# LAKE PONTCHARTRAIN ARTIFICIAL REEF EVALUATION: 2009 & 2010 RESULTS

Blue crab (*Callinectes sapidus)* within a reef ball at a Lake Pontchartrain artificial reef


**PREPARED FOR:**

LAKE PONTCHARTRAIN BASIN FOUNDATION

**FUNDING PROVIDED:**

RAE-NOAA GRANT

FROM THE COALITION TO RESTORE COASTAL LOUISIANA



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Final December 2010

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# Executive Summary

**Purpose and goals.** The purpose of this study was to evaluate fish and invertebrate populations associated with reef-ball artificial reefs deployed in Lake Pontchartrain during April and May 2009 and to obtain additional information about four reefs previously deployed between August 2003 and January 2004. The overall goal of this study was to document links between reefs and Lake Pontchartrain habitat quality and fishery resources. This study had the following components: water quality, reef epifaunal invertebrates, a comparison of fish sampling methods and reef fish stomach content analysis.

**Water Quality.** We found that salinity was higher in summer and fall 2009 than spring and summer 2010. There was a general trend of decreasing salinity with reef site distance from the saltwater passes. No detrimental bottom dissolved oxygen levels, such as those associated with saltwater intrusion before closure of the MRGO, were detected. The lowest dissolved oxygen value was 5.3 ppm from the St. Charles site.

**Epifaunal invertebrates**. The reef epifaunal invertebrate community was more diverse and abundant that our earlier studies. The closure of the MRGO and lack of bottom water hypoxia appears to have improved epifaunal growth. Rapid colonization of hooked mussels to a relatively large size since the 2009 reefs were established is surprising. Although H3 has a better developed epifaunal community than found in previous studies, the community may not have recovered from poor water quality in the past. Epifaunal abundance may be less than bridge pilings because of more predation and turnover due to enhanced predation due to the design of reef balls.

**Comparison of fish sampling methods**. Simple rank ordering of fish abundance revealed major differences among roving diver, gill net, and hook and line sampling methods. Results provide insight on sampling errors to be expected with the different sampling methods employed and problems in comparing data derived from the different methods. Overall, fish occurrence data support the presence of diverse assemblages present at the reef sites, and the need for a combination of sampling methods to assess fish populations.

**Reef fish stomach content analysis.** Sheepshead and black drum had the greatest variety of reef ball epifaunal invertebrates in their stomachs. The sea catfish also utilized reef ball invertebrates. Other species such as the red drum and Atlantic croaker may have also utilized mud crabs and hooked mussels associated with the shell pad along with those on reef balls, but these invertebrates are more abundant on the reef balls than the shell pad.

**Overall Conclusion.** As in past studies of reefs established in 2003, we found that the reefs supported abundant and diverse invertebrate and fish populations and reefs improved fishing in Lake Pontchartrain.

## Introduction

This study evaluates the environmental services provided by four reef-ball artificial reefs deployed in Lake Pontchartrain during April and May 2009 (Lopez, 2009a, 2009b & 2009c) and provides additional information about four reefs previously deployed between August 2003 and January 2004 (Lopez, 2004). Past studies of reefs established in 2003 revealed that invertebrate and fish communities were associated with the reefs and that the reefs enhanced fishing in Lake Pontchartrain (Whitmore and Poirrier, 2006). The overall goal of this study was to document links between artificial reefs and Lake Pontchartrain habitat quality and fishery resources.

Artificial reefs are objects purposefully placed on the bottom to improve living aquatic resources, usually for some biologic or socioeconomic gain (Seaman, 2000). The first Lake Pontchartrain reef was composed of limestone rubble (**Figure1**). It was established west of the Lakefront Airport in Orleans Parish in 2001 (Poirrier and Sinclair, 2002). The other eight Lake Pontchartrain artificial reefs (**Figure 1**) were made by placing reef balls on top of existing shell pads. Sites were selected after careful study and rigorous review and permitting by State and Federal agencies (Lopez, 2004, 2009a, 2009b). Unlike reefs composed of unwanted debris, the Lake Pontchartrain reef ball reefs are composed of commercially fabricated, low profile, high surface area and environmentally safe concrete units know to provide habitat and enhance fishery resources (Reef Ball Development Group, Ltd, 2002). These reefs help restore the former clam shell bottom of Lake Pontchartrain destroyed by over thirty years of shell harvesting (Abadie and Poirrier 2001). The number, size and location of reef balls deployed at the reef sites, and photographs of reef balls are given in references Lopez 2004, 2009a and 2009b. Perhaps, a better term for the Lake Pontchartrain reefs would be designed reefs rather than artificial reefs.

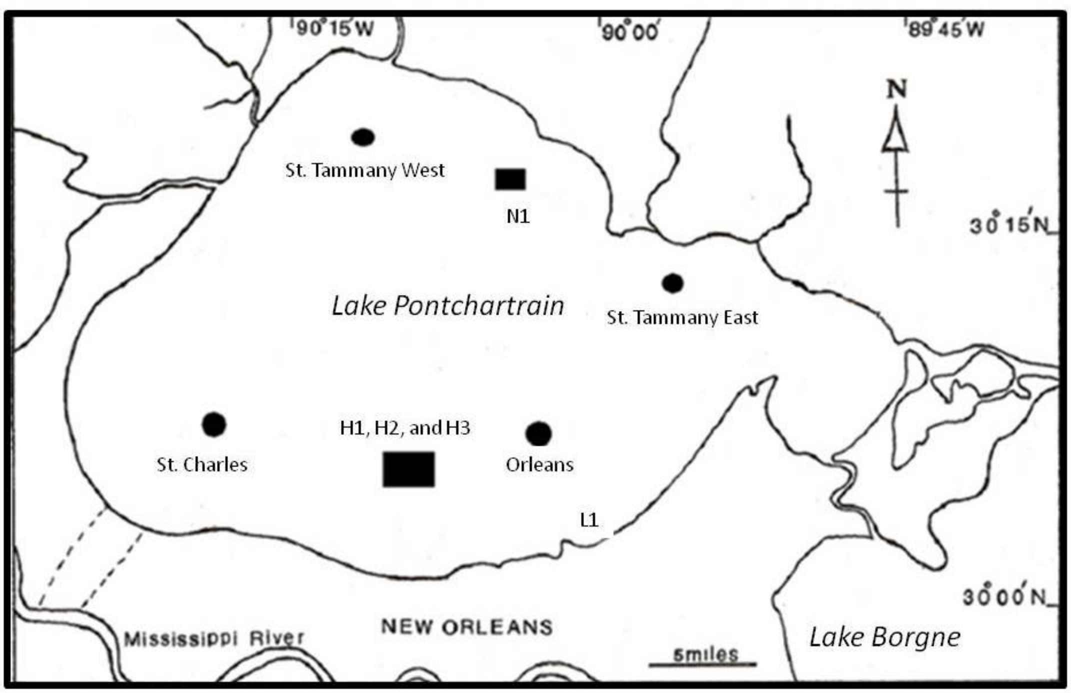


**Figure 1**: Map of Lake Pontchartrain showing reef locations. Circles indicate reefs established during April and May 2009. Rectangles indicate reefs established between August 2002 and January 2004. Reef L1 is limestone rubble reef established in 2001.

Our original intent was to use underwater observations to evaluate fish and invertebrate populations associated with the reefs. Underwater observations were successfully used in a previous study (Whitmore and Poirrier, 2006), but productive diving opportunities were limited by poor water clarity during the 2009 & 2010 study. This study had the following components: water quality, epifaunal invertebrates, a comparison of fish sampling methods and fish stomach content analysis. Water quality measurements focused on obtaining information about salinity and other differences among reef sites and the possible presence of salinity stratification and detrimental low bottom dissolved oxygen at sites. Epifaunal invertebrates that live attached to or on the reefs were scraped from the reef balls and identified. Species present at the different sites were compared and related to the age of the reef and water quality. We resorted mainly to hook and line fishing to sample fish and obtain specimens for stomach content analysis. We compared sampling results obtained with hook and line fishing to available gill net data and previous underwater observations (Whitmore and Poirrier, 2006). Stomach content analyses were used to determine if fish fed on reef epifaunal invertebrates and other organisms associated with the reefs.

# Chapter 1 Water Quality

Water quality data were obtained from reef sites H3, N1, St. Tammany E, St Tammany W, Orleans and St Charles. The was done to (1) help characterize conditions at the time biota was sampled, (2) provide information on differences among reef sites and (3) determine if salinity stratification and detrimental low bottom dissolved oxygen was present.

**Methods**

Depth, Secchi disc visibility, surface and bottom temperature, and salinity and dissolved oxygen were measured on every trip to the reef sites. A YSI model 85 meter was used for temperature, salinity and oxygen measurements. Depth was measured with a weighted Secchi disc and recorded in feet. Time was also recorded.

**Results**

Water Quality data obtained from six Lake Pontchartrain reef sites from August through October 2009 and from May through July 2010 are given in **Table 1**. Data are presented in chronological order and include time, depth, Secchi disc visibility, surface and bottom temperature (C), and salinity and dissolved oxygen measurements as % saturation and ppm.

The St. Tammany East site was visited eight times and the depth recorded ranged from 10.9 to 14 ft. Although depth was not adjusted for wind or lunar water level fluctuations, these depth differences were probably due to depth differences among locations on the shell pad. Other sites had the following depths in feet on the dates visited: H3, 15; N1, 14.4; St Tammany West, 14; St. Charles, 14; Orleans 16.5 and 17.2. Based on these data, site H3 may be slightly deeper than St. Tammany E & W, N1 and St. Charles, while Orleans is the deepest site.

Water temperature showed typical seasonal trends. As would be expected with daily differential heating of surface versus bottom waters, surface waters were generally slightly warmer depending on the time of day and degree of water column mixing by wind.

There were major differences in Secchi disc visibility and salinity between the time periods August through October 2009 and May through July 2010. At the St. Tammany E site, which was visited 4 times in 2009 and 4 times in 2010, Secchi disc visibility ranged from 4.7 to 7 in 2009 and from 3.5 to 4.5 in 2010. Surface salinity ranged from 6.2 to 6.8 and bottom salinity from 6.6 to 7.7 in 2009. In 2010, surface and bottom salinity ranged from 2.4 to 2.5. These temporal salinity differences were due to dry weather during spring and summer 2009, and heavy rains during winter of 2009 and 2010. Closure of the MRGO in June 2009 may also have affected salinity trends. Other sites were not sampled in both years and cannot be directly compared, but based on other data in ongoing studies by Poirrier, salinity was most probably lower at all sites in spring and summer 2010 and higher in summer and fall 2009.

| | H3 | St Tamm. E | N 1 | St. Tamm. W | St Tamm. E | St Tamm. E | St Tamm. E | St Charles | St Tamm. E | Orleans | St Tamm. E | St. Tamm. E | St Tamm. E | St Tamm. W | Orleans |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8/26/2009 | 9/1/2009 | 9/1/2009 | 9/2/2009 | 9/20/09 | 9/21/09 | 9/27/09 | 10/8/2009 | 5/23/2010 | 5/25/2010 | 5/25/2010 | 6/15/2010 | 6/17/2010 | 6/26/2010 | 7/10/2010 |
| Time | 10:00 AM | 11:45 AM | 1:07 PM | 1:45 PM | 1:15 PM | 11:45 AM | 11:45 AM | 10:30 AM | 7:00 AM | 8:40 AM | 1:30 PM | 10:00 AM | 10:15 AM | 9:00 AM | 10:00 AM |
| Depth in ft. | 15 | 14 | 10.8 | 14.4 | 12.8 | 13.6 | 11.6 | 14 | 11.5 | 16.5 | 11.5 | 10.9 | 13.1 | 14 | 17.2 |
| Secchi Vis.,ft | 3 | 7 | 5.5 | 5.5 | 5 | 6.5 | 4.5 | 4 | 4 | 2.5 | 3.5 | 4.5 | 4 | 4.5 | 3 |
| Surface | | | | | | | | | | | | | | | |
| Temp C | 29 | 28.5 | 29.6 | 29.2 | 29.6 | 29.3 | 29.2 | 27.8 | 28.2 | 28.6 | 30.3 | 31.2 | 31.1 | 30.8 | 29.8 |
| Salinity PPT | 5.1 | 6.6 | 6.2 | 5.2 | 6.2 | 6.6 | 6.8 | 5.6 | 2.4 | 2.3 | 2.4 | 2.5 | 2.4 | 1.7 | 2.4 |
| D.O.% | 95.2 | 96.5 | 98.4 | 94.7 | 107.1 | 104.6 | 97.5 | 110.5 | 103 | 84.9 | 87.3 | 93.8 | 90.5 | 89.8 | 106.7 |
| D.O ppm | 7.2 | 7.2 | 7.15 | 7 | 7.8 | 7.68 | 7.1 | 8.4 | 8 | 6.5 | 6.5 | 6.83 | 6.61 | 6.62 | 7.93 |
| Bottom | | | | | | | | | | | | | | | |
| Temp C | 28.2 | 28.4 | 28.5 | 27.6 | 28.6 | 28.7 | 28.4 | 26.5 | 28.3 | 28.6 | 28.9 | 31 | 30.8 | 30.8 | 29.1 |
| Salinity PPT | 5.1 | 6.6 | 6.5 | 5.3 | 7.7 | 7.3 | 7.1 | 6.3 | 2.4 | 2.3 | 2.4 | 2.5 | 2.4 | 1.7 | 2.4 |
| D.O % | 87.5 | 90 | 84.8 | 85.4 | 78.4 | 81.5 | 84 | 68.5 | 97.1 | 82.5 | 82.8 | 90.8 | 94.7 | 88.3 | 101.3 |
| D.O ppm | 6.6 | 6.8 | 6.28 | 6.54 | 5.8 | 6.1 | 6.3 | 5.31 | 7.9 | 6.3 | 6.1 | 6.62 | 6.93 | 6.48 | 7.62 |

**Table 1:** Water Quality data collected in 2009 and 2010. Note that PPT is an estimate of parts per thousand salinity based on conductivity

Slight salinity stratification was found at the St Tammany East and St Charles sites in 2009, but no detrimental bottom dissolved oxygen differences were associated with this stratification. Surface and bottom salinity differences were 1.5, 0.7 and 0.3 at St Tammany East in September 2009 and 0.7 at St. Charles in 2010. It is not clear if these differences were due to local freshwater runoff, movement of saline bottom water through the tidal passes or stratified water that persisted after the MRGO was closed. No stratification was detected at any reef site in 2010.

There should be differences among sites due to distance from the sources of saltwater and circulation patterns. Bottom salinities from sites in 2009 (**Table 1**) are: H3 5.1; N1 5.3; St. Charles 6.3 and St. Tammany East 7.1 (mean of 4 measurements). Bottom salinities from 2010 (**Table 1**) are St. Tammany East 2.4 (mean of 4); Orleans 2.4 and St Tammany West 1.7. St. Charles was higher than would be expected based on distances from saltwater sources but it was sampled in October, later than other sites, when rainfall is generally lower and Gulf tides higher. Analysis of this limited data set for site differences is difficult because sites were sampled at different times and a major decrease in south shore bottom salinity occurred when the MRGO was closed. However, the general trend of decreasing salinity with distance from the passes is present.

Surface dissolved oxygen values expressed as % saturation (**Table 1**) ranged from 84.9 to 110.5 and bottom values ranged from 68.5 to 101.3. The lowest value in ppm was 5.31 from the St. Charles site. None of these values was indicative of detrimental low dissolved oxygen concentrations.

# Chapter 2  Epifaunal Invertebrates Associated with Reefs

Epifaunal invertebrates are organisms which are attached to, or live on, hard substratum. In Lake Pontchartrain, they are abundant on bridge pilings, seawalls and other hard structures and also occur on shells scattered on the bottom. Organisms that occur in or on soft mud bottoms are termed infauna. This part of the study examined the growth of epifaunal invertebrates on the reef balls. Since most epifaunal organisms do not occur on the mud bottom, the increased hard surface area provided by reef ball reefs greatly enhances bottom biodiversity by providing habitat for epifaunal species. In addition, since reef balls increase the area of invertebrate productivity, this increases food production for sport and commercial fish, crab and shrimp.

Many epifaunal species are filter feeders that remove suspended particles including plant detritus, bacteria and algae from the water column. Energy from these items support growth of epifauna, but feces and filtered but un-eaten particles, termed pseudofeces also provide food for the community and nutrients for local algal growth. Epifaunal filter feeding activity also improves water clarity and reduces phytoplankton abundance.

In previous studies (Whitmore and Poirrier, 2006), epifaunal communities at site H3 were poorly developed. It was not clear if this was due to slow recruitment of epifauna to the isolated reef sites, high rates of predation, or episodes of detrimental low bottom dissolved oxygen. A major aspect of this study was to compare the degree of development of the epifaunal community in reefs which were established in April and May 2009, St Tammany East and West and older reefs, H3 and N1, established between August 2003 and January 2004.

## Methods

Epifaunal invertebrates were collected using SCUBA. Invertebrates were scraped from the reef balls with a paint scrapper with a handle and a 10 cm wide blade. They were collected into a fine mesh (< 0.5 mm) 20 X 20 cm frame aquarium net. The contents of the net were handed to an assistant on the boat and placed in plastic jars and preserved in 4% formalin. Sample volumes were about 200 ml. The distribution of invertebrates was not uniform and different areas were sampled to obtain a representative collection.

Epifauna were collected from site H3, a previously established southshore reef in Jefferson Parish on August 26, 2009; N1, a previously established northshore reef in St. Tammany Parish on September 1, 2009; St. Tammany East a new northshore site on September 1, 2009; and St Tammany West a new northshore site on September 2, 2009. Surface and bottom water quality measurements were made on each trip (methods provided in the water quality section of this report). Water clarity and the uneven surface of the reef balls made it impossible to sample from a specified surface of reef balls in turbid water that persisted during this survey.

## Results

Species found on the reef balls at the four sites are presented in **Table 2** and common names for groups and additional information are presented in **Table 3**.

| Table. *2.* Epifaunal invertebrates present at four reefs sites sampled in Late August and early September 2009. | | | | |
|---|---|---|---|---|
| Species present | St Tam. East | St Tam. West | N 1 | H3 |
| *Spongilla alba* | | | | X |
| *Garveia franciscana* | X | X | X | X |
| *Stylochus ellipticus* | | | X | X |
| *Pentacoelom sp.* | | | X | |
| Nematoda | | | | X |
| *Victorella pavida* | X | X | X | X |
| *Conopeum sp* | X | X | X | X |
| *Neanthes succinea* | X | | | |
| *Polydora websteri* | X | X | X | X |
| *Baccardia hamata* | | | | X |
| *Streblospeio benedicti* | | | | X |
| *Mytilopsis leucophaeta* | X | X | X | X |
| *Ischadium recurvum* | X | X | X | X |
| *Amphibalanus subalbidus* | | | X | X |
| *Amphibalanus improvisus* | X | X | X | |
| *Apocorophium lacustre* | X | X | X | X |
| *Melita sp* | | | X | |
| *Rhithropanopeus harrisii* | X | X | X | |
| *Gitanopsis sp.* | X | X | X | |
| *Grandidierella bonnieroides* | | X | X | |
| Total number of species | 11 | 11 | 15 | 13 |
| *Ischadium* mean size (mm) | 22 | 12.9 | 22.8 | 21.5 |
| | | | | |

| *Table 3*. Latin, common names and ecological attributes of epifauna. | | | |
|---|---|---|---|
| Species Latin name/group | Common name/group | Attached/ mobile | Feeding adaptation |
| *Spongilla alba* | Sponge | Attached | Filter feeder |
| *Garveia franciscana* | Hydroid | Attached | Filter feeder |
| *Stylochus ellipticus.* | Flat worm | mobile | Predator |
| *Pentacoelom sp.* | Flat worm | mobile | General |
| Nematoda | Round worm | mobile | General |
| *Victorella pavida* | Bryozoan | Attached | Filter feeder |
| *Conopeum sp.* | Bryozoan | Attached | Filter feeder |
| *Neanthes succinea* | Polychaete | mobile | Predator |
| *Polydora websteri* | Polychaete | Attached | Filter feeder |
| *Baccardia hamata* | Polychaete | Attached | Filter feeder |
| *Streblospeio benedicti* | Polychaete | Attached | Filter feeder |
| *Mytilopsis leucophaeta* | False mussel | Attached | Filter feeder |
| *Ischadium recurvum* | Hooked mussel | Attached | Filter feeder |
| *Amphibalanus subalbidus* | Barnacle | Attached | Filter feeder |
| *Amphibalanus improvisus* | Barnacle | Attached | Filter feeder |
| *Apocorophium lacustre* | Amphipod | Attached | Filter feeder |
| *Melita sp* | Amphipod | mobile | General |
| *Gitanopsis sp.* | Amphipod | mobile | General |
| *Grandidierella bonnieroides* | Amphipod | Attached | Filter feeder |
| *Rhithropanopeus harrisii* | Mud crab | mobile | Predator |

The abundance and diversity of organisms at new sites St. Tammany East and West established in April and May 2009, was surprising (**Table 2**). However, the number of species (11) was lower than the older sites N1 (15) and H3 (13) established between August 2003 and January 2004. This is probably related to recruitment, and species richness should increase with time. Seven of the 20 species were present at all sites. The new sites, St. Tammany East and West, were similar to each other except for two species (**Table 2**). Established south shore site H3 had fewer species than established northshore site N1 and nematodes and two polychaetes, *Polydora websteri* and *Streblospeio* were only found at this site. Site H3 also lacked the mud crab, *R. harrissi,* and the amphipod, *Gitanopsis sp.,* found at all other sites and the amphipod, *Grandidierella,* found at two of the other sites. However, it was the only site with the freshwater sponge, *Spongilla alba.* John Lopez managed to scrape hooked mussels, false mussels and the barnacle, A. *subalbidus,* from the Orleans reef site on September 4, 2010. Twenty-two mussels which ranged in size from 1.2 to 3.3 cm were obtained. Samples were not collected in a net, so no small specimens were retained. However, these samples does support the presence of well-developed mussel population at the Orleans site, which, prior to closure of the MRGO, was subjected to high salinity bottom water low in dissolved oxygen.

The presence of stress tolerant nematodes and polychaetes and the lack of stress intolerant mud crabs and amphipods in samples from H3 may indicate episodes of poor water quality. However, no adverse water quality was detected when sampled in August 2009 (See water quality section). The barnacle, *Amphibalanus subalbidus*, which occurs at lower salinities than *Amphibalanus improvisus* was only found at the older sites. The reason for this may have been the relatively high salinities that prevailed in Lake Pontchartrain after the new reefs were deployed. The new reefs tended to be colonized by higher salinity species, whereas the old reefs tended to support more species from previous low salinity periods. This would explain the presence of the freshwater sponge at site H3. It would also explain the abundance of hooked mussels because, in the low salinity regime of Lake Pontchartrain, they are more abundant during relatively high-salinity periods. Previous studies (Whitmore and Poirrier, 2006) indicated that epifauna at site H3 may have been affected by occasional saltwater intrusion and associated hypoxia from Mississippi River Gulf Outlet (MRGO) water entering through the Inner Harbor Navigation Canal. The MRGO was closed in June 2009 and no detrimental salinity stratification or dissolved oxygen has been detected since closure (Ongoing studies by Poirrier). The presence of stress indicators at H3 may have persisted from previous stress or some undetected pockets of stratified water may have affected this area after closure.

There was rapid colonization by hooked mussels and barnacles that was probably due to the relatively high prevailing salinity in summer 2009. At St. Tammany East, twenty two mussels sampled ranged from 13.3 to 29 mm in length and had an average size of 22mm. Two small *Rangia* clams (5.8 mm and 6.7 mm), although infaunal, were found within the dense epifauna. At St. Tammany West, hooked mussels were less abundant. The five mussels collected ranged in size from 0.7 to 17.7 mm and averaged 12.9 mm. Hooked mussels and barnacles were abundant at site N1. Ninety three mussels were measured which ranged from 0.33 to 26.7 mm and averaged 22.8 mm. Barnacles and hooked mussels were abundant at site H3. Fifty hooked mussels were examined which ranged from 7.3 to 34.1 mm and averaged 21.5 mm in length.

In summary, an abundant and diverse epifaunal community was found on the reefs. The hooked mussels' rapid growth to a relatively large size since the reefs were established is surprising. Although H3 has a better developed epifaunal community than found in previous studies (Whitmore and Poirrier, 2006), the community has not recovered from poor water quality in the past. The closure of the MRGO and lack of bottom water hypoxia appears to have improved epifaunal growth. Although underwater observation of epifauna was restricted in this study due to high turbidity, epifaunal abundance may be less than bridge pilings because of more predation and turnover of epifauna on the curved surface and refuge provided to fish predators by the reef ball reefs.

# Chapter 3 Comparison of Reef Fish Sampling Techniques

Original plans for this study included additional underwater observations of fish associated with the reefs using standard roving diver techniques employed in previous studies (Kelley and Poirrier, 2006). Unfortunately, water clarity in Lake Pontchartrain has been relatively low since Hurricane Katrina. We attempted underwater collection of invertebrates and fish observation in August through October 2009 and experienced two days of relatively clear water at the St. Tammany East site (Secchi disc visibility 5 & 6.5 ft.), but clarity was not sustained or sufficient for reliable fish surveys, which required a bottom horizontal visibility of a 6 ft or greater. We requested and received no-cost extensions to this study in hopes of encountering days of clear water in spring and summers of 2010. Unfortunately, none of our trips had suitable water clarity (see water quality results, **Table 1**).

We resorted to using data from other sampling techniques. The University of New Orleans Nekton Research Laboratory collected fish over the reefs using gill nets for fish tagging studies. Dr. Martin O'Connell and Chris Schieble provided samples from several reef sites. We used hook and line fishing to sample fish present and to obtain information on food habits of fish over the reefs. I compared available fish sampling data using gill nets, hook and line fishing and the roving diver observations from an earlier study (Whitmore and Poirrier, 2006) to evaluate possible differences.

**Material and methods**

Gill net. All sampling was conducted by the UNO Nekton Laboratory. A 100 yd gill net with 2 and 8 inch mesh panels was set over the reef and retrieved after one hour. Fish were identified, measured, tagged and released. Each one hour net set was regarded as a sample. Sites, H 1, H3 and N1 were sampled nine times between 6/22/09 and 7/24/09

Hook and line. Three sheepshead were obtained in early fall of 2009 from the St. Tammany East site by spear fishing and other fish by hook and line fishing. Fish were obtained by hook and line during fishing during late spring and summer of 2010. The St. Tammany East reef was fished eight times (9/20/09, 9/27/10, 5/22/10, 5/23/10, 5/25/10, 6/15/10, 6/17/10 and 6/19/10. The St. Tammany West (6/26/10) and Orleans (7/10/10) sites were each fished once. Two anglers fished the sites generally between 7 AM and 1 PM. Live minnows, *Fundulus similis*, live brown shrimp and dead shrimp were used as bait. A sliding cork or a line with a hook and light weight were used for off bottom fishing and a Carolina rig, which allows the line to move through a bottom weight, was used for bottom fishing. Fish were measured, placed on ice and used for gut content analysis. Each fishing trip was regarded as a sample.

Roving diver. Detailed methods are given in Whitmore and Poirrier (2006). Certified SCUBA divers with training in the underwater identification of estuarine fish conducted the studies. Surveys were only conducted when bottom horizontal Secchi disc water transparency was 6 ft or greater. A team of two divers swam randomly through the survey area and recorded species and number of fish encountered during two ten minute periods. This was done twice for a total of 40 minutes. Each 40 minute survey was regarded as a sample. A total of 29 samples were conducted between 6/2/05 and 8/19/05. All samples were from reef site H3.

**Results**

The sampling data sets presented in **Figure 4** are expected to differ due to spatial, temporal, and salinity differences, inherent sampling error and inadequate number of samples. However, this simple rank order comparison provides insight on the value and limitations of the different sampling methods. The net method employed appeared to favor large, open-water, mobile predaceous fish. Bull shark and other predators may be attracted by other fish caught in the net. Small fish, such as naked gobies, blennies skillet fish and American eel, which swim in and on the reef balls, would not be expected to be captured by the large mesh nets in open water. These fish were easily observed by SCUBA, but not caught by gill nets or by hook and line. Although sheepshead and mullet were abundant and easily observed by SCUBA, they were not present in the gill net samples. Demersal species such as flounder and sting rays were not captured in gill nets, but are present based on SCUBA and hook and line fishing.  Results are presented in **Table 4**. **Table 5** presents a list of Latin names of fish mentioned in Table 4.

Table 4. Rank order comparison of fish sampled with a gill net, hook and line fishing and Scuba observation. Reef sites, total number of samples and sampling time periods are given in the first row of this table.

| Rank order | Gill net: sites N1, H1, H3 & H4: 9 samples 6/22 - 7/24/09 | Hook and line Fishing sites: St Tamm. E & W and Orleans, 10 samples, 9/20 & 27/09, 5/22-7/10/10. | SCUBA: H3 29 samples 6/2/05-8/19/05 |
|---|---|---|---|
| 1 | Atlantic croaker 25 | Spotted seatrout 44 | Naked goby 466 |
| 2 | Gafftopsail catfish 15 | Sea catfish 14 | Sheepshead 37 |
| 3 | Spotted seatrout 10 | Atlantic croaker 12 | Freckled blenny 16 |
| 4 | Sand sea trout 9 | Sheepshead 9 | Striped mullet 6 |
| 5 | Bull shark 5 | Black drum 6 | Pinfish 6 |
| 6 | Sea catfish 4 | Atlantic stingray 5 | Southern flounder 4 |
| 7 | Spot 4 | Gafftopsail catfish 5 | Crevalle jack 4 |
| 8 | Black drum 1 | Red drum 2 | Blue catfish 4 |
| 9 | Skipjack herring 1 | Southern flounder 1 | American eel 2 |
| 10 | | | Skilletfish 2 |
| 11 | | | Atlantic stingray 1 |
| 12 | | | Atlantic croaker 1 |
| 13 | | | Gulf toadfish 1 |

**Table 5**. List of common and Latin names of fish mentioned in this study.

| | |
|---|---|
| American eel | *Angilla rostrata* |
| Atlantic croaker | *Micropogonias undulatus* |
| Atlantic spadefish | *Chaetodipterus faber* |
| Atlantic stingray | *Dasyatis sabina* |
| bay anchovy | *Anchoa mitchilli* |
| black drum | *Pogonias cromis* |
| blue catfish | *Ictalurus furcatus* |
| bull shark | *Carcharhinus leucas* |
| crevalle jack | *Caranx hippos* |
| freckled blenny | *Hypsoblennius ionthas* |
| gafftopsail catfish | *Bagre marinus* |
| Gulf toadfish | *Opsanus beta* |
| Gulf menhaden | *Brevoortia patronus* |
| gray snapper | *Lutjanus griseus* |
| inland silversides | *Menidia beryllina* |
| naked goby | *Gobiosoma bosc* |
| pinfish | *Lagodon rhomboides* |
| red drum | *Sciaenops ocellatus* |
| rough silversides | *Membras martinica* |
| sand seatrout | *Cynoscion arenarius* |
| sea catfish | *Arius felis* |
| sheepshead | *Archosargus probatocephalus* |
| skilletfish | *Gobiesox strumosus* |
| skipjack herring | *Alosa chrysochloris* |
| southern flounder | *Paralichthys lethostigma* |
| spot | *Leiostomus. xanthurus* |
| spotted seatrout | *Cynoscion nebulosus* |
| striped anchovy | *Anchoa hepsetus* |
| striped mullet | *Mugil cephalus* |

On the other hand, SCUBA observations in Lake Pontchartrain did not detect spotted sea trout, black drum, bull shark, sea catfish, gafftopsail catfish which should have been present based upon gill net and hook and line samples. This is generally confirmed by spear fishing in Lake Pontchartrain. Spotted sea trout, black drum and bull sharks are seldom seen, but catfish, particularly sea catfish, are usually observed. These fish may be sensitive to noise and the presence of divers and move out of the diver's visual zone. Fish which school and seek shelter from predators in the reef may be easier to see underwater. One major advantage of SCUBA observations is that fish sampling is non destructive and SCUBA allows observation of attached and mobile invertebrates closely associated with the reefs. A major disadvantage is that it can only be effectively utilized when bottom water clarity is above six feet. On the two days of clear water in fall 2009, gray snapper and spade fish were observed at the St. Tammany East site while collecting invertebrate samples. Numerous sheepshead were also observed and three were speared for gut content analysis.

Hook and line fishing was used in this study to obtain fish for gut content analysis of reef invertebrates utilized as fish food. The relative abundance of species caught was highly dependent upon gear employed and fishing skill and bias, but it does document that the fish caught were present. It is interesting to note that red drum were caught by hook and line, but not observed by SCUBA or present in this limited gill net data set.

Although this simple rank ordering of data does not provide definitive results of relative abundance of fish present, it does provide information on sampling errors to be expected with the methods employed and the difficulty of comparing data from the different methods. Overall, these data support the presence of a diverse fish assemblage present at the reef sites, and the need for different sampling methods to assess fish populations.

# Chapter 4 Reef Fish Stomach Content Analysis

An overarching goal of the study was to determine links between the potential environmental services provided by the reefs and Lake Pontchartrain environmental and fishery resources. This portion of the study asked the following question. Do fish present over the reef utilize organisms growing on or associated with the reef ball reefs? The presence of food items associated with the reefs (**Table 2**, in the epifaunal invertebrate section) in the stomachs of fish obtained by fishing over the reefs would indicate that fish were utilizing food resources provided by the reef. This in turn would imply that any enhanced benthic productivity due to the reefs would also enhance fin-fish fisheries. Although there have been numerous studies of the food habits of estuarine fishes, Darnell (1958) and Levine (1980) performed the most comprehensive studies of the gut contents of Lake Pontchartrain fishes. Results of this study are compared with these earlier studies.

**Methods**

Some fish were obtained in early fall of 2009 by spear and by hook and line fishing. All other fish were obtained by hook and line fishing during late spring and summer of 2010. The St. Tammany East reef was fished on eight days (9/20/09, 9/27/10, 5/22/10, 5/23/10, 5/25/10, 6/15/10, 6/17/10 and 6/19/10. The St. Tammany West (6/26/10) and Orleans (7/10/10) sites were each fished once. Two anglers fished the sites generally between 7 AM and 1 PM. Live minnows, *Fundulus similis*, live brown shrimp and dead shrimp were used as bait. A sliding cork or a line with a hook and light weight were used for off bottom fishing and a Carolina rig, which allows the line to move through a bottom weight, was used for bottom fishing. Fish were placed on ice after capture and stomachs and digestive tracts removed and frozen in plastic bags within eight hours. Stomach contents were rinsed in a 0.5 mm sieve and identified under a dissecting microscope. No attempt was made to quantify total stomach contents or numbers of food items present. Total fish length was measured and recorded before dissection. Sex of spotted seatrout was noted for specimens with well developed gonads.

**Summary Results**

Nine species of fish were obtained (**Table 6**). Although the number of individuals caught in each species is listed in order of abundance, this does not imply a relationship between what was caught and relative fish abundance over the reef. Table 1 does indicate what might be caught with hook and line fishing. This obviously is affected by gear, bait, fishing skill, environmental conditions and luck (stochastic encounters between bait and hungry fish). Stomach contents for individual species are given below in the order of relative abundance presented in **Table 6**.

Table 6. Species of fish examined for prey in stomachs listed in order of abundance, size range of total length in inches and the number with empty stomachs.

| Species | # of individuals | Size range | # with empty stomachs |
|---|---|---|---|
| Spotted seatrout | 44 | 12-24.5 | 14 |
| Sea catfish | 14 | 8-10 | 0 |
| Atlantic croker | 12 | 5.5-10.5 | 1 |
| Sheepshead | 9 | 8-22 | 0 |
| Black Drum | 6 | 17-21.5 | 1 |
| Alantic stingray | 5 | 21.5-34 | 0 |
| Gafftopsail catfish | 5 | 14-22 | 1 |
| Red drum | 2 | 17.5-22 | 0 |
| Southern flounder | 1 | 11 | 1 |

**Spotted seatrout**

**Table 7,** Spotted seatrout, *Cynoscion nebulosus,* stomach contents with individual fish identification number (# ), the date collected, reef site, size as total length in inches, sex and stomach contents.

| Number | Date | Location | Size | Sex | Contents |
|---|---|---|---|---|---|
| (1) | 9/27/2009 | St. Tammany East | 19 | F | empty |
| (2) | 5/22/2010 | St. Tammany East | 15 | M | fish remains |
| (3) | 5/22/2010 | St. Tammany East | 15.5 | M | fish remains |
| (4) | 5/22/2010 | St. Tammany East | 14 | - | fish remains |
| (5) | 5/22/2010 | St. Tammany East | 17.5 | F | fish remains |
| (6) | 5/22/2010 | St. Tammany East | 15 | F | fish remains |
| (7) | 5/25/2010 | St. Tammany East | 14 | F | empty |
| (8) | 5/25/2010 | St. Tammany East | 13.5 | F | fish remains |
| (9) | 5/25/2010 | St. Tammany East | 16 | F | empty |
| (10) | 5/25/2010 | St. Tammany East | 16 | F | empty |
| (11) | 5/25/2010 | St. Tammany East | 14.5 | F | empty |
| (12) | 5/25/2010 | St. Tammany East | 16 | F | fish remains |
| (13) | 5/25/2010 | St. Tammany East | 16 | F | fish remains |
| (14) | 5/25/2010 | St. Tammany East | 16 | F | empty |
| (15) | 5/25/2010 | St. Tammany East | 14 | - | shrimp remains |
| (16) | 5/25/2010 | St. Tammany East | 12 | - | fish remains |
| (17) | 5/25/2010 | St. Tammany East | 13.5 | F | fish remains |
| (18) | 5/25/2010 | St. Tammany East | 14.5 | F | fish remains |
| (19) | 5/25/2010 | St. Tammany East | 13 | - | empty |
| (20) | 6/15/2010 | St. Tammany East | 14 | M | empty |
| (21) | 6/15/2010 | St. Tammany East | 15 | F | fish remains |
| (22) | 6/15/2010 | St. Tammany East | 16 | F | fish remains |
| (23) | 6/15/2010 | St. Tammany East | 17 | M | fish remains |
| (24) | 6/17/2010 | St. Tammany East | 15 | F | empty |
| (25) | 6/17/2010 | St. Tammany East | 15 | F | fish remains |
| (26) | 6/17/2010 | St. Tammany East | 17 | M | fish remains |
| (27) | 6/17/2010 | St. Tammany East | 17 | M | fish remains |
| (28) | 6/17/2010 | St. Tammany East | 12 | M | fish remains |
| (29) | 6/17/2010 | St. Tammany East | 14 | M | fish remains |
| (30) | 6/17/2010 | St. Tammany East | 15 | M | empty |
| (31) | 6/17/2010 | St. Tammany East | 15 | F | fish remains |
| (32) | 6/17/2010 | St. Tammany East | 14 | F | fish remains |
| (33) | 6/17/2010 | St. Tammany East | 12 | F | empty |
| (34) | 6/17/2010 | St. Tammany East | 14.5 | F | fish remains |
| (35) | 6/17/2010 | St. Tammany East | 15 | F | fish remains |
| (36) | 6/17/2010 | St. Tammany East | 13.8 | F | fish remains |
| (37) | 6/17/2010 | St. Tammany East | 16 | M | fish remains |
| (38) | 6/17/2010 | St. Tammany East | 12.7 | F | fish remains |
| (39) | 6/17/2010 | St. Tammany East | 15 | M | fish remains |
| (40) | 6/26/2010 | St. Tammany West | 18.5 | F | fish remains |
| (41) | 6/26/2010 | St. Tammany West | 24.5 | F | empty |
| (42) | 6/26/2010 | St. Tammany West | 22.0 | F | fish remains |
| (43) | 6/26/2010 | St. Tammany West | 14.0 | M | empty |
| (44) | 6/26/2010 | St. Tammany West | 22.5 | F | empty |

Forty-four spotted sea trout were harvested. Of these, 14 had empty stomachs, 30 had fish remains and one had a partially digested penaeid shrimp. Trout size ranged from 12 to 24.5 inches in total length. Unfortunately, the fish remains could not be identified with certainty. Darnell (1958) found that sea trout above 100 mm (4 inches) long fed mainly on fish. The recognizable fishes in large trout stomachs were menhaden, *Brevoortia patronus*, croaker, *Micropogon undualtus*, naked goby, *Gobiosoma bosc*, shad *Dorosoma* spp and mullet, *Mugil cephalus*. These fish prey, with the exception of shad, were found by Whitmore and Poirrier (2006) to be associated with the reef, and that reef balls supported large populations of naked gobies.

Fishing success was strongly related to position on the reef and decreases away from the reef, suggesting that bait fish may seek positions on the reef where they can feed on items passing with currents, and spotted seatrout may take positions related to the distribution of bait fish. This enhances fishing, but may also increase system productivity by decreasing energy spent pursuing prey. Fish may use areas in the reef with reduced currents to conserve energy spent swimming. These fish feed on items brought to them by currents.

**Sea catfish**

The amphipod, *Apocorophium lacustre*, and the mud crab, *Rhithropanopeus harrissi*, were common in the diet of small sea catfish. *Apocorophium lacustre* was abundant in fish 2 and 9. Sea catfish also fed on the hooked mussel, *Ischadium recurvum*. Non-epifaunal items included small infaunal clams, *Rangia cuneata* and *Mulinia lateralis*. *Argulus* is a branchiuran crustacean that is a common external parasite on fish. Its presence in two of the sea catfish, 4 & 8, suggests that they may remove this parasite from other fish by feeding on them. One chironomid larva was found in fish number 11. We did not find chironomids in reef epifaunal samples obtained in 2009, but have found them in epifauna and infauna in previous studies.

Based on published literature, Levine (1980) characterized the sea catfish as a non-specialized, bottom feeder that utilizes a wide variety of benthic and nektonic organisms. Darnell found that sea catfish in the size range of this study feed on benthic microcrustacea and mollusks. Levine (1980) found that the mud crab *R. harrissi* appeared to be selectively sought after. He reported menhaden and shad in the stomachs along with a variety of organisms we found. Overall, he reported mud crabs, amphipods and chironmid larvae to be the most common food items.

Table 8. Sea catfish, *Arius felis*, stomach contents with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs.

| Fish Number | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reef site | All St. Tammany East reef site | | | | | | | | | | | | | |
| Date | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 5/23/2010 | 6/17/2010 | 6/17/2010 |
| Size (inches) | 9 | 9.75 | 9.5 | 10 | 8 | 9.5 | 9.75 | 9.25 | 9.5 | 9 | 8 | 8.5 | 8.5 | 8 |
| *Ischadium recurvum* | X | X | | | | | | | | X | | | | X |
| *Apocorophium lacustre* | | X | | X | | | | | X | | X | X | | |
| *Rhithropanopeus harrissi* | X | X | X | X | X | X | X | | | | X | X | | X |
| Non- epifaunal items | *Rangia cuneata* | | *Rangia cuneata, Mulinia lateralis* | *Argulus* | *Rangia cuneata Mulinia lateralis* | Rangia, Fish remains | Fish remains | Fish, Remains, *Argulus* | | *Rangia, Mulinia* | *Rangia, Mulinia, Chironmi d* | *Rangia, Mulinia,* | *Rangia, Mulinia,* | *Rangia, Mulinia,* |

**Atlantic croaker**

Table 9. Atlantic croaker, *Micropogonias undulatus* with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs

| | (1)<br>St Tamm E<br>5/23/10<br>9 | (2)<br>St Tamm E<br>5/23/10<br>7 | (3)<br>St Tamm E<br>5/23/10<br>8 | (4)<br>St Tamm E<br>5/25/10<br>7 | (5)<br>St Tamm E<br>6/15/10<br>10 | (6)<br>St Tamm E<br>6/15/10<br>9.5 |
|---|---|---|---|---|---|---|
| *Ischadium* | | | | | | X |
| *Rhithropanopeus* | X | X | X | X | X | |
| Non-epifaunal item | *Rangia* | | *Rangia* | | | |
| | (7)<br>St Tamm E<br>6/17/10<br>9.75 | (8)<br>St Tamm E<br>6/17/10<br>9.0 | (9)<br>St Tamm E<br>6/17/10<br>8.0 | (10)<br>St Tamm E<br>6/17/10<br>5.5 | (11)<br>St Tamm E<br>6/17/10<br>10.5 | |
| *Ischadium* | X | | | | X | |
| *Rhithropanopeus* | | X | X | X | X | |

The hooked mussel, *Ischadium recurvum,* and small mud crab, *Rhithropanopeus harrisii*, present in croaker stomachs indicated they feed on reef epifauna. Small *Rangia cuneata* clams, which were also present in croaker number 1 and 3, indicated infaunal feeding.

Levine (1980), based on a summary of prior literature, characterized the croaker as a generalized at or near the bottom feeder. He found this to be also true of Lake Pontchartrain, with mysids, clams, chironomids, amphipods, chironomids, mud crabs, polychaetes and fish in their diet. He found mud crabs in 10% of the fish and less than 2% of their total food. The presence of mud crabs in 9 of the 11 croakers sampled indicates that mud crabs are an abundant and preferred food item in the reef habitat.

**Sheepshead**

Sheepshead had remains of 8 sessile epifaunal invertebrates including the hydroid, *Garvia franciscana*, the bryozoans, *Victorella pavida* and *Conopeum* sp, the false mussel, *Mytilopsis leucophaeta*, the hooked mussel, *Ishadium recurvum*, the barnacle, *Amphibalanus improvisus*, the amphipod *Apocorophium lacustre* and the mud crab, *Rhithropanopeus harrisii* **(Table 10).** However, the submersed aquatic plant, *Ruppia maritima*, the infaunal clams, *Rangia cuneata* and *Mulinia lateralis*, and infaunal amphipod, *Cerapus*, tubes which occur in sand and mud bottoms were also present.

Darnell (1958) characterized the food of sheepshead as crabs, barnacles, mollusks and plant matter. Levine (1980) found Conrads false mussel, *Mytilopsis leucophaeta*, and the clam, *Rangia cuneata*, amphipods and blue crabs to be common and often the digestive tracts were packed with vegetation. This study agrees with these findings but more epifaunal species were found in sheepshead from reef sites than other studies found in fish from trawl samples. Sheepshead are the chief predators of epifaunal invertebrates associated with reef balls.

Table 10. Sheepshead, *Archosargus probatocephalus* with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs.

| Fish Number | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | *(9)* |
|---|---|---|---|---|---|---|---|---|---|
| Reef site | **All St. Tammany East reef site** | | | | | | | | |
| Date | 9/20/2009 | 9/20/2009 | 9/20/2009 | 6/15/2010 | 6/15/2010 | 6/17/2010 | 6/17/2010 | 6/19/2010 | 6/19/2010 |
| Size (inches) | 11.2 | 12 | 22 | 19 | 20 | 8 | 21.5 | 21 | 20 |
| *G. franciscana* | | | | | X | | | | X |
| *Victorella pavida* | X | X | X | | | | | | |
| *Conopeum sp* | X | | | | | X | X | | X |
| *Mytilopsis leucophaeta* | X | | X | | X | | | | |
| *Ischadium recurvum* | X | X | X | X | X | X | X | X | X |
| *Amphibalanus improvisus* | X | | | | | | | | |
| *Corophium lacustre* | X | X | | | | | | | |
| *Congeria leucophaeta* | | | | | | | | | X |
| *Rhithropanusopeus harrisii* | | | | | | X | | | X |
| Non-epifaunal items | | | | *Ruppia* and *Rangia* | *Mulinia, Cerapus* | | *Rangia* | *Rupia, Rangia, Cerapus, Mulinia* | *Rangia, Mulinia* |

**Black drum**

| Table 11. Black Drum, *Pogonias cromis* with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs. | | | | | |
|---|---|---|---|---|---|
| | (1)<br>St Tammany E<br>9/27/09<br>19.3 | (2)<br>St Tammany E<br>9/27/09<br>19 | (3)<br>St Tammany E 9/27/09<br>19 | (4)<br>St Tammany E<br>9/27/09<br>21.5 | (5)<br>St Tammany E<br>6/15/10<br>17 |
| *Victorella pavida* | | X | | | |
| *Conopeum sp* | X | | | X | |
| *Neanthes succinea* | | | X | | |
| *Mytilopsis* | X | | | | |
| *Ischadium recurvum* | X | X | X | X | X |
| *Amphibalanus improvisus* | X | | | | |
| *Rhithropanopeus* | | | | X | |
| Non-epifaunal items | *Rangia,*<br>*C. sapidus* | *Rangia* | *Rangia* | | *Rangia*<br>*Mulinia* |

Seven species of epifaunal invertebrates were found in the black drum stomachs. The hooked mussel, *Ishadium recurvum*, was abundant in the stomachs of all five fish. The other species were the bryozoans, *Victorella pavida* and *Conopeum* sp, the polycheate, *Neanthes succinea*, the false mussel, *Mytilopsis leucophaeta*, the barnacle, *Amphibalanus improvisus* and the mud crab, *Rhithropanopeus harrissi*. The infaunal clams, *Rangia cuneata* and *Mulinia lateralis*, were also present and remains of a blue crab were found in fish number 1.

Darnell (1958) found *Rangia cuneata* and other mollusks and the mud crab, *R. harrisii*, in drum stomachs. Levine (1980) regarded the drum as a semi-specialized bottom feeder. He only found food, *Rangia* and fish remains in 2 of the 11 fish studied. Along with the sheepshead, black drum are important consumers of reef epifauna along with clams and blue crabs.

**Atlantic stingray**

| Table 12. Atlantic stingray, *Dasyatis sabina* with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs | | | | | |
|---|---|---|---|---|---|
| | (1)<br>St Tammany E 6/15/10<br>21.5 | (2)<br>St Tammany E 6/17/10<br>34 | (3)<br>St Tammany E 6/17/10<br>25 | (4)<br>Orleans<br>7/10/10<br>25 | (5)<br>Orleans<br>7/10/10<br>23 |
| *Rhithropanopeus* | X | X | X | | |
| Non-epifaunal items | *Rangia, Mulinia* | *Rangia, Mulinia* | | *Rangia* | Small *Rangia* & mysid shrimp. |

The mud crab, *Rhithropanopeus harrissi,* was present in three of the five stingrays. Since other epifaunal species were absent and sting rays are a demersal species, it is likely they fed on the shell pad forming the floor of the reef and not the reef balls. This is also supported by the presence of the *Rangia* and *Mulinia* clams and mysid shrimp, *Mysisdopis alymara*, in the stomachs.

Neither Darnell nor Levine included the Atlantic stingray in their studies. It is generally regarded as a non-specific bottom feeder that consumes benthic invertebrates such as clams, polychaete worms and crustaceans including amphipods, crabs and shrimp. It is also known to eat small fish.

**Gafftopsail catfish**

| Table 13. Gafftopsail catfish**,** *Bagre marinus* with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs. | | | |
|---|---|---|---|
| (1)<br>St. Tammany East<br>6/17/10<br>14 | (2)<br>Orleans<br>7/10/10<br>21.5 | (3)<br>Orleans<br>7/10/10<br>22 | (4)<br>St. Tammany West<br>6/26/10<br>20 |
| *Callinectes sapidus* | *Callinectes sapidus* | American bird grasshopper, *Schistocerca americana* | *Callinectes sapidus Brevoortia patronus* |

Unlike the sea catfish, no epifaunal invertebrates were found in the stomachs of gafftopsail catfish. Gulf menhaden, *Brevoortia patronus,* were abundant in the stomach of fish number four and menhaden bait balls were observed while fishing at the St. Tammany West reef on 6/26/10 when this fish was caught. Although five spotted seatrout were caught on this trip, no trout had identifiable remains of menhaden in their stomachs. In this analysis, I did not list the blue crab, *Callinectes sapidus,* as a reef species. However, in our previous report, (Whitmore and Poirrier, 2006) we found blue crabs to be abundant in burrows below the reef ball and old exoskeletons indicated they molted in the shelter provided by the reefs. The use of blue crabs and menhaden as food could be regarded as a food link to the reefs. The presence of a grasshopper in a catfish stomach, miles from shore seems difficult to explain, but the American bird grasshopper is a strong flier and moves over long distances in large swarms in response to habitat changes.

Based on a review of the literature, Levine (1980) reported that gafftopsail catfish feed on species of *Callinectes* crabs, penaeid shrimp and fish. Levine found that, in Lake Pontchartrain, fish were common in the diet along with crabs and shrimp. The four fish we studied, with the exception of the grasshopper, agree with Levine (1980).

**Red drum**

Table 14. Red drum, Sciaenops ocellatus with individual fish identification number (#), reef site, the date collected, size as total length in inches, and prey items found in the stomachs

| | (1)<br>St Tammany East<br>9/27/09<br>22 | (2)<br>St. Tammany West<br>6/26/10<br>17.5 |
|---|---|---|
| *Victorella pavida* | X | |
| *Ischadium recurvum* | X | |
| Non-epifaunal item | | *Callinectes sapidus* |

The presence of the sessile bryozan, *Victorella pavida,* and the hooked mussel, *Ischadium recurvum*, indicate that fish number 1 fed on reef epifauna. As mentioned above, although not listed with epifauna, blue crabs, *Callinectes sapidus*, use burrows under the reef balls as habitat and could be considered a food link to the reef for fish number 2.

Darnell (1958) found that red drum fed mainly upon blue crabs and mud crabs, *R. harrisii.* Levine (1980) found that fish, blue and mud crabs were most of the food items and that shrimp and insects were also present.

**Southern flounder**

One 11-inch southern flounder**,** *Paralichthys lethostigma*, with an empty stomach was collected on June 15, 2010. Darnell (1958) and Levine (1980) found that Lake Pontchartrain flounder used mainly, anchovy, *Anchoa mitchilli*, and croaker, *Micropogonias undulatus*, as food.

# Discussion and Conclusion

Overall this study found links between epifaunal invertebrate organisms growing on the reefs and consumption of these organisms by fish. Sheepshead and black drum had the greatest variety of reef ball invertebrates in their stomachs. The sea catfish also utilized reef ball invertebrates. Other species such as the red drum and Atlantic croaker may have also utilized mud crabs, hooked mussels with the shell pad, but these invertebrates are less abundant on the shell pad than on the reef balls. The Atlantic sting ray probably only fed on the shell pad. Epifaunal invertebrates found in fish stomachs were present at all reef sites sampled (**Table 2**).

Links with mobile invertebrates such as the blue crab and bait fish associated with the reef are less clear because these organisms are also present away from the reef. However, blue crabs burrow in the bottom below the reef balls, small reef fish such as gobies and blennies are abundant on reef balls and other bait fish such as menhaden and anchovies form schools in the reef. Utilization of these mobile species as food is supported by fishing success related to position on the reef. Fishing is poor slightly away from the reefs and varies with position on the reef indicating a relationship between current position of bait fish and the position of spotted sea trout and other small fish predators.

**Water Quality**

Salinity was higher in summer and fall 2009 than in spring and summer 2010. A general trend of decreasing salinity with site distance from the saltwater passes was present. Slight salinity stratification was found at the St Tammany East and St Charles sites in 2009, but no detrimental bottom dissolved oxygen levels were present. The lowest dissolved oxygen value in ppm was 5.3 from the St. Charles site.

**Epifaunal Invertebrates**

An abundant and diverse epifaunal community was found on the reefs. The closure of the MRGO and lack of bottom water hypoxia appears to have improved epifaunal growth. Rapid growth of hooked mussels to a relatively large size since the 2009 reefs were established is surprising. Although H3 has a better developed epifaunal community than found in previous studies (Whitmore and Poirrier, 2006), the community may not have recovered from poor water quality in the past. Epifaunal abundance may be less than bridge pilings because of more predation and turnover of epifauna due to the design of reef balls.

**Fish sampling methods**

Simple rank ordering of fish abundance revealed major differences among roving diver, gill net, and hook and line sampling methods. Results provide insight on sampling errors to be expected with the different sampling methods employed and problems in comparing data derived from the different methods. Overall, these data support the presence of a diverse fish assemblage present at the reef sites, and the need for a combination of sampling methods to assess fish populations.

**Stomach content analysis**

Sheepshead and black drum had the greatest variety of reef ball epifaunal invertebrates in their stomachs. The sea catfish also utilized reef ball invertebrates. Other species such as the red drum and Atlantic croaker may have also utilized mud crabs and hooked mussels associated with the shell pad, but these invertebrates are less abundant on the shell pad than on the reef balls. Feeding links with mobile invertebrates and bait fish associated with the reef are less clear. Utilization of bait fish associated with the reef is supported by the success of hook and line fishing being related to position on the reef. Fishing is poor slightly away from the reefs and varies with position on the reef indicating a relationship between the position of bait fish in currents and the position of predaceous fish.

As in past studies of reefs established in 2003, we found that the additional Lake Pontchartrain reefs supported abundant and diverse invertebrate and fish populations and reefs improved fishing.

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## Acknowledgments

This study was funded by the Lake Pontchartrain Foundation. John Lopez provided administrative support, some epifaunal specimens and encouragement. Renee Caillouet provided expert navigation, boatmanship, collected most of the fish and recorded water quality data.

# Appendix

**Master List of organisms associated with Lake Pontchartrain Artificial Reefs (from Whitmore & Poirrier, 2006; Poirrier 2010)**

## Invertebrates

Phylum Porifera (sponges)
- *Spongilla alba*

Phylum Cnidaria
- Class Hydrozoa (hydroids)
  - *Garveia franciscana*

Phylum Platyhelminthes (flatworms)
- Class Turbellaria
  - *Stylochus ellipticus*
  - *Pentacoelom sp.*

Phylum Nematoda (round worms)

Phylum Ectoprocta (bryozoa)
- *Victorella pavida*
- *Conopeum sp*

Phylum Annelida
- Class Polychaeta
  - *Neanthes succinea*
  - *Polydora websteri*
  - *Baccardia hamata*
  - *Streblospeio benedicti*

Phylum Mollusca
- Class Bivavlia (mussels)
  - *Mytilopsis leucophaeta,* Conrad's false mussel
  - *Ischadium recurvum,* hooked mussel

Phylum Arthropoda
- Class Crustacea
  - Subclass Malacostraca
    - Order Amphipoda
      - *Apocorophium lacustre*
      - *Melita sp*
      - *Gitanopsis sp*
      - *Grandidierella bonnieroides*
    - Order Decapoda
      - *Rhithropanopeus harrisii* (mud crab)
      - *Callinectes sapidus* (blue crab)
      - Farfantepenaeus azetecus (brown shrimp)
  - Subclass Cirripedia (barnacles)
    - *Amphibalanus subalbidus*
    - *Amphibalanus improvisus*

## Fish

| | |
|---|---|
| American eel | *Angilla rostrata* |
| Atlantic croaker | *Micropogonias undulatus* |
| Atlantic spadefish | *Chaetodipterus faber* |
| Atlantic stingray | *Dasyatis sabina* |
| bay anchovy | *Anchoa mitchilli* |
| black drum | *Pogonias cromis* |
| blue catfish | *Ictalurus furcatus* |
| bull shark | *Carcharhinus leucas* |
| crevalle jack | *Caranx hippos* |
| freckled blenny | *Hypsoblennius ionthas* |
| freshwater drum | *Aplodinotus grunniens* |
| gafftopsail catfish | *Bagre marinus* |
| Gulf toadfish | *Opsanus beta* |
| Gulf menhaden | *Brevoortia patronus* |
| gray snapper | *Lutjanus griseus* |
| inland silversides | *Menidia beryllina* |
| naked goby | *Gobiosoma bosc* |
| pinfish | *Lagodon rhomboides* |
| red drum | *Sciaenops ocellatus* |
| sand seatrout | *Cynoscion arenarius* |
| sea catfish | *Arius felis* |
| sheepshead | *Archosargus probatocephalus* |
| skipjack herring | *Alosa chrysochloris* |
| skilletfish | *Gobiesox strumosus* |
| southern flounder | *Paralichthys lethostigma* |
| spot | *Leiostomus. xanthurus* |
| spotted seatrout | *Cynoscion nebulosus* |
| striped anchovy | *Anchoa hepsetus* |
| striped mullet | *Mugil cephalus* |