

# Loxahatchee River Oyster Restoration & Monitoring Project Final Report



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The Nature Conservancy & NOAA  
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The Nature Conservancy  
&  
The Loxahatchee River Preservation Initiative with the South Florida Water Management District

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## **Executive Summary**

The Loxahatchee River District and an amazing group of partners and volunteers worked together to restore oyster habitat and to conduct insightful research and monitoring on the new habitat in the Loxahatchee River Estuary. The results of this project showcase the importance of oyster habitat in the Loxahatchee River not only for the water filtering capability of oysters, but perhaps more importantly, the documentation of extensive fauna associated with the new habitat. Community involvement was an integral component of the project, beginning with homeowners who granted permission to restore habitat beneath their docks. Volunteers assembled mesh bags filled with oyster and fossilized shells and concrete Reef Balls™ and placed them under the docks to provide an optimal substrate for settlement of larvae from naturally occurring oysters in the river. Research and monitoring before and after construction of habitat provided new details on utilization of this habitat. Results from this research and monitoring indicate peak oyster recruitment in the spring and fall months, impressive oyster settlement and growth on the newly restored oyster reefs, substantial increases the abundance, diversity and composition of oyster related fauna, a dramatic increase in residency of fish (grey snapper), all of which show the critical value of restored oyster reefs in the Loxahatchee River. The public has learned about this project and the findings through a host of public outreach efforts and media coverage. While some research and monitoring elements of this project will continue, this final report presents the work completed under the terms of the contracts.

## **Project Partners**

The Nature Conservancy  
Loxahatchee River District  
Florida International University  
Loxahatchee River Preservation Initiative  
South Florida Water Management District  
Martin County Artificial Reef Program  
NOAA Community-Based Restoration Program

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## Background

Scientists acknowledge the collapse of estuarine fisheries as one of the most critical environmental crises worldwide. A major cause of this collapse is widespread alteration and degradation of essential fish habitats. Some examples of this are the loss of oyster reefs and the alteration of coastal hydrology. Within estuarine ecosystems, structurally-complex habitat types such as oyster reefs are assumed to be critical for supporting fishery production. These habitats are purported to be “nurseries” for juvenile fishes, i.e., providing abundant food and/or protection from predators. As juveniles mature into adults they move to other habitats within the estuary and near shore marine environment. Proper conservation and management of nursery habitats are essential for the support of fishery production within estuaries.

Because of the extent to which man has altered coastal habitats, restoration is becoming one of the most important tools in the management and conservation of coastal resources. Foremost among coastal restoration initiatives, especially in South Florida, are efforts to restore populations of the Eastern oyster (*Crassostrea virginica*). These oyster restoration projects are carried out in a number of different ways, with the primary goal of increasing the available area for juvenile oyster settlement, growth and eventual reef development. As with any restoration project, it is critically important to develop extensive post-project monitoring protocols.

The Loxahatchee River is located near Jupiter, Florida. The Loxahatchee River District (LRD) is a special district of the State of Florida created to preserve and protect the Loxahatchee River. In addition to serving as the regional wastewater utility, LRD is greatly involved in research and monitoring throughout the Loxahatchee River watershed and estuary. In 2003, LRD began monitoring Loxahatchee River oyster populations. LRD scientist's field mapped the distribution of oysters throughout the Northwest and Southwest Forks of the Loxahatchee River using high accuracy GPS (LRD, 2003). In addition, they examined the percentage of live oysters at 4 sites in the Northwest (NW) Fork and 4 sites in the Southwest (SW) Fork. LRD repeated the survival monitoring in December of 2004 (LRD, 2004). In May of 2007, the LRD began monitoring oyster recruitment in two areas of the NW Fork that represented the upper and lower salinity limits that appeared optimal for oyster recruitment and survivability. LRD expanded the recruitment monitoring in December 2008 with the addition of two more sites in the SW Fork. All recruitment monitoring continues today. In the summer of 2008, LRD scientists mapped the oyster distribution of in the NW Fork and SW Fork and evaluated the health at each oyster reef (LRD, 2008).

LRD staff, Dr. Craig Layman, and his team of graduate students from Florida International University (FIU) developed a series of monitoring and research studies to evaluate the role of restored oyster reefs as critical habitat for the diversity of oyster-associated fauna. LRD's oyster monitoring work focused on oyster settlement and growth. Dr. Layman's team focused on the importance of oyster reefs for providing structurally complex habitat that other organisms utilize (e.g., small fishes, crabs, and shrimp). These fauna ultimately provide an important resource that numerous ecologically and economically important fishes in South Florida (e.g., gray snapper, snook) utilize. These data provide additional information as to how oyster restoration ultimately improves the health and function of the Loxahatchee River Estuary, as well as other estuaries in Florida.

## Project Description

The area under some docks in the Loxahatchee River Estuary have historically been used in an informal manner to create a dimensional habitat by leaving old dock remnants in place, and in some cases adding a variety of debris. In 2008, LRD optimized the concept of this habitat creation, specifically for oyster recruitment and attracting the associated fauna, by placing bags of oyster and fossilized shell and concrete artificial reef modules, or Reef Balls™, beneath residential docks in the Northwest Fork of the Loxahatchee River. Restoring the areas under docks eliminated the concerns expressed by the permitting agencies for maintaining waterway navigation to boaters

We targeted a section of the NW Fork of the Loxahatchee River for restoration because extensive water quality data indicated preferred conditions for oysters. In addition, efforts presently underway by regional water managers to restore historical river flows during the dry season should further improve water quality conditions for oysters in this segment of the river (SFWMD, 2006). While this segment of the river presently contains some naturally occurring oyster reefs, oyster maps suggest the area is substrate limited for additional oyster reef formation. Extensive water quality analysis by LRD indicate preferred conditions for oysters, but the river floor of sand and muck substrates may hinder the establishment of oyster reef. Extensive dredge and fill activities in the 1960's and 1970's for waterfront development may have eliminated historical oyster reefs leaving behind sand and muck substrate where new oysters simply could not re-establish. This oyster restoration project was developed to provide substrate for naturally occurring oyster larvae to settle resulting in functional oyster reefs.

One of the first tasks was to find property owners willing to participate in the project. Andrea Graves of The Nature Conservancy's (TNC) Blowing Rocks Preserve led the task of engaging and involving property owners to secure homeowner permission for the use of docks. After sending letters to area homeowners, 24 expressed interest in the project. LRD scientists then conducted site surveys of each dock. Fifteen (15) riverfront homes did not have suitable conditions (e.g. they already had live oyster below their dock), were not within the preferred area, or decided not to participate in the project. LRD then secured permits from the Florida Department of Environmental Protection and the US Army Corps of Engineers.

The community rallied in support of this project with contributions of both time and effort. Volunteers and interns from TNC and the LRD WildPine Ecological Laboratory collected oyster shell from area restaurants. Volunteers also worked with Martin County and TNC to create concrete reef modules (Reef Balls™) that we deployed in the deeper areas under docks to provide additional oyster habitat and vertical relief. The Public Outreach & Education Section, later in this report, provides additional details on the various volunteer groups involved in the project.

To ensure shell used for the restoration did not scatter beyond the limits of the dock, volunteers placed the shell into flexible plastic diamond mesh bags. This commonly used construction approach keeps the shell material together while new oyster recruitment eventually encases the plastic mesh material. We created oyster bags using flexible ¾ inch plastic diamond mesh material (Naltex Duronet, Item 1142, by DelStar Technologies Inc.). The material comes in a continuous roll "sleeve". We the material to approximate 36 inch lengths and knotted one end. To construct the shell bag we placed the mesh sleeve of over a 10 inch PVC pipe, filled the pipe with shell, removed the pipe from the mesh bag, and then tied a simple knot to secure the remaining open end. Volunteers created more than 1,300 shell bags that were used to restore 9 dock sites.

Our original plan was to use fresh oyster shells donated from area restaurants for this project. However, we found that the scale of the project necessitated additional shell material, beyond what we could obtain from restaurants. Following recommendations from other groups conducting oyster restoration work in Florida, we used large fossilized shell provided by SMR Aggregates in Sarasota, Florida. Following the assembly of shell bags, we loaded and transported bags to restoration sites using the WildPine Lab’s 22 Ft aluminum work/research boat, “RiverKeeper”, where volunteers worked with LRD staff to carefully place oyster bags beneath the docks. We placed shell filled bags in one layer in tight proximity directly under the docks as shown in Figure 1. In addition, we placed concrete Reef Balls™ (Lo-Pro size, 2 Ft wide x 1.5 Ft high) at the deepest portions of some docks to provide additional vertical relief and habitat.

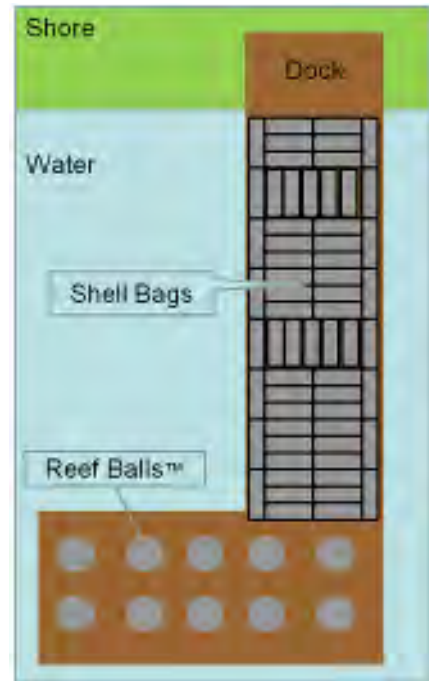


Figure 1. Plan view of typical restoration site.

Tables 1 and 2 provide a summary of the restoration dates, locations and materials used. Three of the sites consist of only oyster shell and four sites only fossilized shell. We used a combination of both oyster and fossilized shells on sites 4 and 7. This variety of materials and deployments provided an opportunity to evaluate the effectiveness of the different materials. Figure 2 shows the locations of the restoration sites in the NW Fork of the Loxahatchee River. Fortunately we were able to find willing homeowners throughout the area we targeted for restoration. This variety of restoration sites along the salinity gradient in this area will provide insightful monitoring and research for water managers working to restore river flows.

Table 1. Restoration site locations.

Site #	Installation Date	Homeowner	Address	Northing*	Easting*	Latitude**	Longitude**
1	10/10/2008	Sabin	255 River Dr., Tequesta FL 33469	958,287	942,842	26 58.038	-80 07.192
2	11/20/2008	Hulligan	19759 Loxahatchee River Rd., Jupiter FL 33458	958,007	940,404	26 57.995	-80 07.641
3	11/24/2008	Walker	315 River Dr., Tequesta FL 33469	959,225	942,053	26 58.194	-80 07.336
4	3/25/2009	Pase	19463 Camp Lane, Jupiter FL 33458	956,921	941,486	26 57.814	-80 07.443
5	3/26/2009	Riccardi	271 River Dr., Tequesta FL 33469	958,650	942,716	26 58.098	-80 07.215
6	3/26/2009	Gianos	275 River Dr., Tequesta FL 33469	958,693	942,694	26 58.105	-80 07.219
7	6/5/2009	Malinowski	9185 SE Cove Pt., Jupiter FL 33458	960,554	939,546	26 58.416	-80 07.796
8	8/17/2009	Camp	183 River Dr., Tequesta FL 33469	956,745	943,521	26 57.783	-80 07.069
9	8/17/2009	Isom	187 River Dr., Tequesta FL 33469	956,800	943,517	26 57.792	-80 07.070
* NAD83, Florida East, Ft							
** Degrees, Decimal Minutes							

Table 2. Summary of materials used for restoration.

Site #	Installation Date	# Shell Bags	Estimated Area* (sq ft)	Shell Type	# Reef Balls
1	10/10/2008	150	395	Oyster	15
2	11/20/2008	225	592	Oyster	21
3	11/24/2008	65	171	Oyster	10
4	3/25/2009	115	302	Oyster & Fossilized Shell	10
5	3/26/2009	150	395	Fossilized Shell	10
6	3/26/2009	150	395	Fossilized Shell	10
7	6/5/2009	125	329	Oyster & Fossilized Shell	0
8	8/17/2009	175	460	Fossilized Shell	0
9	8/17/2009	175	460	Fossilized Shell	0
<b>TOTALS</b>		<b>1330</b>	<b>3498</b>		<b>76</b>

\* Based on estimated area of each shell bag 2.63 sq ft (each 12-14 in Wide by 24-30 in Long)

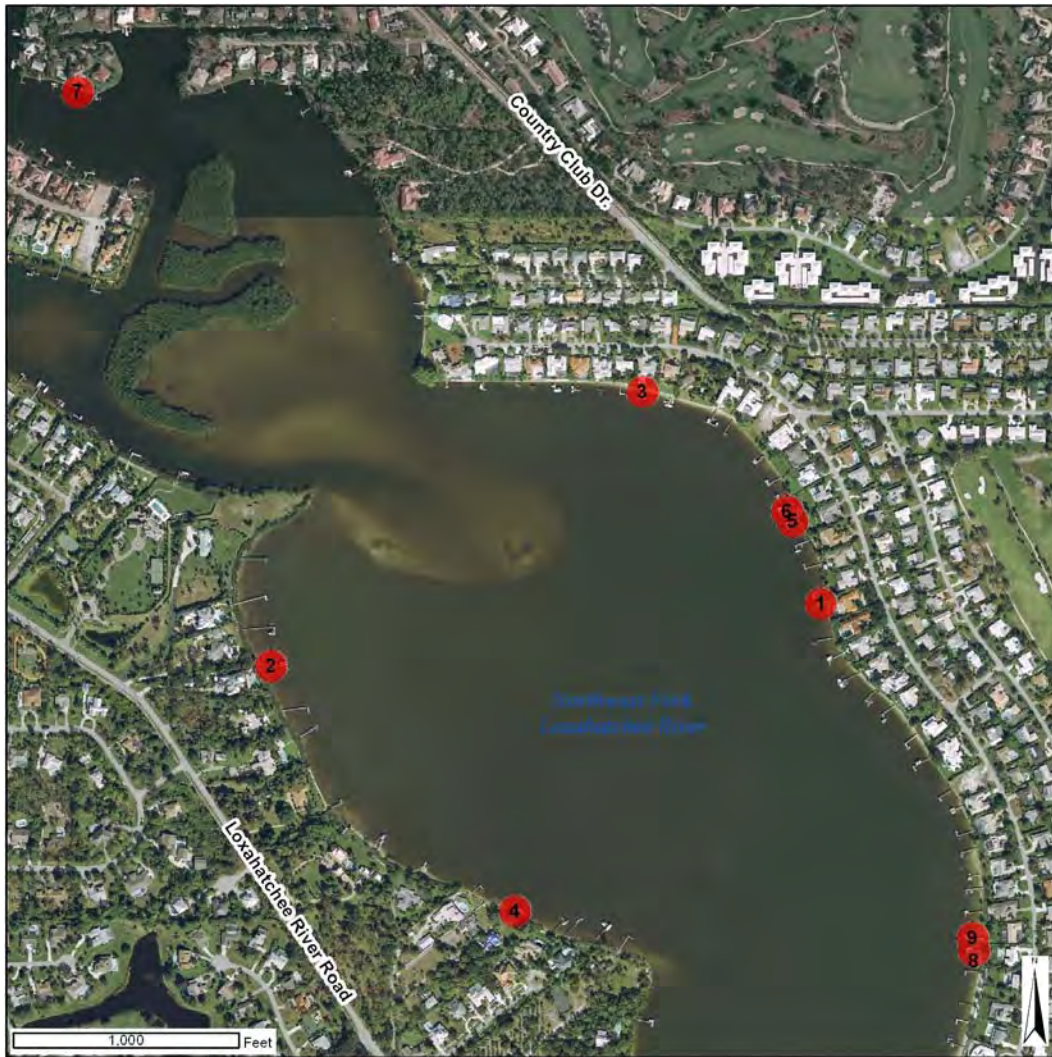


Figure 2. Locations of restoration sites in the Northwest Fork of the Loxahatchee River.



## Monitoring

An integral component of this project was the monitoring and research on oysters and associated habitat. LRD and their partners from Dr. Craig Layman's laboratory at FIU sought to collect data to help substantially expand our understanding of the function of oysters and oyster habitat. The objectives of the research and monitoring under this project were to:

1. Evaluate the oyster recruitment patterns in the Loxahatchee River.
2. Evaluate oyster recruitment at the restoration sites
3. Develop a baseline data set of oyster reef-associated fauna that can be used to place the success of restoration projects in context.
4. Explore how oyster reef restorations affect the ecology of the shoreline from both community- and population perspectives.
5. Compare the suitability of loose oyster shell vs. shell bags as habitat for oyster-associated organisms.
6. Develop trophic (i.e., food web) models of the oyster reef habitat.

The findings from each of these areas helps to provide a better understanding of oysters and associated fauna that can foster better management decisions, further appreciate the value of the habitat, and, perhaps, lead to additional restoration work not only in the Loxahatchee River, but throughout Florida and beyond.

The following sections explain the work and results obtained in support of each objective.

### 1. Evaluate oyster recruitment patterns in the Loxahatchee River.

To assess oyster recruitment in the river, we utilized "oyster T's". The oyster T's allowed us to evaluate the numbers of larval oysters, known as spat, which settled onto the oyster shell attached to the oyster T. The "arrays", or sampling unit, consists of a string of 12 clean and pierced oyster shells were strung together with plastic line so the inner shells are facing down were hung from a T made of PVC pipe. Each oyster-T consisting of 2 sets of shells, or arrays, measured approximately 60 cm high and 30 cm wide as shown in Figure 3. We hammered each oyster T into the river bottom so that the shells were suspended in the water column with the lower shell 20 cm above the substrate. We deployed the two sets of oyster-T's, for a total of 4 replicate sampling units, at each upstream and downstream site in both the NW Fork beginning May 2007 and in the SW Fork beginning October 2008.

Following a one month deployment in the river, we recovered the arrays, brought the shells back to the laboratory, and then evaluated each shell for oyster spat recruitment under a dissecting microscope. To eliminate variations in oyster recruitment on the top and bottom shell, we excluded the top and bottom shells on each array from analysis. The count of settled spat on the underside of the 10 remaining shells (40 total shells per site) provided an assessment of oyster recruitment during the deployment period.



Figure 3. "Oyster T" showing two hanging arrays of shell used to monitor oyster recruitment.



Figure 4. Locations of the up- and downstream “Oyster-T” recruitment sampling stations (yellow dots) in the NW and SW Forks of the Loxahatchee River.

The monthly oyster spat monitoring showed variable settlement patterns as indicated in Figures 5 and 6 for the NW and SW Forks of the Loxahatchee River. In general, these data showed oyster recruitment occurred every month that we sampled except February. The highest oyster spat settlement occurred in September 2007 at the downstream site with an average of more than 20 oyster spat per shell. The monitoring data from the SW Fork monitoring was also variable with the highest recruitment occurring in October 2008, January 2009, April 2009, August 2009 and September 2009.

The oyster spat recruitment counts were significantly lower in the SW Fork, with typically less than half the spat settlement measured in NW Fork sampling sites. The lower oyster recruitment may be due to less oyster seed source from the fewer naturally occurring oysters or more variable conditions than those found in the NW Fork. For example, salinities in the SW Fork are consistently higher (between 25-35 ppt) than in the NW Fork during the dry season (winter months). In contrast, the SW Fork can experience extreme freshwater influences during the summer wet season as a result of substantial freshwater discharges into the SW Fork from the S-46 water control structure draining water from the C-18 canal.

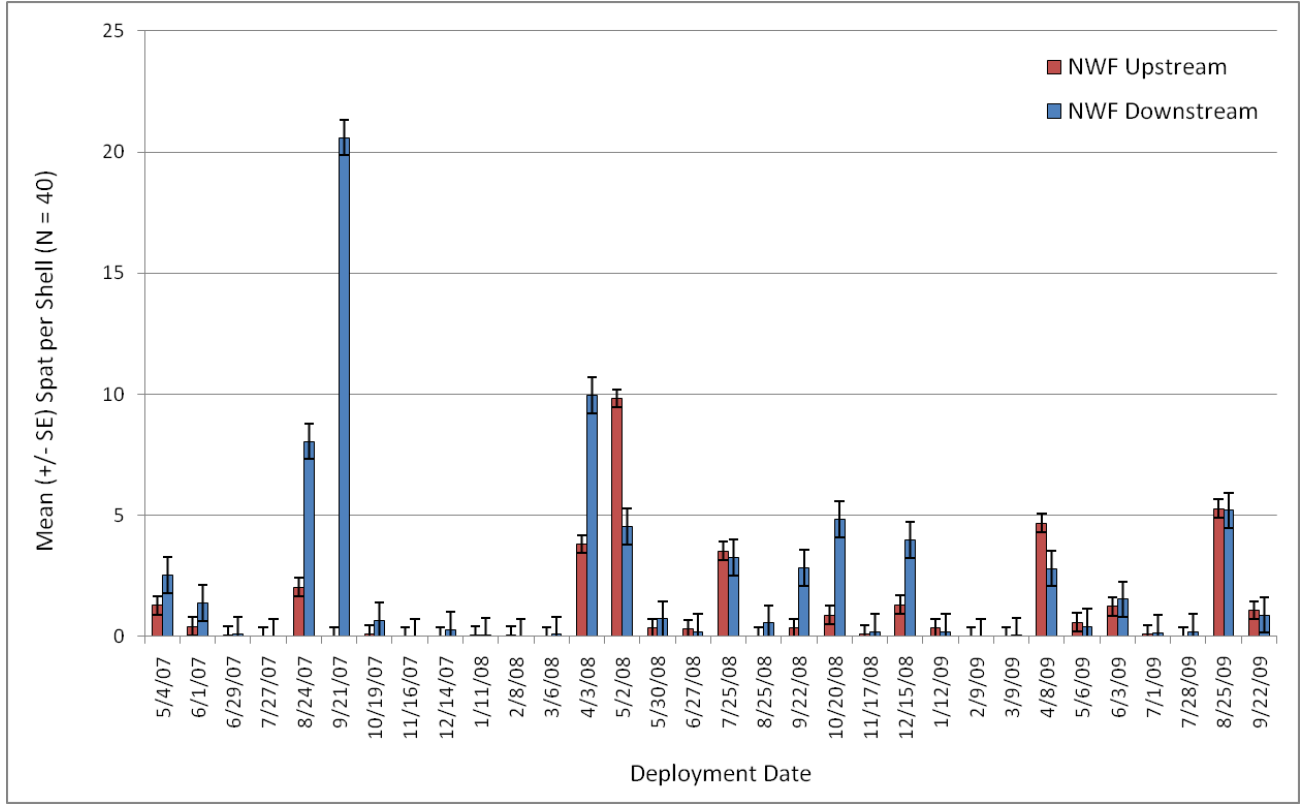


Figure 5. Plot of oyster spat recruitment using "Oyster T's" in the Northwest Fork of the Loxahatchee River.

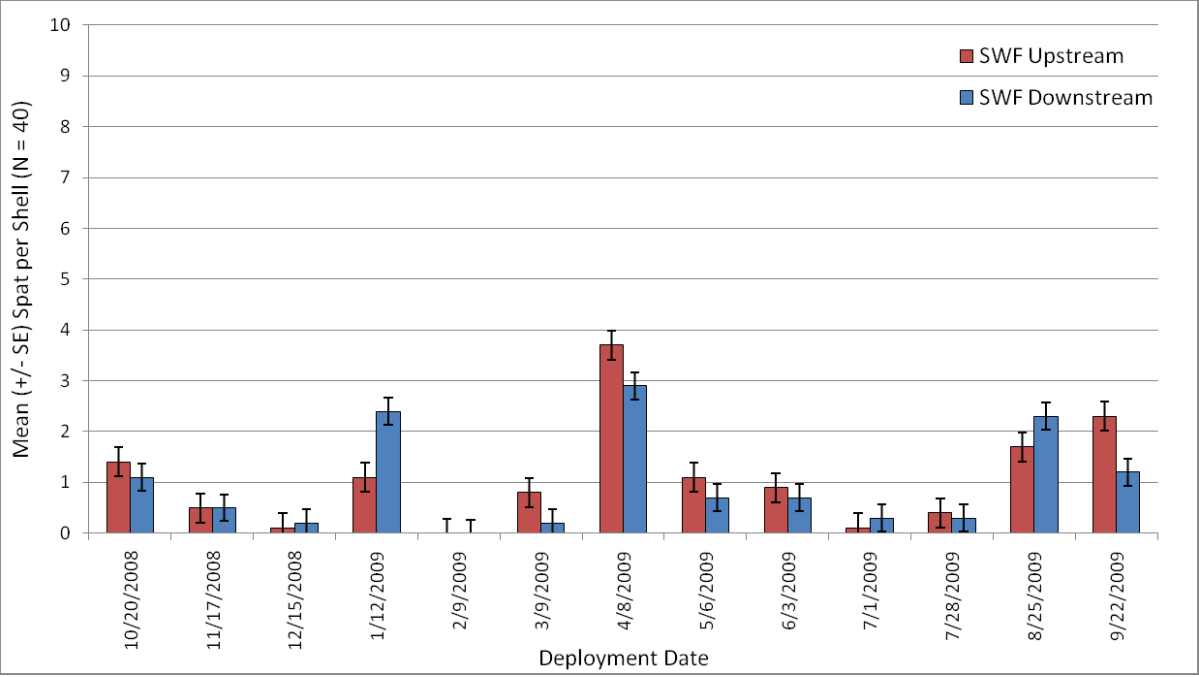


Figure 6. Plot of oyster spat recruitment using "Oyster T's" in the Southwest Fork of the Loxahatchee River.

## 2. Evaluate recruitment at the restoration sites.

In order to evaluate recruitment at each of the restoration sites LRD scientists collected and evaluated new oyster settlement from shells collected from the shell bags used in the restoration. Sampling began in July 2009 with the expectation of evaluating the spring 2009 as the first significant oyster recruitment event since the restoration work began in October 2008. We randomly selected three oyster bags from each restoration site to evaluate recruitment by assessing the numbers of settled oysters, or spat on shells removed from the oyster bag used in the restoration. To evaluate oyster recruitment across the depth gradient at each restoration site, we collected one bag each from the shallow, middle and deep sections of each restored dock. From each bag we randomly selected 10 shells (fossilized or oyster) from each bag and each new oyster spat counted, measured, and determined to be alive or dead.

The initial assessment of the seven restoration sites (deployed prior to sampling) indicates excellent oyster recruitment, growth, and survivorship for all sites and restoration material types (fossilized vs. oyster shell). Figure 7 shows several new oysters on a typical shell used in the restoration. Each shell showed an average of 4 to 10 new spat per shell, with ranges of zero to more than 60 new spat per shell (Figure 8).



Figure 7. Newly settled oysters on a shell used for restoration.

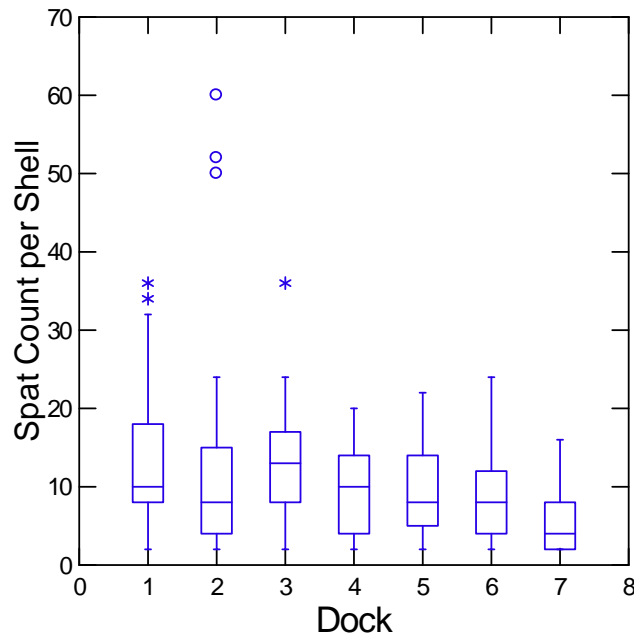


Figure 8. Box plot of the count of oyster spat per shell at each restoration site.

While other restoration projects have shown success using fossilized shell for oyster restoration projects throughout Florida, we were eager to compare the results of oyster recruitment on both oyster and fossilized shell in the same water body. Figure 9 shows similar oyster spat settlement on both fossilized shell and oyster shell during this initial assessment. Several oyster shells showed very high spat counts. We plan to continue monitoring the recruitment and success of each substrate type.

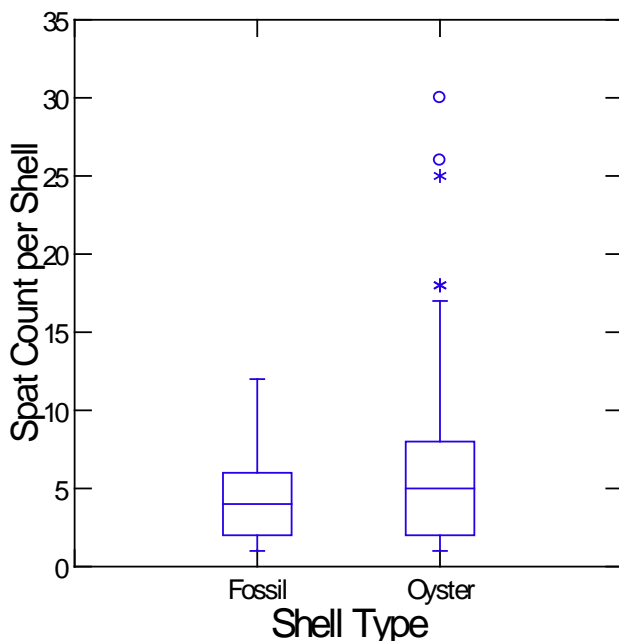


Figure 9. Box plot of oyster spat counts by shell type used for restoration.

Prior to the first restoration deployment in October 2008, our oyster recruitment monitoring data from 2007 (described in Section 1) suggested that we might expect an increase in oyster spawning in August or September. However, delays with permitting prevented restoration to after the anticipated fall spawning event. We assumed restoration deployments in October and November 2008 missed the expected fall recruitment event. Because the oyster shells used for restoration would accumulate biofouling throughout the winter months, prior to the anticipated spring recruitment, we were concerned that the fouled shell might not be as suitable for new oyster settlement. However, our data show consistent oyster recruitment at all restoration sites regardless of date of installation as shown in Figures 10 and 11 (left pane). We are uncertain if recruitment occurred throughout the winter 2008/2009, or if the peak recruitment in the spring 2009 overcame the biofouling.

Current velocities, light penetration and other parameters likely vary with water depth at the restoration sites. Because variation in these parameters has the potential to affect the success of oyster recruitment across the depth gradient, we evaluated the oyster recruitment data across the depth gradient by sampling location the shallow, mid, and deep portions of all restoration sites. While the true elevation may vary by restoration site, water depths across the gradient were generally similar with the shallow areas less than 1 Ft deep, middle areas 1 to 2.5 Ft deep, and deep areas 2.5 to 5 Ft deep. Both oyster spat counts and sizes indicate no noticeable differences as shown in the right panes of Figures 10

and 11. Figure 12 illustrates the generally consistent proportional recruitment of new oyster spat at each depth and each restoration site.

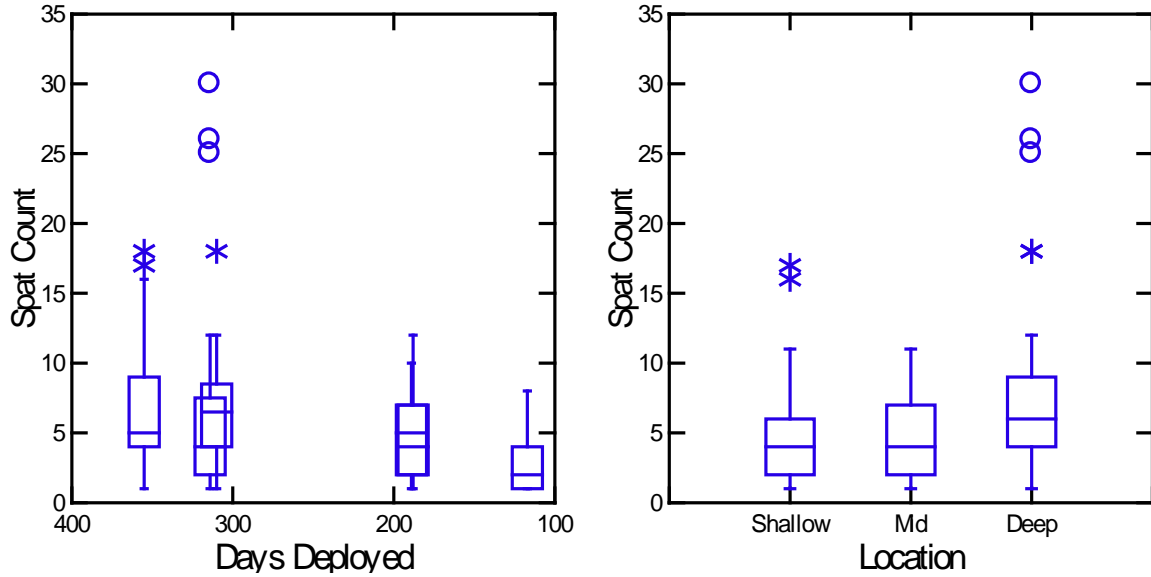


Figure 10. Oyster spat counts by number of days deployed (left pane) and by relative water depth (right pane).

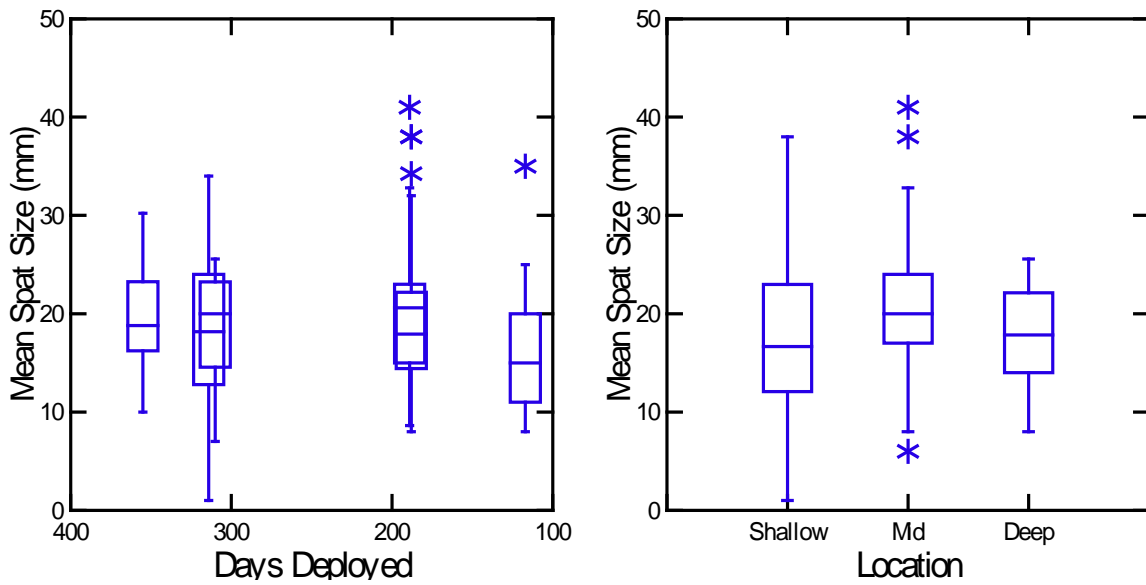


Figure 11. Oyster spat size by days deployed (left pane) and relative water depth (right pane).

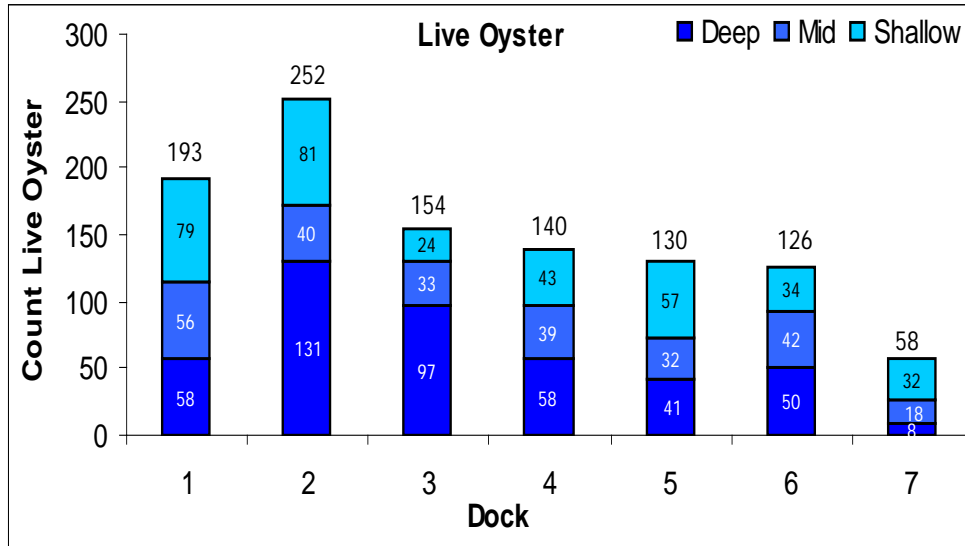


Figure 12. Proportion of total oyster spat counts on 10 shells at each restoration site by depth.

As of the July 2009 sampling event, all of the restoration sites show impressive survivorship with the proportion of alive to dead oysters for all docks greater than 95% as shown in Figure 13. Sampling of the established natural oyster reef in the summer 2008 showed the proportion of live oysters all greater than 80% (LRD, 2008).



Figure 13. Pie charts showing the proportion of live (green) to dead (red) shell at each restoration site. Also shown are the natural reef areas mapped in 2008.

We intend to continue monitoring the oyster recruitment and survivorship at these restoration sites. In an effort to track the progress of these same shells sampled over time, and to avoid disturbing

the other shells bags at each restoration site, we will sample the same collection of shells as those sampled in July 2009. We have placed the previously sampled shells back into smaller oyster bags and reattached the bag to the restoration site. Even though the orientation and exposure of the shells will change, we can now evaluate the same set of shells and track the progress of the restoration without disturbing more shell bags at the restoration site.

LRD recently implemented an additional monitoring program to evaluate oyster recruitment at each of the restoration sites. Working with a student from Jupiter High Schools' Jupiter Environmental Research and Field Studies Academy, JRFSa, we have deployed additional oyster T's at each of the restoration sites to evaluate oyster recruitment. The data from the monthly sampled oyster T's will provide additional data to understand the intensity of oyster settlement at each site and provide a benchmark for recruitment on bagged oyster shell beneath the dock. Furthermore, the data from these additional oyster T's will provide insight into oyster recruitment throughout that portion of the Loxahatchee River, compared to the single upstream and downstream stations presently monitored and explained in Section 1 of this report.

### **3. Develop a baseline data set of oyster reef-associated fauna that can be used to place the success of restoration projects in context.**

"Benthic tray traps" are a common approach to sample demersal fishes and invertebrates that utilize oyster reefs as habitat. These sampling units are plastic bakery trays (50 x 58 x 10cm) with fiberglass sheet screening attached securely to the tray bottom with zip ties. Prior to deployment, 5 gallons of oyster shells were dried in ambient air conditions to ensure all epifauna was dead. We then placed the shells onto the bottom of each tray so that the entire tray bottom is covered. At each field site, an area on the bottom substrate that was equal to the dimensions of the tray trap was excavated and the trap was then placed into the excavated opening such that organisms can move laterally and seamlessly across the natural benthos and into a tray trap (Figure 14). Traps were left in place for 60 days and then collected. To collect organisms, the tray was lifted vertically, allowing water to drain through the fiberglass screening and the tray bottom, trapping the benthic organisms and small demersal fishes within the tray and among the oyster shells. All fishes and invertebrates were collected by hand, kept on ice in the field, and returned to the laboratory for identification and processing. Our focus was on assessing less motile (e.g., crabs) and motile (e.g., blennies) organisms that live among live and dead oyster shell.



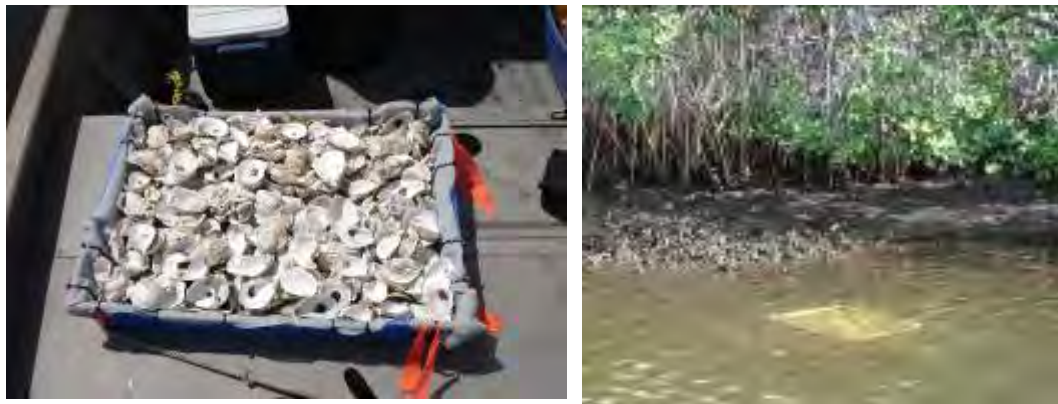


Figure 14. A sampling tray filled with oyster shell (left) and a deployed tray located at one of the river's natural oyster reefs (right).

We have conducted the sampling at 3 fixed locations every second month since March 2007 across approximately two river miles: Boy Scout Camp (Figure 15), Oyster Island and 7th Dock. This sampling design allows for both spatial and temporal pattern analysis. The "7th" dock site was added in January 2008.



Figure 15. Sampling sites for oyster reef-associated fauna monitoring. Numbers indicate long-term monitoring sites (1 = Boy Scout Camp, 2 = Oyster Island, 3 = 7th Dock). Letters indicate sites used for assessment of oyster restoration projects (A = Long Pine, B = Don's, C = Sabin's).

Since May 2007, we have identified a total of 16 invertebrate species and 15 fish species in the Loxahatchee River oyster habitat (Table 3). The most obvious pattern that emerged was that total organism biomass peaked at the end of the dry season (Figure 16). The lowest biomass is typically

found in November, which is the end of the wet season. This suggests that reduced salinities may be affecting the densities of certain oyster-associated fauna, perhaps through mortality or a behavioral response in which the organisms migrate downstream. Six taxonomic groupings accounted for >95% of biomass across all sampling dates: *Panopeus* mud crabs, *Eurypanopeus* mud crabs, crested goby (*Lophogobius cyprinoides*), frillfin goby (*Bathygobius soporator*), green porcelain crabs (*Petrolisthes armatus*), and Alpheid snapping shrimp. Two of these organisms seem especially sensitive to salinity changes, the green porcelain crab and the Frillfin Goby. The most downstream site, "7th Dock", was characterized by the least temporal variation. This pattern also suggests that salinity may drive abundance patterns, as we might expect the least freshwater influence at the most downstream site.

Table 3. List of all species captured in benthic tray traps since May 2007 in order of relative abundance.

Invertebrates	
<i>Panopeus herbstii</i>	black-fingered mud crab
<i>Eurypanopeus depressus</i>	depressed mud crab
<i>Neopanope sayi</i>	Say's mud crab
<i>Petrolisthes armatus</i>	green porcelain crab
<i>Callinectes sapidus</i>	blue crab
<i>Pachygrapsus transversus</i>	mottled shore crab
<i>Libinia spp.</i>	spider crab
<i>Portunus spp.</i>	swimming crab
<i>Alpheus spp.</i>	snapping shrimp
<i>Synalpheus brevicarpus</i>	short-clawed sponge shrimp
<i>Palaemonetes spp.</i>	grass shrimp
<i>Penaeus spp.</i>	penaeid shrimp
<i>Upogebia sp.</i>	mud shrimp
<i>Ophionereis sp.</i>	brittle star
<i>Tagelus spp.</i>	razor clam
<i>Nassarius sp.</i>	nassa snail
Fishes	
<i>Lophogobius cyprinoides</i>	crested goby
<i>Bathygobius soporator</i>	frillfin goby
<i>Gobiosoma bosc</i>	naked goby
<i>Lutjanus griseus</i>	gray snapper
<i>Lupinoblennius nicholsi</i>	highfin blenny
<i>Malacoctenus macropus</i>	rosy blenny
<i>Hypleurochilus aequipinnis</i>	oyster blenny
<i>Parablennius marmoreus</i>	seaweed blenny
<i>Astrapogon alutus</i>	bronze cardinalfish
<i>Apogon binotatus</i>	barred cardinalfish
<i>Haemulon sp.</i>	grunt
<i>Archosargus probatocephalus</i>	sheepshead
<i>Eucinostomus sp.</i>	mojarra
<i>Erotelis smaragdus</i>	emerald sleeper
<i>Epinephelus itajara</i>	goliath grouper

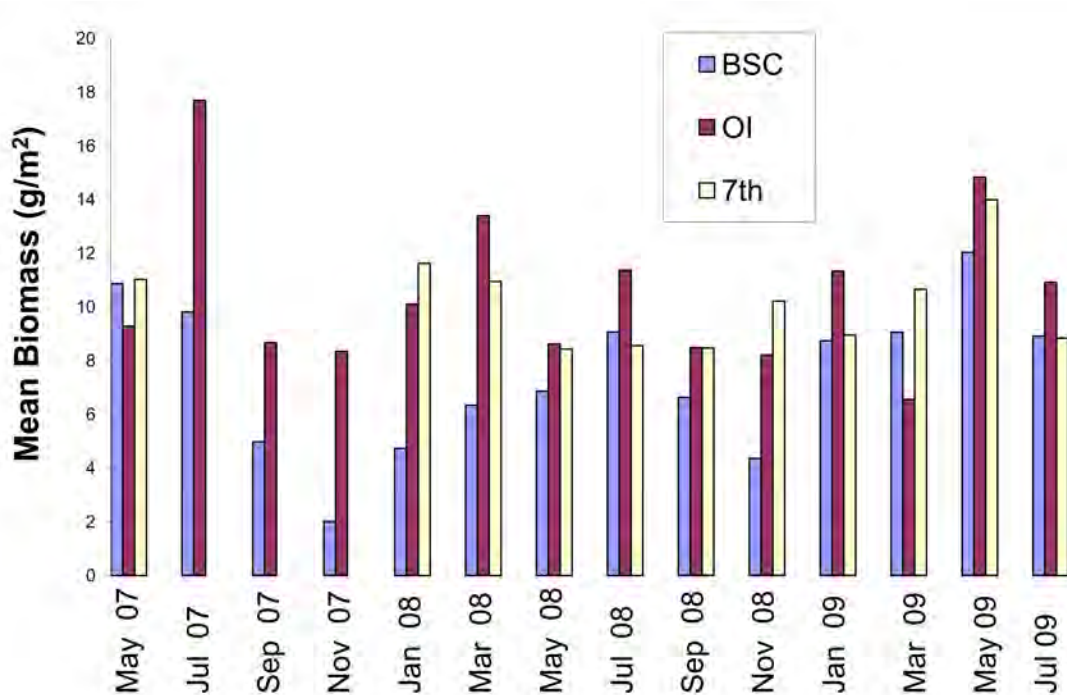


Figure 16. Mean biomass of oyster-associated fauna at the three long-term monitoring sites: Boy scout Camp, Oyster, and 7th Dock.

#### 4. Explore how oyster reef restorations affect the ecology of the shoreline from both community- and population perspectives.

In July 2008, we added two additional sites (Lone Pine, Don’s Dock) to our benthic sampling program in anticipation of oyster restoration activities. From July 2008 to March 2009, we filled benthic tray traps with five gallons of sand and sediment and placed these under each dock. The tray was pressed into the depression left behind following sediment collection, in order to assure that they were flush with the surrounding substrate. Following oyster restoration in late March 2009, these sediment trays were removed from beneath the restored dock (Don’s Dock). We replaced the sediment trays with three trays filled with loose oyster shell as described in section 3. Since the restoration process at this dock utilized bagged oyster shell, we placed an additional three trays under this dock, each containing five gallons of oyster shell placed into a mesh bag. We continued to monitor the sediment trays at the unrestored control dock (Lone Pine).

Upon the completion of oyster restoration in late March, the density and species richness of oyster-associated organisms increased (Figures 17, 18). Following restoration, we identified several species at the restored dock that we had not previously identified in any of our Loxahatchee River oyster sampling (e.g., juvenile grunts and cardinalfish). Slight increases in the density and species richness at the control dock likely represent seasonal shifts (i.e., end of the dry season) that we have documented at other sites throughout the river. But communities at the control sites remained less diverse and overall biomass of organisms remained lower. We plan to continue to monitor these sites over time, and compare these oyster-associated communities with those from our long-term monitoring sites.

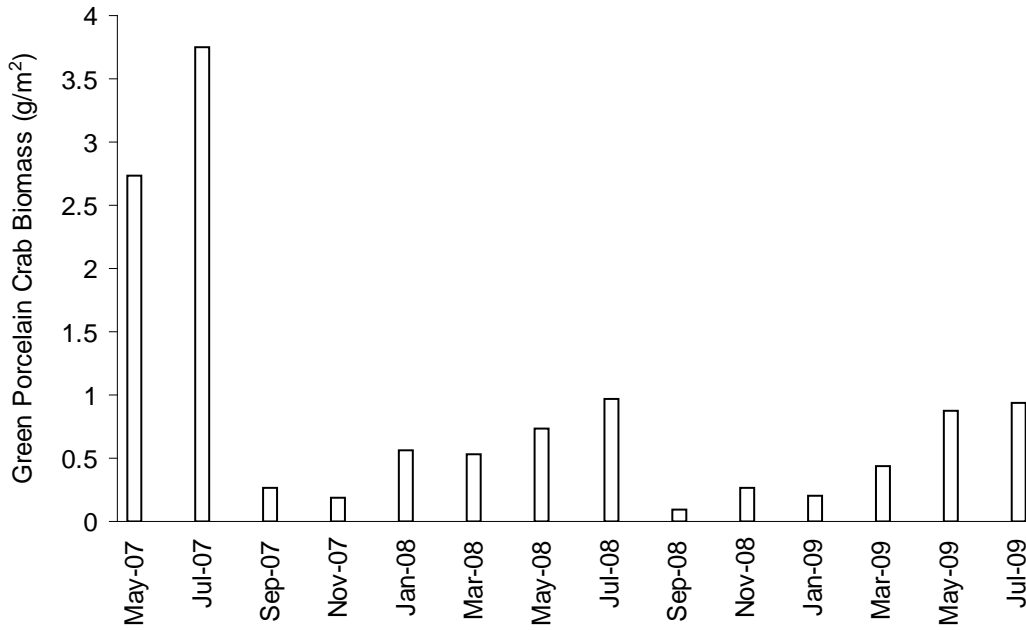


Figure 17. Mean biomass of green porcelain crabs summed across the three long-term monitoring sites.

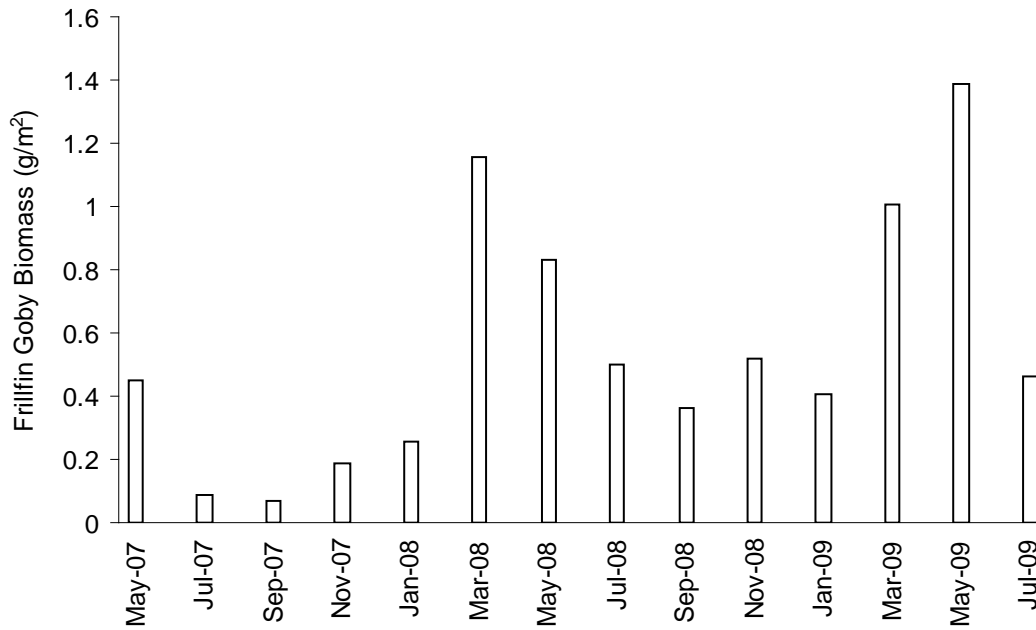


Figure 18. Mean biomass of frillfin gobies summed across the three long-term monitoring sites.

In addition to the substantial shifts in abundance, diversity and composition of oyster-reef associated fauna, transient fish species composition is noticeably different following restoration. Water clarity precludes robust quantitative analysis (i.e., per unit area density estimates) of fish fauna, but we used a standardized “roving diver” technique to present an order of magnitude estimate of fish abundance. We observed significant increases in the numbers of individuals and species richness as illustrated in Figures 19, 20 and 21. Gray snapper and checkered puffer fish were the two most commonly observed fish species at dock sites that were devoid of oysters. We also commonly observed juvenile grunts and sheepshead following restoration events. In addition, the abundance of gray snapper significantly increased, as based on order of magnitude estimations. At docks devoid of oysters, we estimated the abundance of snapper at 0-10 individuals. Following restoration, the estimated abundance of gray snapper improved to the 11-100 or 100+ individuals categories. These rough estimates suggest the restored oyster reef may support a potential increase by as much as an order of magnitude of snapper biomass and production.

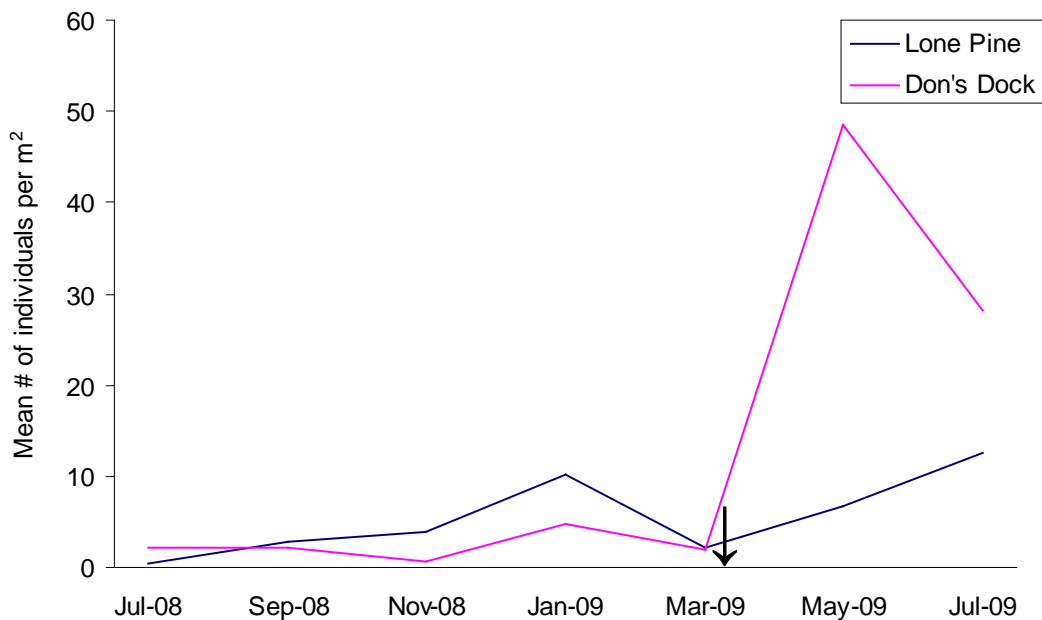


Figure 19. Mean number of individual organisms at the control dock (Lone Pine, no oysters) and the restoration dock (Don's Dock) before. The date of oyster restoration is indicated by the arrow.

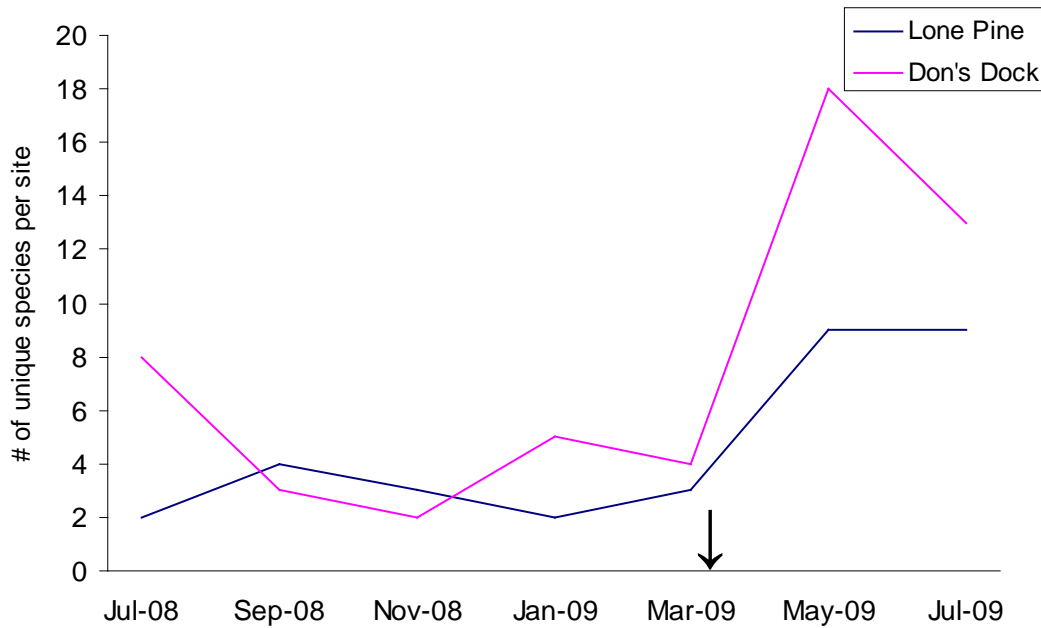


Figure 20. Species richness at the control dock (Lone Pine, no oysters) and the restoration dock (Don's Dock). The date of oyster restoration is indicated by the arrow.

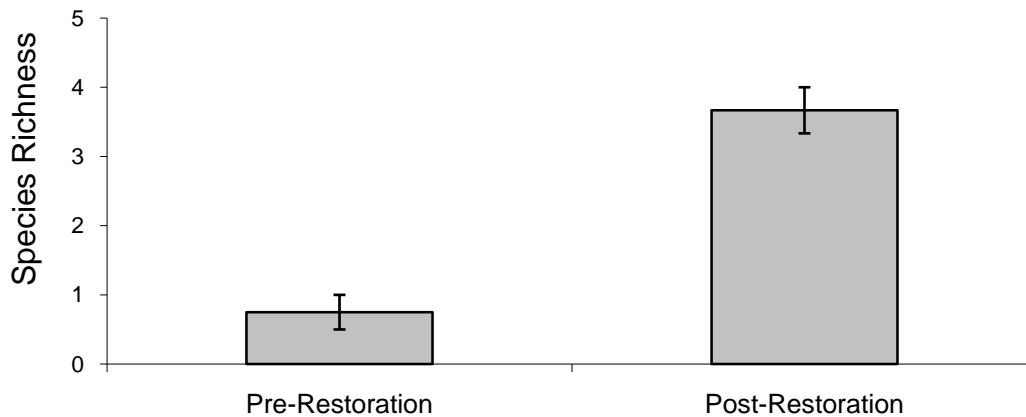


Figure 21. Mean number of transient fish species recorded in roving diver surveys under docks before and after dock restoration projects. Multiple surveys are represented from multiple dock sites.

Because of the difficulties in estimating precise transient fish densities (due to water clarity), we developed an alternative approach to examining the resulting effect of restoration with respect to fish ecology. This perspective was based on the behaviors of individual fish with respect to the oyster habitat. In essence, we use site-specific habitat affinities of individual fish as a proxy for habitat quality. This approach rests on the assumption that fish will choose to spend more time in habitats that are more optimal for their individual fitness. We use acoustic telemetry as a means to remotely monitor the behavior of individual Gray Snappers, and then compare their emergent behavior patterns before and

after reef restoration. To our knowledge, this is the first attempt to use behavioral patterns of individuals to monitor restoration efforts in an aquatic system.

We captured juvenile gray snappers by hook and line at one site (Sabin dock) in October 2007 (before restoration) and January 2009 (after). We surgically implanted Vemco™ V7 transmitters (22.5 x 7mm) in the fish through a small incision parallel to the ventral midline anterior to the pelvic fin girdle. The tags were set to “ping”, i.e., emit a unique signal, at approximately 4 minute intervals. We captured and tagged six fish on each sampling date. We developed a specialized “directional” receiver so that the receiver detection range was focused specifically on the area directly under the docks. A Styrofoam backing was placed on the side of the receiver that was opposite to the dock. This was so that fish passing in the channel behind the receiver would not be recorded. In situ range testing confirmed the effectiveness of this design.

Before restoration, receivers detected individual gray snapper on average  $15 \pm 9$  (mean  $\pm$  SD) times/day by the directional receiver during the 4 weeks post tagging. The fish that we tagged after the restoration were detected an average of  $245 \pm 65$  times/day (Figure 22). Closer inspection of the detection patterns revealed distinct differences in movement of snapper before and after restoration (Figure 23). Before the restoration, snapper seem to roam along the shoreline, and from dock to dock in distinct schools. This is perhaps due to the patchy nature of resources along oyster-free shorelines. Following restoration, snapper “residency” increases. That is, individual snapper appear to spend much longer periods of time on the new reefs, and are not moving along the shoreline. With resources now concentrated under the dock, snapper would have less reason to forage longitudinally along the shoreline. If we assume site fidelity to reflect habitat quality, our data provide a novel angle to assess the value of oyster habitat. The restoration projects have thus not only affected the structure of the ecosystem (i.e., abundance and diversity of species), but also its function (in this case, emergent behavior patterns of individuals).

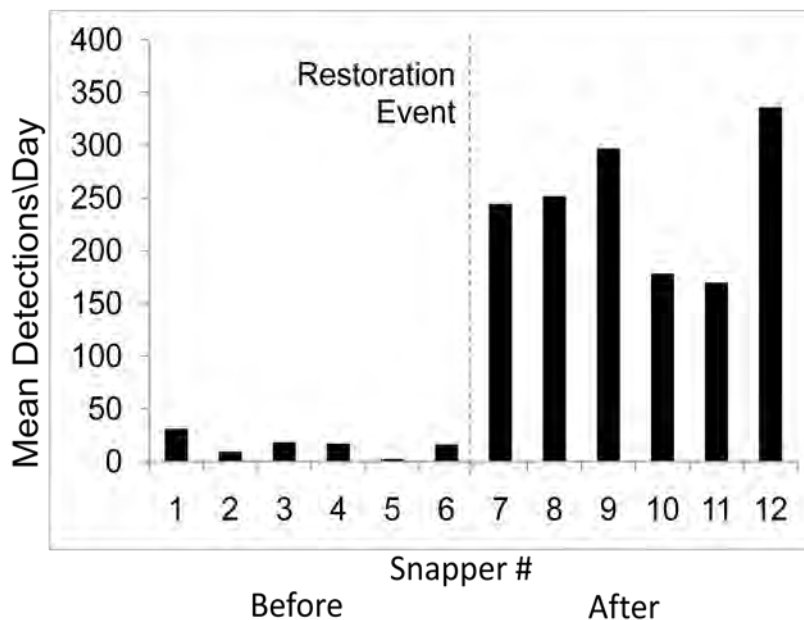


Figure 22. Mean number of detections of 6 individually tagged gray snapper before and after the restoration at the Sabin dock.



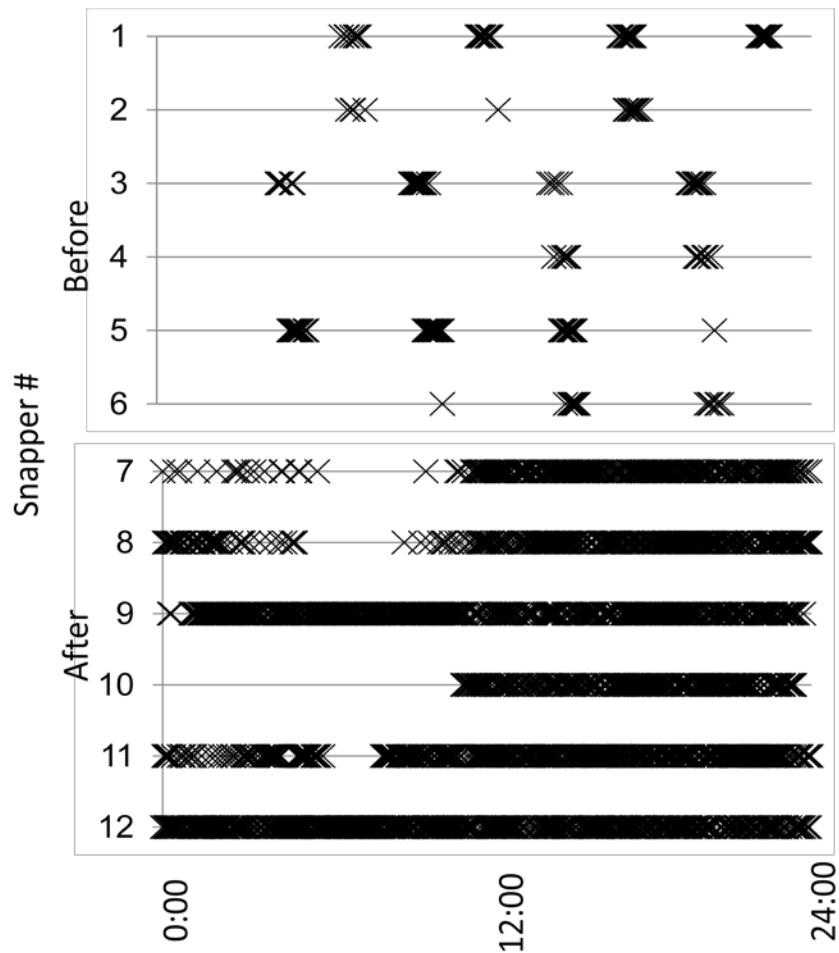


Figure 23. Mean number of detections of 6 individually tagged gray snapper before and 6 after restoration at the Sabin dock. These 12 fish correspond to the mean values represented in Figure 9, with each row representing a single fish. Each “X” indicates a single

### 5. Compare the suitability of loose oyster shell vs. shell “bags” as habitat for oyster-associated organisms.

Although our standard protocol for sampling oyster reef fauna involves placing loose oyster shell into benthic tray traps, we decided to utilize the restoration event as an opportunity to compare the ecological consequences of using bagged versus loose oyster shell when creating oyster reef habitat. Following the first two sampling periods at Don’s Dock, there appears to be ambiguous results. While biomass was slightly higher for loose oyster shell in May, the opposite was true in July (Figure 24). It appears that bagged oyster shell may be providing habitat for a greater number of species than loose oyster (Figure 25). Perhaps the mesh bag material may be acting to exclude some predators, providing predator-free habitat for additional benthic species to colonize. Larger sample sizes, additional survey periods and more rigorous statistical analysis will be needed to fully explore these potential differences.

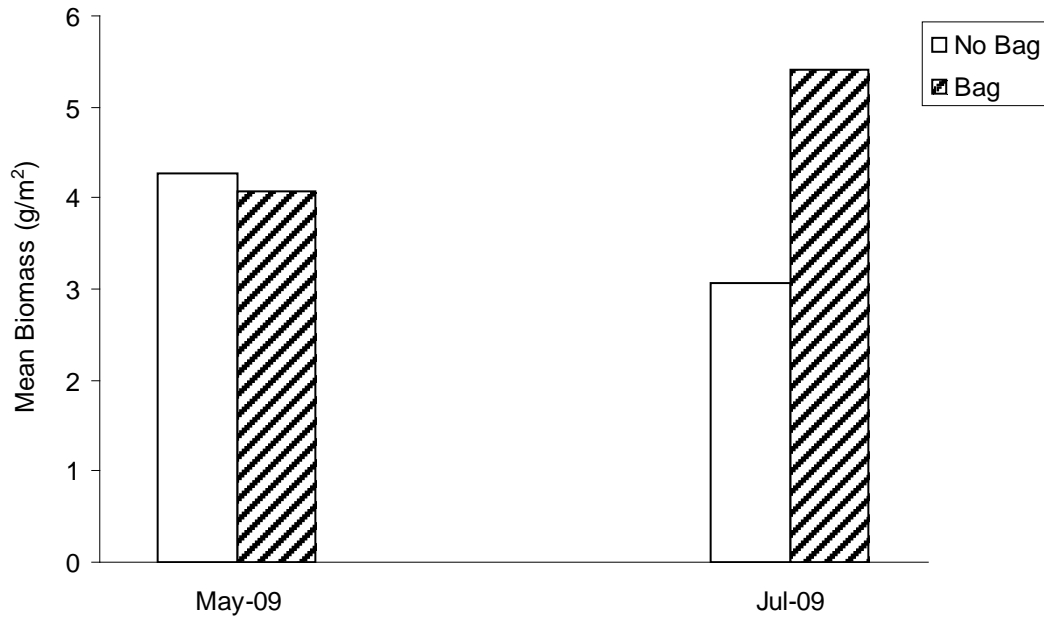


Figure 24. Mean biomass of organisms collected in trays filled with loose shell (no bag) or bags of oyster shell.

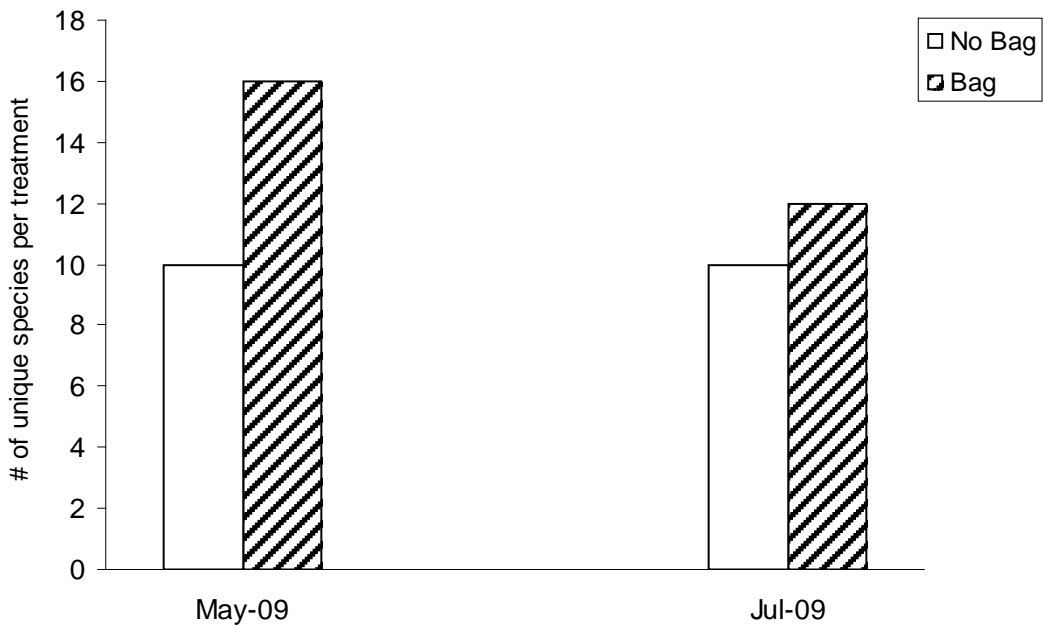


Figure 25. Species richness of organisms collected in trays filled with loose shell (no bag) or bags of oyster shell.

## 6. Develop trophic (i.e., food web) models of the oyster reef habitat.

Two complementary approaches, direct diet analysis and stable isotope ratios, provide the most thorough depictions of the flow of energy from basal resource pools (e.g., primary producers) to higher trophic level consumers (e.g., snapper and Snook). We hypothesize that oyster habitats support a high biomass of fish largely because their structural complexity gives rise to high densities of associated macroinvertebrates and small benthic fishes as described in Section 3. Diet data and stable isotopes provide the information to make the direct link between these oyster-associated fauna and higher order consumers of interest.

We have accumulated an extensive data base of diet contents of gray snapper across multiple habitats in the river. In oyster habitat, we presently have data from 89 individuals. These data directly suggest the importance of oyster-associated fauna for snapper. Table 4 shows the two most common organisms in oyster habitat, *Panopeus* and *Eurypanopeus* (two xanthid crabs), make up 38% of the diet of snapper collected from the mesohaline section on the river, including those from restored oyster reefs. Other shrimp, fish, and isopods, common on oyster reefs were found in snapper stomachs. To date, we have detected no significant difference in snapper diet on restored and existing oyster reefs, but we plan to increase our sample sizes on the restored reefs to better evaluate these findings before reporting these data.

Table 4. The relative percentage (by volume) of diet items for gray snapper collected in the mesohaline section of the river (n = 89 individuals).

<i>Xanthid spp.</i>	38.0%
<i>Aratus pisonii</i>	31.9%
Other Crab	8.3%
<i>Sesarma sp.</i>	6.4%
Shrimp	4.7%
Unidentifiable Material	3.9%
Unidentifiable Fish	2.2%
Unidentifiable Arthropod	2.2%
Isopod	1.4%
<i>Pachygraspus sp.</i>	0.6%
Mussel	0.3%
Amphipod	0.3%

Second, we have devoted significant time to collecting specimens that will be used for stable isotope analysis. We have collected, processed and sent to the Yale Stable Isotope Laboratory 340 individual samples of 21 taxa that inhabit oyster reefs. We are awaiting the final results from the Yale lab at this time. We plan to compile these data into the most comprehensive depiction to date (in the scientific literature) of an oyster reef food web. By combining the isotope and diet data, we will be able to provide detailed depictions of the flow of energy from the oyster-associated fauna to upper trophic levels. This manuscript is being prepared at this time, and will be finished late 2009 or early 2010.

We will provide all future manuscripts and monitoring reports to all stakeholders upon completion, and post them on LRD's website at: <http://www.loxahatcheeriver.org/reports.php>.

## Public Outreach & Education

Community involvement was, and continues to be, an integral part of all stages of this project. First, this project would not be possible without the waterfront homeowners who granted permission to restore the areas beneath their docks. Numerous other volunteers have worked hard collecting, assembling and deploying the restoration materials. Lastly, students and volunteers continue to conduct exciting research that helps all of us better understand the function and value of natural and restored oyster habitat in the Loxahatchee River.

Some of the volunteer work for the procurement of materials for this project included the collection of oyster shell from area restaurants and the building of concrete Reef Balls™ used at the restoration sites. Several area restaurants including The Crab House in Jupiter, Spoto's Oyster Bar in Palm Beach Gardens, and the Lobster House in Tequesta worked with us by saving shucked oyster shells. This work created a logistics challenge for the restaurant managers and tied up valuable freezer space between weekly volunteer shell collections. However, the shell from the restaurants created a valuable recycling component to the project by keeping the shell out of the landfill. Volunteers and LRD staff collected the shells from the restaurants where they were stockpiled at the LRD Laboratory. Jupiter High School Environmental Academy interns worked to bag the shell and stockpile them for the next restoration event. Other times, organized oyster bagging events worked well by assembling larger teams of people to produce substantial numbers of bags for the restoration of multiple sites.

Table 5 provides a summary the volunteer groups and their time directly associated with each restoration site on this project. The Boy Scouts, Macy's Furniture Store employees, and Home School/JHS Environmental Academy assembled large groups of volunteers who performed a huge amount of work. To date, over 335 volunteers invested more than 1,220 hours to produce and deploy 1,330 oyster bags at 9 restoration sites.

**Table 5. Summary of volunteer participation directly involved in project construction including reef ball construction, oyster bagging and deployment.**

Site #	Installation Date	Volunteers	Estimated # Volunteers	Estimated Volunteer Hours
1	10/10/2008	Jupiter HS Environmental Academy; Camp Cloverleaf Lake Placid 4-H; Riverfest	66	186
2	11/20/08	Jupiter HS Environmental Academy; Camp Wet – Environ Studies Center	35	210
3	11/24/2008	Palm Beach County Staff; Camp Wet--Environ Studies Center	17	158
4	3/25/2009	Home School Group; Interns; Camp Wet—Environ Studies Center	25	210
5	3/26/2009	Home School Group; Public; Blowing Rocks Preserve; Rio Center Girl Scouts	40	84
6	3/26/2009	Home School Group; Public; FL Oceanographic Society; Martin County 4-H; Camp Welaka Girl Scouts; Jupiter HS Environmental Academy; Blowing Rocks Preserve	88	139
7	6/5/2009	Macy's Staff	6	36
8	8/17/2009	Boy Scouts	29	116
9	8/17/2009	Boy Scouts	29	116
TOTALS			335	1,255

Through our partnership with the Martin County Artificial Reef Program a variety of local community groups worked on making concrete Reef Balls™ that were used on this and other restoration projects. The Reef Ball events provide a unique opportunity to educate the volunteers about habitat restoration. Table 6 summarizes the 9 Reef Ball construction events held between March and September 2008. Volunteers spent more than 714 hours learning about artificial reefs and constructed 77 Reef Balls that we used for this project. The Nature Conservancy’s Blowing Rocks Preserve helped by stockpiling the Reef Balls on their property. This provided an ideal site to load the Reef Balls onto the boat for transportation to the restoration site.

Table 6. Summary of Reef Ball construction events associated with the oyster restoration project.

Activity Date	Volunteer Group or Event	# of Volunteers	# of Reef Balls Constructed	Volunteer Hours (Est)
March 30, 2008	RiverFest	12	4	12
Week of 6/9/2008	Camp Cloverleaf Lake Placid 4-H	50	12	150
Summer 2008	Camp Wet—Environ Studies Ctr	45	40	450
June 24, 2008	Blowing Rocks Preserve	5	8	10
July 2008	Rio Center Girl Scouts	20	3	20
July 22, 2008	Florida Oceanographic Society	24	2	24
July 28, 2008	Martin County 4-H	24	3	24
August 4, 2008	Camp Welaka Girl Scouts	13	2	13
September 23, 2008	JERFSA—Blowing Rocks Preserve	12	5	24
<b>TOTALS</b>		<b>205</b>	<b>77</b>	<b>714</b>

This project has also provided excellent opportunities to educate the public about the importance of oysters and oyster habitat. News media outlets (TV and newspapers) were excited by the project and provided some excellent coverage, summarized in Table 7 and included in the Appendix.

This project provided a great presentation topic for seminars and meetings. Because of this, several participants in the project were invited to speak at a variety of events including the Loxahatchee River Watershed Science Symposium, the Jupiter Kiwanis Club, the Palm Beach County Reef Research Team meeting, the Treasure Coast and Florida Chapters Meetings of the Florida Association of Environmental Professionals, the Florida Chapter Meeting of the American Water Resources Association, the Loxahatchee River Management Coordinating Council, as well as a lecture at Florida International University.

People also learned about oysters, oyster habitat, and this restoration project through a variety of digital and printed materials too. The talented staff from the Loxahatchee River Environmental Center, or River Center, developed The Oyster Restoration Fact Sheet that was distributed to visitors of the River Center as well as a variety of groups interested in the Loxahatchee River. The River Center staff developed the showcase Oyster Poster, as part of the environmental education poster series produced by the Loxahatchee River District. We distributed this poster to environmental organizations and agencies throughout Florida. The River Center staff also publishes a monthly digital newsletter called River Tidings. This newsletter featured oysters and oyster habitat in the recent “River Segment Series” of the newsletter. In addition, oysters and oyster habitat are a featured topic in the education programs and displays that more than 20,000 annual visitors experience at the River Center. Lastly, the Loxahatchee River District featured the oyster project in their quarterly billing insert that was mailed to roughly 65,000 wastewater customers.

We are proud to have recently received the Treasure Coast Chapter of the Florida Association of Environmental Professionals “Best Project” award for 2009. They awarded this project because of the unique combination of community involved restoration work and the outstanding research conducted on this project by the team from Dr. Craig Layman’s laboratory at Florida International University and LRD’s Wildpine Laboratory. We look forward to continuing the work that this project helped to initiate.

Table 7. Summary of media coverage and public outreach activities.

April 30, 2008	Andrea Povinelli of The Nature Conservancy's Blowing Rocks Preserve gave a presentation at the Loxahatchee River Watershed Science Symposium titled "Turning the Tide: Restoring Oysters in the Loxahatchee River"
May 16, 2008	Stuart News article titled "Shucks! Old oyster shells help new ones"
June 8, 2008	Jupiter Courier article titled "Spoto's joins Loxahatchee reef project"
June 15, 2008	Jupiter Courier editorial titled "Pair of projects could help Mother Nature"
June 25, 2008	Stuart News photo of reef ball titled "Building the molds for oyster restoration"
July 2008	The <i>Shellfish Restoration Clamor</i> newsletter produced and distributed by The Nature Conservancy's Global Marine Initiative included the oyster reef restoration project
September 2008	The Nature Conservancy Fact Sheet titled "Oyster Reef Restoration in the Loxahatchee River"
November 20, 2008	WPTV Channel 5 and WPBF Channel 25 TV coverage and avi video file
November 30, 2008	Jupiter Courier article titled "Reef Builders go to Work"
January 2009	Loxahatchee River District billing insert mailed to 65,000 wastewater customers
March 15, 2009	Jupiter Courier article titled "Loxahatchee River Oyster Reefs Flourishing"
June 2009	Loxahatchee River Environmental Center River Tidings Lovin' the Loxahatchee River Segment Series #3—Oyster Reefs
January 14, 2009	Presentation to Jupiter Kiwanis Club
May 12, 2009	Presentation to Palm Beach County Reef Research Team
August 5, 2009	Presentation to Treasure Coast Chapter of Florida Association of Environmental Professionals.
September 11, 2009	Presentation to Joint Meeting of the Florida Chapter of the American Water Resources Association and the Florida Association of Environmental Professionals.
September 28, 2009	Presentation to the Loxahatchee River Management Coordinating Council
September 2009	Oyster Poster published by Loxahatchee River District available at the Loxahatchee River Environmental Center
November 10, 2009	Lecture for Coastal Marine Conservation course at Florida International University

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Appendix  
Newspaper Articles and Public Education Materials

# Martin County

SECTION B • FRIDAY, MAY 16, 2008 • TCPALM.COM

S

## Shucks! Old oyster shells help new ones

**BY R.J. HARRINGTON**  
Correspondent

**STUART** — Shucked oyster shells from local restaurants could help create a home for future oysters that help clean the Loxahatchee River.

Martin County Artificial Reef Program, the Loxahatchee River District and the National Oceanic and Atmospheric Administration have partnered on a project to place more than 60 concrete structures the size and shape of bowling balls in the river. The reef balls provide a flat surface

for oyster larvae to attach to and grow into adults.

A number of area restaurants, including the New England Fish Market and Restaurant in Jensen Beach, are collecting oyster shells. Volunteers pick them up daily and they are then used to create artificial reefs for live oysters. NOAA and The Nature Conservancy are cooperating in this part of the program.

Albrey Arrington, director of water resources for the Loxahatchee River District, said oysters are vital to the health of the river.

“One oyster can filter more than 50 gallons of water daily,” he said. “So we’re hopeful that the reef balls and the ongoing collection of oyster shells will go a long way towards helping to clean up these waterways.”

Arrington said in addition to water filtration, oysters help stabilize and protect shorelines, provide food and habitat for wildlife, including shrimp and blue crab and serve as hunting grounds for fish such as snapper.

Once established, the new reefs will offer not only an opportunity for hab-

itat restoration, but present a venue for research. Using ultrasonic transmitters and receivers, scientists will track fish movement to determine the relationship of gray snapper to oyster reefs as a food source.

Arrington said organizers hope to have permits from the Department of Environmental Protection by summer and will then begin placing the reef balls, mainly under docks.

The Nature Conservancy’s Blowing Rocks Preserve on Jupiter Island is coordinating with willing home-

owners along environmentally significant areas of the river for placement of these artificial reefs below their docks.

Karl Wickstrom of the Rivers Coalition, said his group placed some reef balls near the Florida Oceanographic Institute on Hutchinson Island and within a short time oysters have begun to congregate there.

“This is great news,” said Wickstrom, who is editor-in-chief of the Florida Sportsman Magazine. “We’re grateful that these groups have come together to support this program.”

# Martin County

SECTION B • WEDNESDAY, JUNE 25, 2008 • TCPALM.COM

## Building the molds for oyster restoration



ALEX BOERNER • alex.boerner@scripps.com

Ashley Brown of Jupiter, right, an intern with the Loxahatchee River District, and Carl Howard of Hobe Sound, left, a park ranger at Jonathan Dickinson State Park, work to build reef balls Tuesday morning behind the maintenance building at Blowing Rocks Preserve in Jupiter. Inflatable balls are placed inside the molds, which then are filled with concrete. When dry, the molds and balls are removed to reveal the reef ball. The two were part of a group of nine working with guidance through the Martin County Artificial Reef Program that builds reef balls for the Loxahatchee River as part of the oyster reef restoration program.

## WATER RATE HIKE

Jupiter Town Council OKs  
20% increase

PAGE A3



## FINE FISHING

Realtors' Family Fishing  
Tournament a success

SPORTS, B1

# YourHub.com

Jupiter, Tequesta, Juno Beach, Jupiter Farms & Palm Beach Gardens

JTAA HAS A SAY  
Youth sports, B2



An edition of  
Treasure Coast  
News/Press-Tribune

# The Jupiter Courier

THE COMMUNITY CHOICE FOR NORTHERN PALM BEACH COUNTY

Florida's No. 1  
weekly newspaper,  
Florida Press  
Association 2007

http://jupitercourier.com

SUNDAY, JUNE 8, 2008

50 cents

## Spoto's joins Loxahatchee reef project

BY JOCELYN O'NEILL/  
LOXAHATCHEE RIVER DISTRICT  
Posted on YourHub.com

Spoto's Oyster Bar in Palm Beach Gardens is joining the effort to rebuild oyster reefs in the Loxahatchee River by recycling their oyster shells.

Spearheaded by the Loxahatchee River District and established by the National Partnership between the National Oceanic and Atmospheric Administration and The Nature Conservancy, this project calls for partnerships with local restaurants to collect oyster shells that would otherwise be thrown away but can be used to create artificial reefs. A network of community volun-

teers, spearheaded by The Conservancy's Blowing Rocks Preserve, are providing their docks along environmentally significant areason the Loxahatchee River for the placement of these oyster reefs. Additionally, the artificial oyster reefs will offer not only an opportunity for habitat restoration, but present a venue for research.

An ultrasonic transmitter will be implanted into 25 gray snappers collected at the restored oyster reefs. Then receivers will be implanted in the artificial reefs to determine the relationship of gray snapper to oyster reefs as a food source.

The community volunteer effort includes the need for individuals to

pick up oyster shells from area restaurants twice a week and deliver them to the Loxahatchee River District in Jupiter.

Volunteers are also needed to help bag the oysters to create the artificial reefs.

Deployment of the artificial reefs will require many volunteers. Groups and individuals alike are encouraged to participate.

For more information about volunteer opportunities or to learn more about the project, please call Jocelyn O'Neill at The River Center, (561) 743-7123.

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JERRY METZ • Posted on YourHub.com  
An oyster reef thrives on the northwest fork of the Loxahatchee River.

# Community Viewpoint

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The Jupiter Courier

A Scripps Howard Newspaper

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*"Give light and the people will find their own way"*

## Pair of projects could help Mother Nature

Two projects are under way to help Mother Nature, and both involve water.

In the Loxahatchee River, Spoto's Oyster Bar in Palm Beach Gardens is joining with the Loxahatchee River District and others to collect oyster shells that will help create artificial oyster reefs.

One of the goals is to create locations where oysters can thrive, but another is the opportunity to study gray snapper, to see if they would use the oyster reefs as a food source. Oysters were once quite prominent in the Loxahatchee River, and this project could help bring back a larger oyster population.

In the second project, the Palm Beach County Division of Environmental Resources is looking into the possibility of placing breakwaters south of the Jupiter Inlet, to help keep sand on the beaches. These breakwaters, which would be granite and limestone, would help break up the heavy surfs that plague this area.

In this case, part of the problem is manmade and part is Mother Nature.

Most of the time, sand moves naturally from north to south, and the natural ebb and flow of the sand is, to a degree, interrupted by any natural inlet or natural river mouth.

We have both at the Jupiter Inlet, even though this inlet was created just north of its natural location, and the Jupiter Inlet District created to manage it in 1921. Because the inlet was moved and deepened, with a couple of jetties along its sides, the loss of sand is accelerated, according to Mike Grella, who heads the inlet district.

The district, over the years, has been scooping the sand trapped around DuBois Park and putting it back up on the beaches south of the inlet, but this is only a temporary solution, since a northeastern storm, or even the unusual surf conditions the area experienced last year can quickly snag the sand, pulling it back into the ocean.

It is hoped that these breakwaters, wherever they are placed, will at least keep the sand on the beaches, despite occasional heavy seas.

Water, including the ocean, the river and the inlet, helps give Jupiter its unique character.

These efforts could help the river that flows throughout the town and the public beaches along its eastern boundary.

## RUN FOR THE PIES

Runners race through Tequesta on Thanksgiving

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## BAND TRIUMPHS

Spirit of Jupiter No. 2 at state championship

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## Discover Tri-Rail

Student pleasantly surprised at convenience, cost

VIEWPOINT, A6



An edition of Treasure Coast News/Press-Tribune

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## Reef builders go to work



AMY KRASKER • Posted on YourHub.com

Students from Jupiter High Environmental Academy form a human chain to unload bags of oyster shells and place them under the dock to create the artificial oyster reef.

### Jupiter High students help river district, Nature Conservancy build oyster beds

BY AMY KRASKER  
Posted on YourHub.com

Oysters are the bedrock of river life. They help stabilize shorelines. They provide homes for shrimp and blue crabs and support hunting grounds for sport-fish species, such as snapper. And, they keep rivers clean.

"In the Loxahatchee River, oyster populations have declined due to a lack of hard surfaces where oyster larvae can attach," said Bud Howard, director of water resources for the Loxahatchee River District. "We're working with local partners, including riverfront homeowners, to restore oyster habitat by creating new reefs in the river."

The Loxahatchee River District and The Nature Conservancy installed one of their first artificial oyster reefs in the northwest fork of the Loxahatchee River last weekend. The two groups are working together to restore oyster reef habitat by placing used oyster shells and concrete reef balls under docks.



AMY KRASKER • Posted on YourHub.com  
Riverfront resident Bill Hulligan volunteered to participate in the oyster reef project and allowed the team to place an artificial reef under his dock along the river.

Students from Jupiter High Environmental Academy formed a human chain to unload bags of oyster shells and place them under the dock to create the artificial oyster reef.

Local restaurants, including the Crab

House and Spoto's Oyster Bar, volunteered to recycle oyster shells for the restoration effort.

The shells will be put in mesh bags and placed beneath docks along the northwest fork of the Loxahatchee River in Jupiter and Tequesta.

The Martin County Artificial Reef Program and more than 200 volunteers have helped make the reef balls, which typically attract fish as soon as they are placed in the water.

The conservancy and the Loxahatchee River District continue to seek home and dock owners along the northwest fork of the river to participate in the oyster restoration project.

Often referred to as the "last free-flowing river in southeast Florida," the Loxahatchee's northwest fork also is recognized as a federally designated Wild and Scenic River.

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# Oyster Reef Restoration in the Loxahatchee River



## Why Restore Oyster Reefs?

Oyster reefs provide important benefits to the overall health of the Loxahatchee River by cleaning water, stabilizing shorelines and providing essential fish habitat. Oyster reefs have declined in the river due to a lack of hard surfaces where oyster larvae can attach.

The Loxahatchee River District and The Nature Conservancy are working in partnership with cooperating agencies and the local community to restore oyster reefs in the river. The newly created reefs will provide habitat and food for fish, crab, shrimp and other important estuarine species.

## What We Are Doing

The goal of the project is to create artificial reefs in areas of the river known to have the right conditions for oysters. On the river's northwest fork, ReefBalls™ and bags of recycled oyster shell will be placed under the docks of willing homeowners. Small limestone rocks will be placed along the shoreline in several sections of the southwest fork. These materials will create the foundation for healthy living oyster reefs.



## Oyster Reefs

- Filter and clean water
- Stabilize and protect shorelines
- Provide food and habitat for wildlife, including shrimp and crabs
- Serve as hunting grounds for fish species, such as the gray snapper

# Measuring Success

Project scientists will closely monitor the restoration project to measure oyster recruitment on the new reefs. Regular surveys will track the number and variety of fish and invertebrate species inhabiting the restored reefs.

Scientists will also assess the value of the new reefs as critical fish habitat. Using ultrasonic transmitters and receivers, fish movements will be tracked to determine the relationship of gray snapper to oyster reefs as a food source.



# How You Can Help

This is a community-based restoration project and we will only be successful with your help. We are looking for homeowners on the Northwest Fork of the Loxahatchee River to host a reef below their dock. Volunteers are also needed to make ReefBalls™ and fill bags with shells. Please call (561) 744-6668 for more information.



# Working Together

- Florida International University
- South Florida Water Management District
- Loxahatchee River Preservation Initiative
- Palm Beach County Environmental Resource Management
- Martin County Artificial Reef Program
- The Crab House
- Spotos Oyster Bar
- Friends of the Loxahatchee River, Inc.



**For More information:**  
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The National Partnership between the NOAA Community-based Restoration Program and The Nature Conservancy implements innovative conservation activities that benefit marine, estuarine and riparian habitats across the United States. The NOAA Restoration Center has worked with community organizations to support locally-driven projects that provide strong on-the-ground habitat restoration components that offer educational and social benefits for people and their communities, as well as long-term ecological benefits.







## Richard C. Dent

### A Career Dedicated to the Loxahatchee River

After 35 years of service, this January marks the retirement of Loxahatchee River District Executive Director, Richard C. Dent.

In 1973, Rick Dent began his career with the Loxahatchee River District as Director of Planning & Resources. Shortly thereafter, he became Deputy Director, followed by the position of Executive Director in 1986.

Throughout his tenure, Mr. Dent has elevated the District's professional stature and level of expertise in both environmental and business management. The results are several awards for excellence in operations, sustained low rates for customers, and creation of innovative projects, such as a nationally-acclaimed wastewater recycling program. He has authored dozens of technical publications dealing with wastewater technologies, as well as environmental issues facing the Loxahatchee River.

In addition, Mr. Dent's leadership has cultivated a roster of employees with tenures of 15, 20 and 25 years. He has upheld the District's mission to preserve and protect the river by establishing the first-ever catalogue of river data, the state-certified WildPine Laboratory, Friends of the Loxahatchee River, a volunteer water quality monitoring network, the relocation and expansion of Busch Wildlife Sanctuary, and the creation of The River Center.

On behalf of the Loxahatchee River District, Rick Dent has served as a member of the Loxahatchee Greenways Project, the Loxahatchee River Management Coordinating Council, the Loxahatchee River Preservation Initiative, and as a Director of the Jupiter/Tequesta/Juno Beach Chamber of Commerce.

We thank Rick for his dedication to our community and for striving to preserve and sustain our river for generations to come.



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## Community Rallies Behind Creation of Oyster Reefs

Recently, several oyster reefs were installed along the Loxahatchee River through a collaboration of environmental managers, area businesses, residents and local students.

Oyster reefs are one of the most valuable habitats in the river, offering a rich habitat for numerous fish, crabs, shrimp, and other small aquatic species. They provide a fertile hunting ground for juvenile fish like grouper, snapper, and snook. Oyster reefs also function as biological filters, continuously cleaning water in our estuary. In fact, a single oyster can filter up to 50 gallons of water per day. But, altered environmental factors over the last 60 years have diminished oyster populations in our local waterways.

Through a partnership with the National Oceanic and Atmospheric Administration, the Nature Conservancy and the Loxahatchee River District, oyster shells were collected from area restaurants and used to create artificial reefs. Local residents along the river, like Bill Hülligan, volunteer the space beneath their docks to place these oyster shells, which ultimately will transform into healthy, living oyster reefs. Student volunteers from Jupiter High's Environmental Academy assisted Loxahatchee River District WildPine Laboratory staff throughout all stages of the project.

Scientists from LRD's Wildpine Laboratory and Florida International University will monitor the success of this oyster reef restoration effort. As larval oysters settle onto the artificial reefs, the reef will begin to grow and provide the essential habitat and water filtering services provided by natural oyster reefs.



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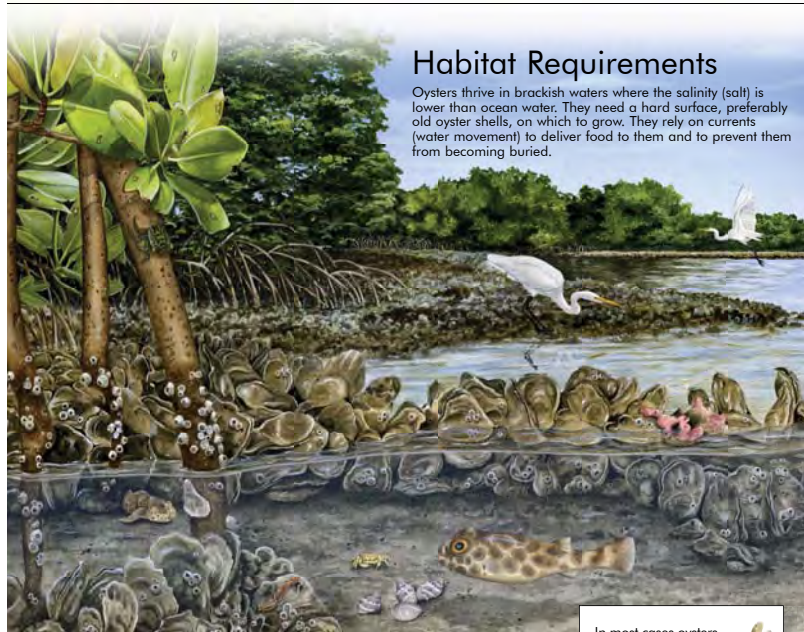


## Oyster Reefs are Important



- Hundreds of species are associated with oyster reefs. They provide habitat for juvenile fish and invertebrates as well as substrate for sessile organisms.
- One adult oyster can filter up to 50 gallons of water per day contributing to the water clarity needed for seagrasses to thrive.

- Oyster reefs stabilize shorelines and reduce erosion.
- Oysters are an economically important species throughout the southeastern United States.
- Oyster reefs serve as feeding grounds for wading birds and fish such as snapper, grouper, and snook.



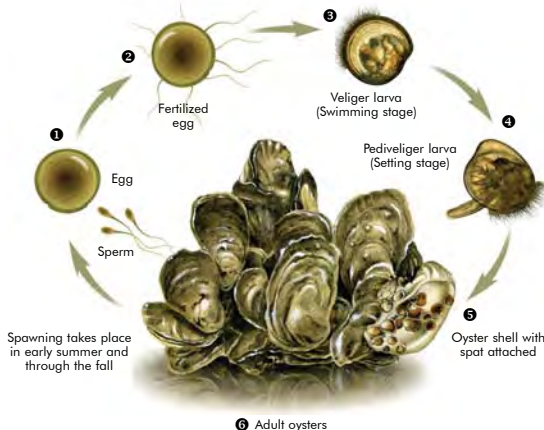
## Habitat Requirements

Oysters thrive in brackish waters where the salinity (salt) is lower than ocean water. They need a hard surface, preferably old oyster shells, on which to grow. They rely on currents (water movement) to deliver food to them and to prevent them from becoming buried.

## Adaptations

Oysters are marine organisms that can live in both the intertidal (between high and low tides) and subtidal (always submerged) zones. The intertidal reefs are exposed to the air during low tide. Oysters are able to survive by tightly closing their shell until high tide returns. This adaptation allows them to avoid predation from organisms that must remain in the water (i.e., marine snails). Their hard shells also prevent many predators from reaching their soft bodies.

In most cases oysters are hermaphroditic. They begin life as a male, change to a female, then change back to a male. Oysters may go back and forth between sexes several times during their lifetime.



## Life Cycle

- When water temperature warms above 68°, eggs and sperm are released into the water column where they must join together for fertilization.
- Within 24 hours a shell and cilia (tiny hairs for swimming and feeding) develop. The larvae swim for up to two weeks before settling to the bottom.
- Spat (juvenile oysters) must settle out onto a hard surface, preferably other oyster shells. They reach adulthood in about two years and will remain attached to the same surface for the rest of their life.

Oysters can live up to 20 years.

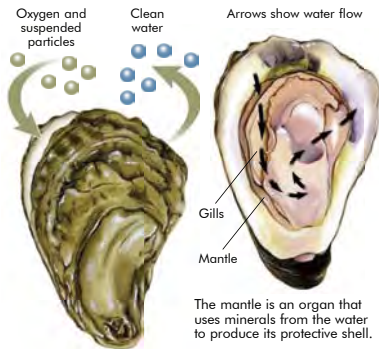
# O EASTERN Oyster

*Crassostrea virginica*

Oyster reefs are vital to our estuaries. They provide suitable habitat for small organisms and are feeding grounds for important species such as snapper and grouper. Their reefs also provide stabilization for our shorelines. Oysters remove nutrients from the water improving water quality, which is critical for seagrasses and fish.

## Filter Feeding

Oysters use their gills to absorb oxygen and strain food out of the water. One adult can strain plankton and organic matter out of the water at a rate of up to 50 gallons per day (or 1500 times its body volume). A healthy oyster reef contributes significantly to overall water clarity in the estuary.



## Threats

- **Physical removal.** Oyster reefs are vulnerable to over harvesting and disturbance by development.
- **Sedimentation.** Dredging and stormwater runoff can result in the burying of oyster reefs.
- **Boating impacts.** Boat wakes can erode the shoreline and disturb oyster reefs. Boat props can drag along the bottom and dislodge oyster clumps.



Brackish water has a level of salinity between ocean water and fresh water. Oyster reefs thrive in brackish water.

## Restoration

Restoring oyster reefs is an effective way to improve water quality and provide new habitat for fish and invertebrates.

- Empty oyster shells collected from local restaurants are placed in depleted oyster reef areas to provide hard substrate for spat settlement and calcium needed for shell growth.
- Limestone, oyster mats, and artificial reef materials such as concrete ReefBalls™ are other methods being used to provide new substrate for spat to settle.



The Nature Conservancy  

Protecting nature. Preserving life.



Loxahatchee River District  
"Preserving Nature by Design"™  
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