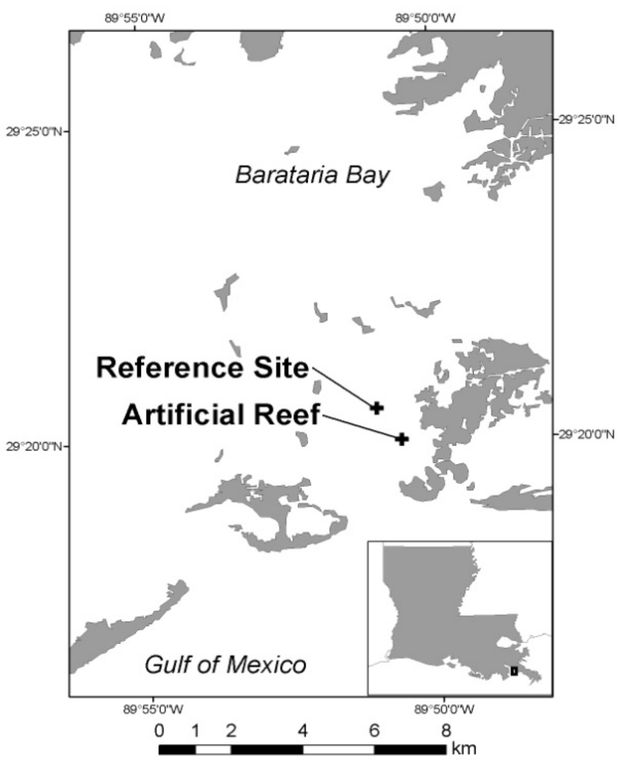


Figure 1. Location of Bay Ronquille sampling sites.

Water Quality and Meteorological Data

Water quality was measured at each site at the start of each sampling trip. Temperature, salinity, and dissolved oxygen (DO) were measured and recorded using a YSI model 85. Turbidity was also measured and recorded using a secchi disk. Finally, tidal stage, defined as incoming, outgoing, slack high or slack low, and bay conditions, defined as calm, light chop, moderate chop, or rough were recorded. Meteorological data including air temperature, wind speed and wind direction were also recorded. To determine if water quality was consistent between sites a two-way analysis of variance (ANOVA) was run to analyze differences between sites and seasons.

Sampling Methods

Samples were collected twice per quarter. Both gill nets and a purse seine were used to collect finfish over the two sites. The gill nets measure 45.7 m long and 1.8 m deep, consisting of five 9.1 m randomly arranged panels with mesh sizes of 1.27, 1.91, 2.54, 3.18, and 3.81 cm. The purse seine measures 20m in length, with a mesh size of 2mm x 2mm.

Gill nets were set for one hour at each site. After one hour, the nets were pulled, cleaned and reset in the same location to obtain replicate samples in time. The purse seine is set twice as well, in order to obtain replicate samples. The first purse seine was set before the first gill net set and the second after the final gill net set was pulled. Fish were bagged by gear type, net panel (for the gill nets), location (reef or reference), set (first or second), and placed on ice. All fishes remained on ice until brought back to the laboratory for analysis. Those samples that were not analyzed immediately were stored frozen at -80°C to insure no degradation of gut content materials. All fish were identified to species. Measurements of total length (TL) and standard length (SL) in mm (to 1 mm) and weight (W) in grams (to 0.1 g) were recorded for all fishes collected.

In the laboratory, the stomachs and esophagus of the spotted sea trout and Atlantic croaker were removed and weighed to the nearest 0.1g to determine full stomach wet weight. Stomachs then were fixed in 10% formalin for 24 to 48 hours, and subsequently transferred to ethanol and stored until analysis. Contents of the stomach and esophagus were removed, analyzed under a dissecting microscope, and identified to the lowest taxonomic level. Prey items then were separated and grouped by lowest taxonomic grouping and dried at 60°C for 24 hours in a DX 600 drying oven. When possible, individual organisms were counted and recorded. Once dried, contents were weighed using a Precision XB Series balance to 0.0001g to determine dry weight of individual prey items.

Data Analysis

Overall community composition was assessed using the PRIMER package (Plymouth Routine in Multivariate Ecological Research; Warwick 1990). A square-root transformed Bray-Curtis similarity index was run to determine the percent similarity between sites (reef vs. mud-bottom reference site) and seasons (winter, spring, summer and fall). Analysis of similarity (ANOSIM) was performed to assess the differences in community structure between sites and seasons. Following the ANOSIM, the SIMPER function was used to analyze the percentage similarity within group and to determine the factors contributing to the average dissimilarity between groups. A two-way ANOSIM and two-way SIMPER were run using site and season as factors.

The average raw (nominal) catch-per-unit-effort (CPUE) for all species was compared between sites and seasons using a two-way analysis of variance (ANOVA) (SAS Institute 2002). A separate analysis was conducted for CPUE for all species excluding Gulf menhaden, which dominated all catch totals. Each gear type (gill net and purse seine) was run independently due to the inherent selectivity of all gear types. Catch totals for some ecologically and economically important species were assessed separately to determine their distribution over space and time. These included CPUEs for spotted sea trout, Atlantic croaker, bay anchovy, Gulf menhaden, penaeid shrimp (white shrimp, *Litopenaeus setiferus* and brown shrimp, *Farfantepenaeus aztecus*), spot (*Leiostomus xanthurus*). Data for the total number of fishes collected was analyzed without transformation. However, due to the high number of zeros for individual species, this data was log (x+1) transformed. Because of the economic and ecological importance of spotted sea trout and Atlantic croaker, another comparison was run to see if there was a difference in the size of these species between the two sites. An ANOVA was run comparing standard length, total length and weight of spotted sea trout by site. All analyses that produced significant results at the $\alpha = 0.05$ level were further compared with a Tukey HSD *post hoc* test to determine which components of the variables accounted for differences.

Diet analysis was conducted for both spotted sea trout and Atlantic croaker over both sites. The contribution of each prey item to the diets of the two species were assessed using three different methods, including percent composition by weight, percent composition by number, and frequency of occurrence. Percent composition by weight (%W) was used for the majority of statistical analysis because it has been well documented to accurately assess nutritional contribution of individual prey items (Wells 2007, McCawley 2003, Bowen 1996). As such, an index of relative importance (IRI) was constructed using the %W values for all prey items at each site using the formulas adapted by McCawley (2003). First a percent frequency of occurrence was calculated using the formula:

$$\%FO = \frac{Number\ of\ stomachs\ containing\ one\ prey\ category}{Number\ of\ stomachs\ containing\ prey}$$

The index of relative importance was then calculated as (McCawley, 2003):

$$IRI = (\%N + \%W)\ x\ \%FO$$

where: N = number;
W = weight; and,
FO = frequency of occurrence.

Finally, a percent IRI (%IRI) was then calculated using:

$$\%\,IRI = \frac{IRI\ foreach\ prey\ category}{Sum\ of\ all\ IRI\ values} \times 100$$

The IRI was used to examine the overall composition of diets for each species (spotted sea trout and Atlantic croaker) at each site (artificial reef and mud-bottom reference site). The IRI is useful because it describes the diets based on the contribution of each prey item by weight.

Overall dietary analysis was assessed using the PRIMER package. A square-root transformed Bray-Curtis similarity index was constructed from the %W data to minimize the effects of the most abundant prey items (McCawley 2003, Wells 2006). Differences between sites and seasons were then assessed using the analysis of similarity (ANOSIM) option in PRIMER. The percent of similarity within each grouping (site and season) was then assessed using the SIMPER procedure.

RESULTS

Water Quality

Results of the ANOVA analysis showed that there are no statistical differences in water temperature, salinity, dissolved oxygen or turbidity between sites. Therefore, the assumption of the reference site having similar physical and water quality characteristics as the artificial reef site holds true.

Community Structure

Fish collection occurred from March 2005 – February 2007, with a total of fourteen trips completed, including four spring, summer, and winter samples and two fall samples. Field research was suspended in the fall of 2005 due to Hurricane Katrina, which passed very near to the study site and resulted in the loss of all fishing gear. Sampling resumed with gillnets in January of 2006 and with the purse seine in March of 2006 after the gear was replaced.

A total of 4,149 fishes were collected, including 43 finfish and three shrimp species. The ten most commonly caught species made up 95% of the total catch (Table 1).

The two most common species were Gulf menhaden and bay anchovy, which made up 40% and 22% of the total catch, respectively. Eighty-nine spotted sea trout and 410 Atlantic croaker were collected.

Table 1. Total catches and percentages of ten most commonly caught species pooled over all sites and seasons.

Species	Total Number Caught	Percentage of Catch
C. nebulosus	89	2.1
C. arenarius	52	1.3
B. patronus	1657	39.9
A. felis	227	5.5
Penaeid shrimp	162	5.0
L. xanthurus	82	2.0
M. americanus	91	2.2
M. undulatus	410	9.9
B. chrysoura	51	1.2
A. mitchilli	900	21.7
M. martinica	236	5.7
TOTAL	**3957**	**94.5**

PRIMER analysis results show no significant differences in overall community structure between sites. Average dissimilarity between sites for the reef and mud-bottom groups was 79%, with menhaden, bay anchovy, Atlantic croaker and hardhead catfish (*Arius felis*) contributing most to the dissimilarity between sites (over 50% cumulative dissimilarity). These four species all were found in higher abundance over the mud-bottom site.

There was a significant seasonal difference in community structure ($p < 0.1$) based on ANOSIM results. All season comparisons resulted in greater than 80% dissimilarity between season groups. Gulf menhaden was the most abundant species during sampling pooled over all seasons and months, and is therefore seen in high abundances throughout all seasons. Spring samples (season two) were characterized by high abundances of gulf menhaden, bay anchovy, and Atlantic croaker. Summer samples (season three) resulted in high abundances of rough silversides (*Membras martinica*) and hardhead catfish, as well as gulf menhaden. Fall and winter samples (seasons four and one respectively) both showed high abundances of menhaden and silversides as well as hardhead catfish. Abundances of spotted sea trout were similar in the spring and summer (around 0.90 for both months) and low in the fall and winter. Atlantic croaker had their highest abundance in the spring season, in which they were the most abundant species (abundance = 3.40) other than gulf menhaden.

There was no statistical difference between sites in the average overall CPUE, average CPUE without the addition of menhaden, or the average CPUE for the purse seine ($p > 0.05$, ANOVA) (See Figure 2). There were seasonal differences, with post-hoc tests revealing significant differences in overall CPUE between the fall and winter ($p < 0.05$, ANOVA). Seasonal differences are amplified when gulf menhaden are excluded from the analysis. Catch totals were significantly higher in the spring than both fall and winter when gulf menhaden is excluded from the analysis based on ANOVA post-hoc test ($p < 0.02$). The differences in these analyses are most likely due to the extremely high catches of gulf menhaden in the fall. In one month, 739 menhaden were caught, which accounted for 45% of all gulf menhaden, and 18% of all fishes combined for the entire study. The exclusion of menhaden from the analyses allows seasonal differences for the majority of the species to become more apparent.

Analysis of CPUE for individual species revealed that only spotted sea trout showed significant differences between sites and seasons. Catch totals over the reef were significantly higher than those over the mud ($p < 0.05$) and significantly higher in the spring than the fall or winter ($p < 0.01$) based on ANOVA and post-hoc tests. Seasonal differences in distribution existed for Atlantic croaker, with significantly higher catches in spring than fall or winter ($p < 0.005$), bay anchovy, with significantly higher catches in the winter ($p < 0.05$), and spot, with higher catches in the summer than the winter or spring ($p < 0.005$) according to ANOVA and post-hoc tests. No differences were seen for gulf menhaden or penaeid shrimp over sites or seasons ($p > 0.1$, ANOVA).

Results of the size analysis showed that fish collected over the reef were generally larger than over the mud. Spotted sea trout and Atlantic croaker both had significantly higher standard length and weight at the artificial reef site ($p < 0.001$ for both species and analyses) (see Figure 3).

Diet Analysis

Spotted sea trout consumed mostly fish material, primarily of the genus *Anchoa*, and penaeid shrimp. Five different families of fishes were collected from spotted sea trout stomachs, including Engraulidae (*Anchoa* sp.), Ariidae, Clupeidae (*B. patronus*), Sparidae, and Sciaenidae (*Cynoscion* sp. and *M. undulatus*). A variety of decapod crustaceans in addition to penaeid shrimp were found amongst gut contents, including hermit crabs (Family Diogenidae), and swimming crabs (Family Portunidae). Other prey items, including gastropods, bivalves, tunicates and isopods, were found relatively infrequently and in small amounts. Prey items that combined for less than 2% of the total %W of prey items were excluded from any analyses because they contributed very little to the overall diet. By dry weight, penaeid shrimp, including both white shrimp and brown shrimp, made up the greatest percentage of diets, while fish tissue was found more frequently, pooled over all sites and seasons. Results of the diet analysis for spotted sea trout appear in Figure 4.

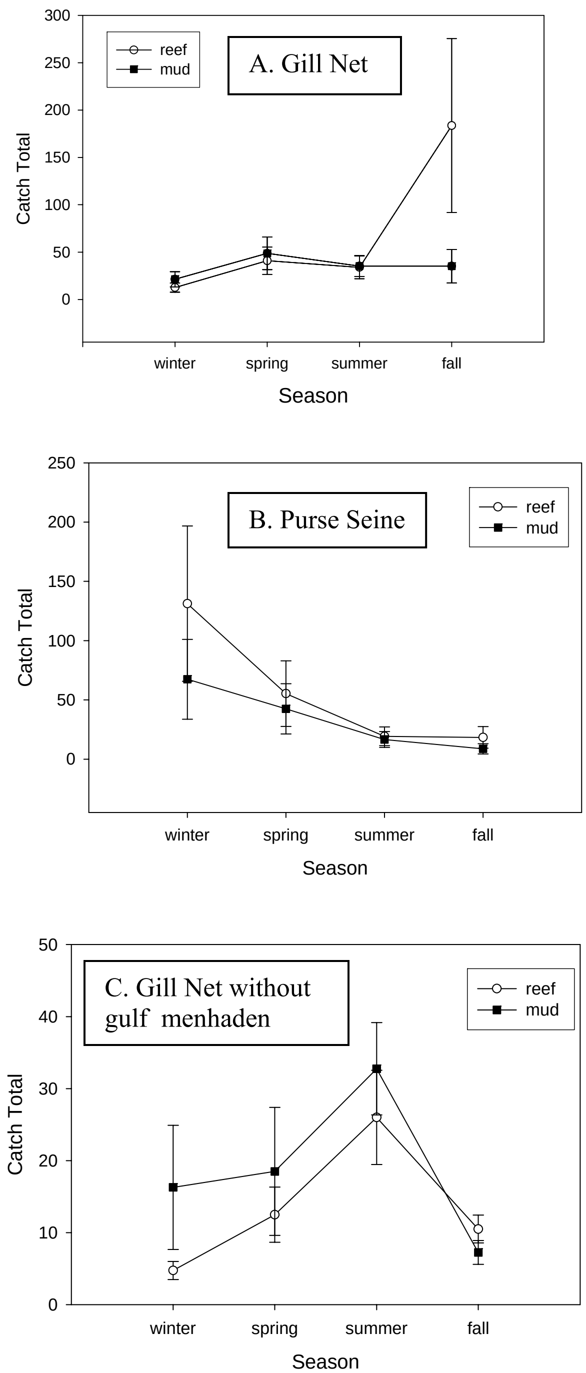


Figure 2. Average CPUE for A. gill net samples, B. purse seine samples, and C. gill net samples without gulf menhaden. Bars represent standard error for the sample.

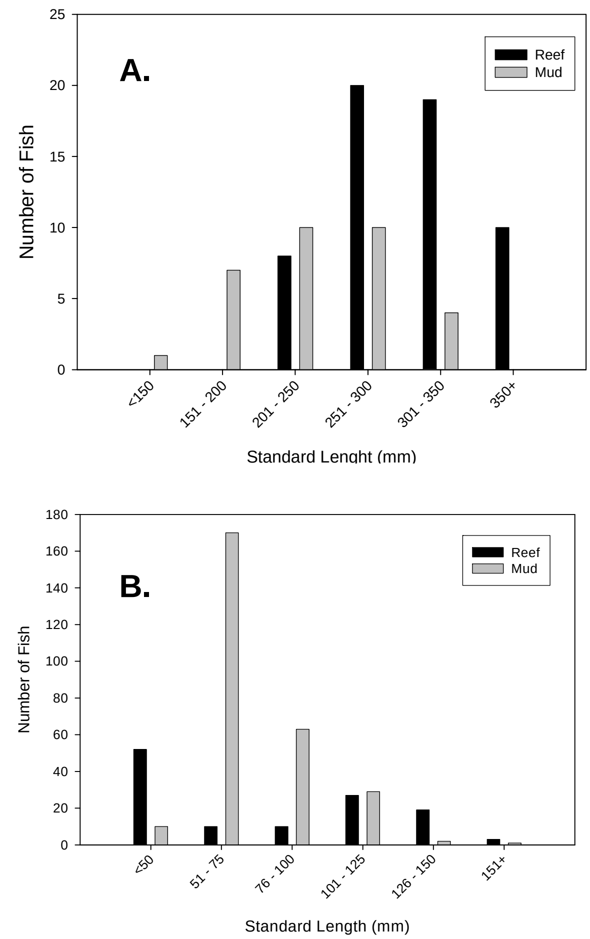
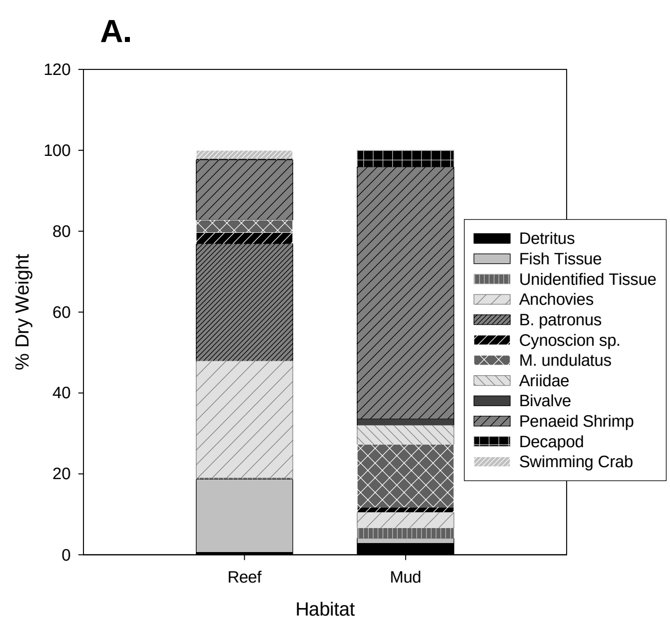


Figure 3. Size distribution of A. spotted sea trout and B. Atlantic croaker between sites



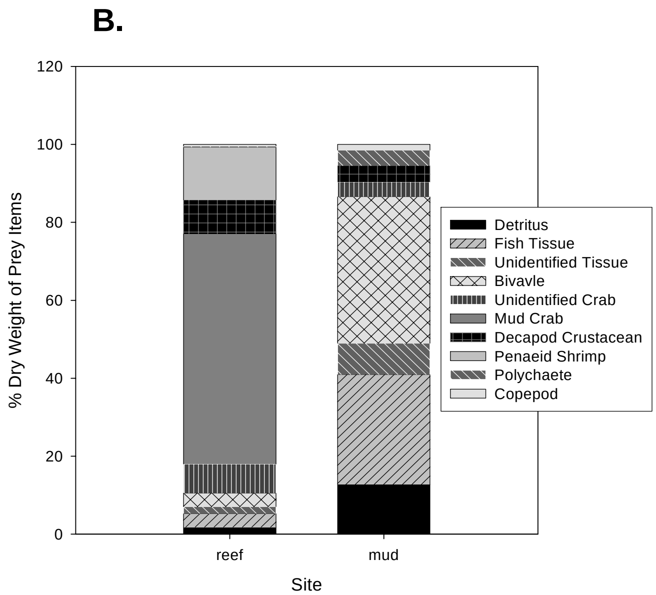


Figure 4. Stomach contents of A. spotted sea trout and B. Atlantic croaker by site based on percent dry weight.

Table 2. Results of the IRI for spotted sea trout (top) and Atlantic croaker (bottom) between sites. Values are reported in %IRI.

Spotted Sea Trout Prey	Artificial Reef	Mud-Bottom
Detritus	0.348	9.597
Fish Tissue	36.462	15.608
Anchovies	42.608	28.338
B. patronus	4.948	0.000
Cynoscion sp.	0.657	0.523
M. undulatus	1.593	3.702
Ariidae	0.000	1.764
Bivalve	0.875	11.156
Decapod Crustacean	0.272	2.716
Penaeid Shrimp	11.733	26.597
Swimming Crab	0.505	0.000
Atlantic Croaker Prey	**Artificial Reef**	**Mud-Bottom**
Detrituts	19.288	43.233
Fish Tissue	0.300	4.427
Bivalve	5.016	46.654
Unidentified Crab	4.431	0.160
Mud Crab	41.802	0.000
Decapod Crustacean	3.214	1.414
Penaeid Shrimp	1.763	0.000
Polychaete	0.210	2.869
Copepod	23.976	1.241

Results of the IRI indicate that mud crabs were the most important prey item for Atlantic croaker over the reef site (37%), and bivalves were the most important prey at the mud-bottom site. Detritus contributed largely over both sites (17% reef and 43% mud), but again this is most likely a product of their demersal feeding habits, and detritus alone probably contributes very little to the caloric intake of Atlantic croaker. IRI results tend to agree with PRIMER results in determining the differences between diets of Atlantic croaker at the two sites. Results of the IRI for Atlantic croaker appear in Table 2.

Results of the PRIMER analysis showed no statistical differences in the diets of Atlantic croaker between seasons (ANOSIM, $p > 0.1$) however there were some shifts in abundances of prey items over the seasons. Fish collected over the artificial reef site consumed more fish material and penaeid shrimp in the spring season. During the summer months, diets shifted to consist mostly of xanthid crabs, and other decapod crustaceans. Fall diets had a relatively even distribution of prey items, and no Atlantic croaker were caught in the winter months over either site. Fish collected over the mud-bottom site consumed high numbers of bivalves throughout all seasons, as well as detritus and unidentified material. There was a slightly higher abundance of fish tissue in the guts during the summer months, and slightly higher abundances of polychaete worms in the fall.

DISCUSSION

Estuarine fish communities showed no distinct differences between the mimic-oyster reef site and the mud-bottom reference site. The dominant species collected were found in high abundances over both sites, and those species that were collected solely at one location were found too infrequently (three times or fewer) to have an impact on the overall community structure. These results are consistent with those found by Harding and Mann (2001b) in a similar study of transient fish species in Chesapeake Bay. The authors sited no site-specific linkages based on habitat and equated this to the generalist nature of many of the fish species examined in the study. This situation most likely holds true in Barataria Bay, where the majority of the species collected are generalist and opportunistic in nature, and have a ubiquitous distribution throughout south Louisiana estuaries. Coen *et al* (1999) described numerous species that can be considered "residents" of oyster reefs, and would therefore be found in higher abundance at reef locations than non-reef. However, these are mostly small benthic fishes, and due to the limitations of our sampling gear, could not be collected. Therefore, these results can only be considered for larger more mobile fish species, and not small benthic species such as gobies, blennies, and flatfishes.

The only species that showed any marked difference in distribution between sites was spotted sea trout. The increased abundance of spotted sea trout over the reef is consistent with studies by Harding and Mann on bluefish

(2001a) and striped bass (2003) in the Chesapeake Bay. These three species occupy a similar niche in their respective environments and therefore are likely to utilize habitats in a similar manor. Spotted sea trout are known to feed opportunistically and have relatively low site fidelity. Therefore, the most important aspect of a habitat for such a species may be the availability of prey. Several studies have emphasized the ability of fishes to choose habitat based on prey availability (Burke 1995, Eklov 1997), and the ability of oyster reefs to aggregate prey (Breitburg *et al.* 1995, Coen *et al.* 1999, Harding and Mann 2001a, 2001b, 2003). Harding and Mann (2001a, 2003) concluded that the increased abundance of bluefish and striped bass over oyster reefs was likely due to the increased availability of teleost prey. The authors regularly observed approximately thirty fish species in the vicinity of the reef structure, making oyster reefs an attractive foraging ground for piscivorous fishes such as bluefish, striped bass, and spotted sea trout. In addition to being more numerous, spotted sea trout found over the reef site were also significantly larger than those found over the mud. This is also consistent with a study of transient fish species on oyster reefs in the Chesapeake Bay (Harding and Mann 2001b), as well as previously mentioned studies of bluefish and striped bass. The authors found that as habitat complexity increased the size of some transient species, including Atlantic menhaden (*Brevoortia tyrannus*), Atlantic croaker, and striped bass, increased. The increased abundance and size of spotted sea trout over the artificial reef is likely an effect of the site-specific prey availability influenced by the presence of reef structure. This is further evident by the higher abundance of teleost prey in stomachs of sea trout at the reef (41% anchovies) and more fish with recently consumed prey (more than solely unidentified tissue) than the mud-bottom site (76%). While there was no difference in the diversity of prey items between sites, the difference in abundance of certain prey items may be attributed to the presence of the artificial reef structure.

Atlantic croakers were also positively affected by the presence of the reef as evident through the diet analysis. While there was no difference in the abundance of Atlantic croaker between sites, there was a large difference in their diets. Atlantic croaker over the mud-bottom had diets consisting mostly of small bivalves, a prey item also found over the reef, though in much smaller amounts. Fish collected over the reef appear to preferentially select for mud crabs, a prey item not commonly found over the mud bottom, over other sources of prey. Atlantic croaker were also found to be larger over the reef, consistent with the previously mentioned study of transient fish species over an oyster reef in Chesapeake Bay (Harding and Mann 2001b). Therefore, there may also be site-specific prey available to fishes with demersal feeding habits as well. The interstitial space provided by the artificial reef structure provides habitat for small benthic invertebrates, such as the mud crabs that are a key prey item for Atlantic croaker.

Another way to compare the diets and prey availability between sites would be to examine quality of prey through the use of caloric density. This would help to determine if the presence of the reef leads to an increase in high value prey sources in addition to increased availability of prey. McCawley (2003) illustrated a method to assess the importance of prey items based on caloric density through the use of the index of caloric importance (ICI). Results of the dietary analysis can be enhanced by the planned addition of the ICI to this project in the future.

The preliminary findings of the artificial reef study suggest that although overall community structure is not affected by the presence of the reef, the feeding ecology of some estuarine fish species can be positively affected by the addition of structure such as artificial oyster reefs. This could potentially have management implications in an effort to enhance and restore fish habitat that has been altered by anthropogenic influences.

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