LOXAHATCHEE RIVER WATER QUALITY AND BIOLOGICAL MONITORING

TASK 2: FINAL REPORT
ASSESSMENT OF 2007-2008 LOXAHATCHEE RIVER OYSTER MAPPING & RECRUITMENT

In Partial Fulfillment of Agreement No. 4600001281

For the Period

October 2007 through September 2008

Respectfully Submitted by

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December 19, 2008

Introduction

Since 1971 the Loxahatchee River District (LRD) has been fulfilling its mission to preserve and protect the Loxahatchee River through an innovative wastewater treatment and reuse program and an active water quality and natural resource monitoring program. LRD staff have monitored water quality and natural resources throughout the Loxahatchee River and associated waters (see Figure 1) in an effort to document the condition and ecological health of the river and to determine the location and extent of issues that need attention. Over these past 35 years, the Loxahatchee River District has contributed significantly to the understanding of the ecology of this river. While numerous authors have prepared reports regarding the Loxahatchee River, perhaps none are as comprehensive as the *Restoration Plan for the Northwest Fork of the Loxahatchee River* (SFWMD 2006). This document characterized the watershed, discussed various restoration alternatives, and identified the preferred restoration flow scenario. In particular, Chapter 10 of the restoration plan recognized oysters as critical biological organisms, or Valued Ecosystem Components (VEC), that serve as important benchmarks for evaluating the effectiveness of restoration activities. As such, the plan recommended oyster mapping and monitoring to assess the health and response of oysters to restored (i.e., increased) freshwater deliveries during low flow periods.

In the present report we describe our oyster reef mapping and spat monitoring efforts, characterize the spatial distribution and health of oyster reefs in the Loxahatchee River during 2008, and compare these results to data collected during 2003. In 2003, LRD, and their partners at the South Florida Water Management District (SFWMD), conducted an assessment of the oysters in the Loxahatchee River Estuary (LRD, 2004).

In 2008, LRD staff mapped and assessed all of the oyster reefs found in the Northwest and Southwest Forks of the River. Both the 2003 and 2008 datasets characterize and quantify baseline conditions, including temporal variability, prior to modification of freshwater inflows resulting from the Comprehensive Everglades Restoration Project and the Northwest Fork Restoration Plan (CERP 2001; SFWMD 2006).

Study Area

The Loxahatchee River Estuary encompasses approximately 400 ha and drains a watershed of approximately 700 km^2 located in northeastern Palm Beach County and southeastern Martin County, Florida, USA. Freshwater discharges into the estuary from the North Fork, the Northwest Fork, and the Southwest Fork of the Loxahatchee River. Flood control efforts since the 1950's substantially altered the hydrology of the basin. Historically (pre-1950), most surface water runoff reaching the estuary originated in the Loxahatchee and Hungryland Sloughs and flowed gradually to the Northwest Fork. In the 1930's the Lainhart Dam, a small fixed-weir dam, was constructed in the Northwest Fork at river mile 14.5 to reduce "over" drainage of upstream reaches of the Northwest Fork during the dry season. In 1958 a major canal (C-18) and flood control structure (S-46) were constructed to divert flows from the Northwest Fork to the Southwest Fork, which increased the intensity and decreased the duration of storm-related discharge to the estuary. Furthermore, in 1947 the Jupiter inlet District began a series of jetty expansions and routine dredging at the Jupiter Inlet, the rivers eastern link to the ocean. The inlet improvements increased saltwater intrusion into the primarily freshwater Northwest Fork. As a result of these anthropomorphic alterations, upstream freshwater flows and downstream tidal flows have changed and, therefore, influence the historical extent of saline waters throughout the estuary. LRD has recorded saltwater intrusion more than nine miles up the Northwest Fork from the Jupiter Inlet (LRD, 2006).

Historical accounts indicate the Loxahatchee River supported a large and robust oyster population throughout the central embayment and within a few miles of the Jupiter Inlet prior to the early twentieth century. Over the past sixty years changes in water quality have altered environmental conditions required by oysters to persist and propagate. In 1990, Law Environmental documented the minimal presence of oysters within the central embayment and North Fork, with more substantial oyster reefs near the mouths of the Northwest and Southwest Forks (Law Environmental, 1991). LRD's 2003 survey found the American or Eastern Oyster (*Crassostrea virginica*) was, by far, the most prevalent oyster species observed in the

Loxahatchee River. The Flat Oyster (*Isognomon alatus*), only occasionally found in the Loxahatchee River, is primarily found on bulkheads and pilings.

Ongoing restoration efforts seek to increase base freshwater flows into the Northwest Fork, while not compromising the ecological integrity of downstream reaches (i.e., estuary) nor impairing valued ecosystem components of the estuary such as oysters and seagrasses (SFWMD 2006).

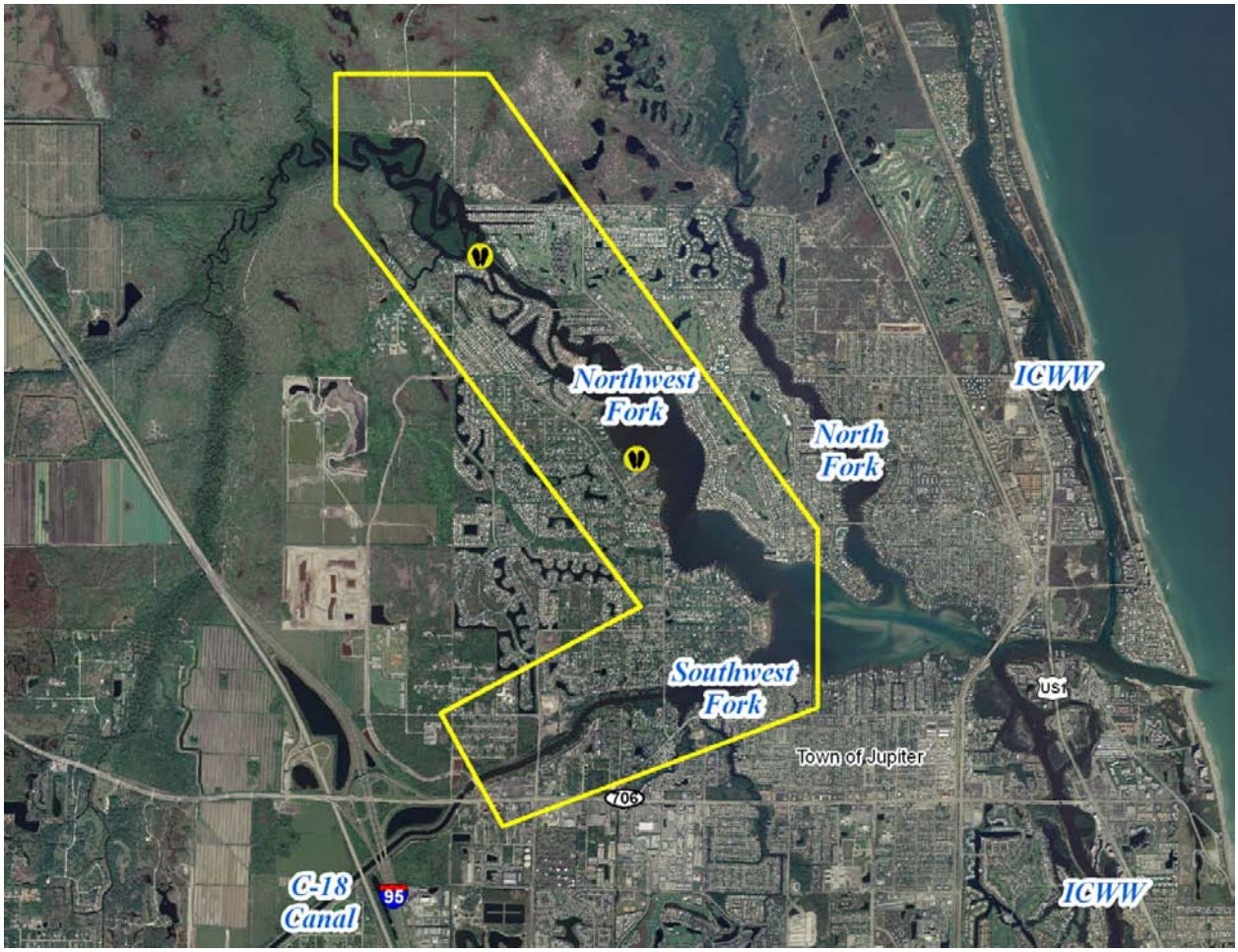


Figure 1. Oyster reef mapping and assessment project area, Loxahatchee River, Jupiter, Florida.

Materials and Methods

Oyster Mapping and Assessment

From July through September 2008, staff from LRD's WildPine Laboratory mapped oysters throughout the Northwest and Southwest Forks and the associated tributaries. Within these areas, work focused on areas known to historically support oysters as well as areas likely to sustain oysters because of suitable conditions, including salinity, bottom type, and water depth. To maximize our ability to detect oyster reefs, which predominantly occur in the intertidal zone in the Loxahatchee River, we generally scheduled surveys around low tide. Divers snorkeled the survey areas making visual observations and probing bottom sediments to feel for the presence of oyster shell. Once an oyster reef was located, a diver marked the perimeter of the reef and determined if the reef included live oysters. Field biologists mapped oyster reefs larger than one square meter and containing more than five live oysters used a mapping grade Differential GPS (Trimble® Pro XR). Relic oyster reefs, i.e., those containing no live oysters, and oysters on pilings and bulkheads, were not mapped.

LRD's biologists quantified density and shell height of live and articulated dead oysters in each mapped oyster reef in order to assess oyster health. We randomly deployed 0.25 m^2 (0.5 m x 0.5 m) quadrats within each mapped oyster reef; we analyzed one to five quadrats per oyster reef depending on the size of the reef. Staff mapped each quadrat location with DGPS and then collected all oysters within the quadrat, placing them in containers for counting and measuring. During removal, biologists were careful not to disturb or remove the underlying layer of dead oyster shells that are important for new oyster recruitment. Biologists enumerated and measured the shell height, the distance from the umbro to the opposite margin, of all live and articulated dead oysters collected. We returned all oyster shell material to the area from which it was collected following our assessment.

Oyster Recruitment Monitoring

To assess oyster recruitment patterns in the Loxahatchee River, we deployed oyster spat monitoring arrays at two locations in the Northwest Fork. Each array consisted of 12 dead

adult oyster shells strung together with the inner shell facing down. We suspended two oyster shell arrays in the water column from a PVC T-bracket approximately 20 cm above river bottom (Figure 2). Staff installed four replicate oyster arrays (two T's) at two locations, one upstream, one downstream (Figure 1). Following a one month deployment, we recovered the array and brought them back to the laboratory for analysis. We exclude the top and bottom shells from the analysis and then counted the number of settled spat on the underside of each of the remaining 10 shells.

Figure 2. Oyster recruitment monitoring array.

Quality Assurance / Quality Control Efforts

LRD staff recorded all field data onto paper data sheets then entered the data into a computerized data management system. Following data entry, each record was cross-checked back to the original data sheets a minimum of two times. We plotted the entire data set to examine and confirm any outliers. We post-processed the GPS perimeter polygon and quadrat point locations using the Trimble Pathfinder Office Software, utilizing the Palm Beach CORS base station data, to maximize the position accuracy. In the GIS (ArcMap® ver 9.3) we ran the "check geometry" function to identify and repair overlapping boundaries of each polygon and ensure accurate acreage calculations.

Results & Discussion

Oyster Mapping & Assessment

LRD staff mapped a total of 91 oyster reefs, with a total area of over 15 acres, throughout the Northwest and Southwest Forks of the Loxahatchee River (Table 1). Figures 3 and 4 show the locations of the oyster reefs mapped in 2008 and 2003. The 56 oyster reefs in the Northwest Fork comprised over 90 percent of the total acreage mapped in 2008. The Southwest Fork contained 35 oyster reefs, but these smaller reefs totaled 1.2 acres. Collectively, the 2008 survey found nearly 50 percent more acreage of oyster than the 2003 survey.

Table 1. Numbers of oyster reefs and total oyster reef acreage for 2003 and 2008 mapping projects in the Loxahatchee River, Jupiter, Florida.

	2003	2008
Northwest Fork		
# Reefs	**48**	**56**
Acres	**9.5**	**13.9**
Southwest Fork		
# Reefs	**24**	**35**
Acres	**0.7**	**1.2**
Totals		
# Reefs	**72**	**91**
Acres	**10.2**	**15.1**

We characterized American oyster density and size for the Northwest and Southwest Forks of the Loxahatchee River in Table 2. In total, we measured 9,188 individual American oysters collected from 164 quadrat samples taken from 91 oyster reefs. In an effort to remove some of the influence of the newly recruited oysters, we also computed summary statistics excluding oysters with a shell height less than 2.5 cm. When we exclude the small, new recruit oysters, from the density calculations, oyster density is similar between the Northwest and Southwest Forks. This may suggest more recruitment occurred in the Northwest Fork. Alternatively, this could be (in part) a sampling artifact because we collected more Northwest Fork surveys during high recruitment months (described in the recruitment section below). Excluding newly recruited oysters, i.e., those smaller than 2.5 cm, approximate American Oyster density was 120 individuals per square meter (or 30 per 0.25 m^2). Of these, approximately 79 percent were alive, with similar results in the Northwest and Southwest forks at 80% and 74%, respectively.

Figures 5 and 6 characterize our 2008 mapped oyster reefs based on observed live oyster densities. In general, oyster reefs in the Northwest Fork were most healthy (i.e., had highest

densities of live oysters) between river miles 4 and 6. Many of the long lived and well studied oyster reefs in the vicinity of the mangrove islands, south of the Island Way Bridge, showed moderate densities ranging from 50 to 150 live oysters per square meter. Oyster densities in the Southwest Fork showed similar spatial variability in live oyster density (Figure 6). Most apparent is the lack of high density oyster reefs (>150 live oyster m^2) in the Southwest Fork. The forthcoming oyster habitat restoration project by LRD and their partners, planned for the area west of Loxahatchee River Road, will significantly increase suitable oyster recruitment substrate, and hopefully will increase the acreage of oyster reefs in this area. This river reach presently supports some oyster reefs with moderate densities (50 to 150 live oysters per m^2), which suggests suitable substrate is the factor most likely limiting oyster occurrence and densities in this area. The mouths of the Sims Creek and Jones Creek tributaries, southeast of the Loxahatchee River Road Bridge, also contained moderate densities of live oysters.

Figures 7 and 8 present the spatial distribution of the percentage of live oysters sampled from the 2008 oyster reefs. In the Northwest Fork, the lowest proportion of live oyster was found in the reefs found furthest up- and down-stream (Figure 7). In the Southwest Fork, there were similar findings were present in the upstream oyster reefs, and substantially more spatial variability in the percentage of live oysters throughout the area (Figure 8). The variability might be due, in part, to variable storm water inflows through the C-18 Canal, Sims Creek, and Jones Creek.

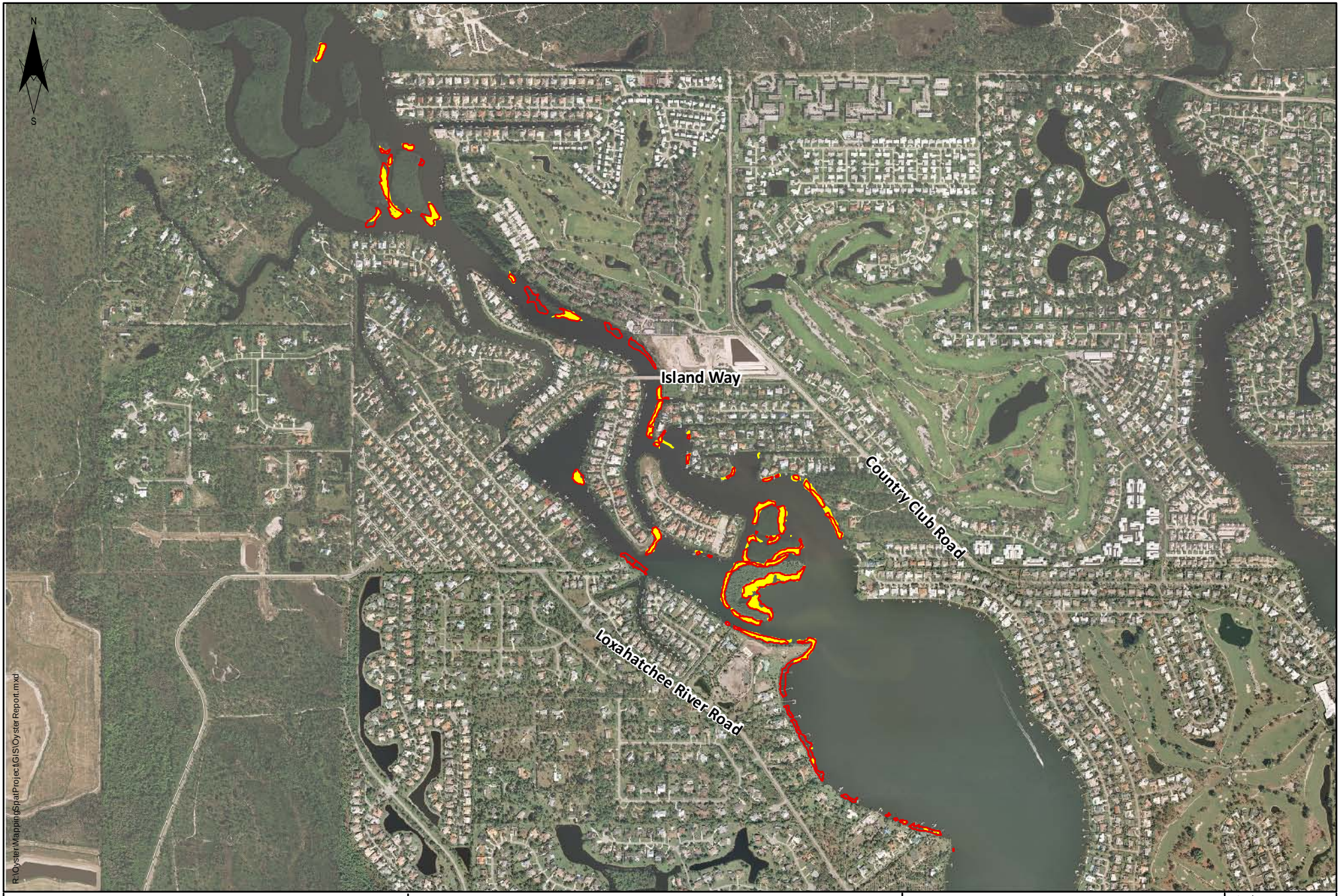
Across the entire Loxahatchee River, American oyster average size (i.e., shell height) was 3.2 cm, or 4.8 cm when newly recruited oysters, those <2.5 cm, were excluded. Oysters in the Southwest Fork were generally larger than those in the Northwest Fork, at 4.4 and 5.7 cm when excluding the new oysters less than 2.5 cm. Figures 9 and 10 present the spatial distribution of the oyster reefs by oyster size. Oysters in the Northwest Fork were generally smaller in the reefs upstream of the Island Way Bridge (Figure 9). The reefs containing the largest oysters were found along the south shoreline, south of the Island Way Bridge. Figure 10 shows the scattered distribution of the generally larger, live oyster shells throughout the Southwest Fork.

Table 2. Summary statistics for live and dead oyster shell counts and measurements from 164 0.25 m^2 quadrats sampled between July 2008 and September 2008, Loxahatchee River, Jupiter, Florida.

	American Oyster (*Crassostrea virginica*)				
	Northwest Fork		Southwest Fork		Total
	Live	Dead	Live	Dead	
# of quadrats containing oysters	114	50	114	50	164
Total # live oysters	6006 (2856)	1491 (1125)	1251 (479)	440 (428)	9188 (4888)
Mean # live oysters per quadrat	53 (25)	25 (10)	13 (10)	9 (9)	56 (30)
Min # live oyster per quadrat	1 (1)	6 (4)	1 (1)	2 (2)	1 (1)
Max # live oyster per quadrat	313 (68)	132 (50)	93 (17)	37 (37)	313 (68)
Mean Shell Height (cm)	2.8 (4.3)	4.5 (5.5)	2.6 (4.9)	6.0 (6.2)	3.2 (4.8)
Min Shell Height	0.5	0.5	0.5	1.0	0.5
Max Shell Height	11.0	15.0	11.5	13.0	15
Std Dev Shell Height	1.7 (1.3)	2.3 (1.8)	2.1 (1.7)	2.1 (1.9)	2.1 (1.7)

( ) excludes new recruit American Oysters with shell height less than 2.5 cm.

Like the 2003 survey, flat oysters were much rarer. Of the 9,224 total oysters measured, we found a total of 36 Flat Oysters (*Isognomon alatus*) in 20 of the 164 total quadrats sampled. The average size for the Flat Oysters was 6.3 cm. In contrast to the American Oyster, the Flat Oysters in the Northwest Fork were larger than those found in the Southwest Fork at 7.0 cm and 5.6 cm.



Loxahatchee River District
2500 Jupiter Park Drive
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Figure 3.
Locations of oyster reefs mapped in 2003 and 2008 throughout the Northwest Fork of the Loxahatchee River, Jupiter, Florida.

2008 Oyster Beds
2003 Oyster Beds
Feet
0 500 1,000 2,000
Aerial Photo: 2007

Project/Report	2008 Oyster
Date	Sept 2008
Revised	
By	BH

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Figure 4.
Locations of oyster reefs mapped in 2003 and 2008 throughout the Southwest Fork of the Loxahatchee River, Jupiter, Florida.

2008 Oyster Beds
2003 Oyster Beds
Feet
0 125 250 500
Aerial Photo: 2007

Project/Report	2008 Oyster
Date	Sept 2008
Revised	
By	BH

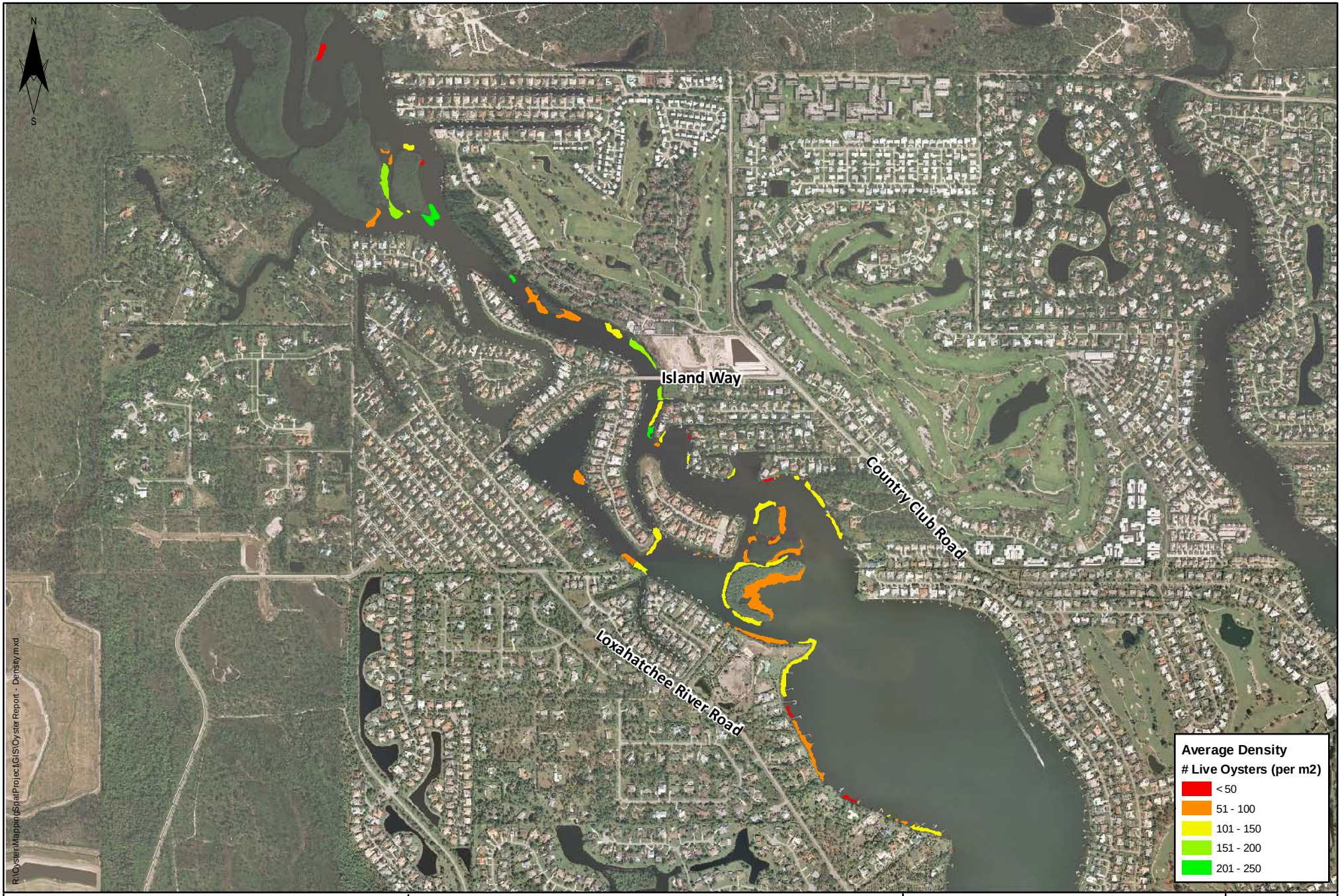

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Figure 5.
Average live oyster density per m2 in each reef mapped in 2008 throughout the Northwest Fork of the Loxahatchee River, Jupiter, Florida. Excludes small (<2.5 cm), new recruit, oysters.

0 500 1,000 2,000 Feet

Aerial Photo: 2007

Project/Report	2008 Oyster
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Figure 6.
Average live oyster density per m2 in each reef mapped in 2008 throughout the Southwest Fork of the Loxahatchee River, Jupiter, Florida. Excludes small (<2.5 cm), new recruit, oysters.

Feet
0 125 250 500
Aerial Photo: 2007

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Figure 7.
Percentage of live oysters sampled in each reef mapped in 2008 throughout the Northwest Fork of the Loxahatchee River, Jupiter, Florida.

0 500 1,000 2,000 Feet

Aerial Photo: 2007

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Date	Sept 2008
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Figure 8.
Percentage of live oysters sampled in each reef mapped in 2008 throughout the Southwest Fork of the Loxahatchee River, Jupiter, Florida.

Feet
0 125 250 500
Aerial Photo: 2007

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Figure 9.
Average shell height (cm) of live oysters in each reef mapped in 2008 throughout the Northwest Fork of the Loxahatchee River, Jupiter, Florida. Excludes small (<2.5 cm), new recruit, oysters.

Feet
0 500 1,000 2,000
Aerial Photo: 2007

Project/Report	2008 Oyster
Date	Sept 2008
Revised	
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Figure 10.
Average shell height (cm) of live oysters in each reef mapped in 2008 throughout the Southwest Fork of the Loxahatchee River, Jupiter, Florida. Excludes small (<2.5 cm), new recruit, oysters.

0 125 250 500 Feet

Aerial Photo: 2007

Project/Report	2008 Oyster
Date	Sept 2008
Revised	
By	BH

Oyster Recruitment

Monthly oyster spat monitoring showed variable settlement patterns at the upstream and downstream monitoring sites in the Northwest Fork of the Loxahatchee River. Peak oyster spat settlement occurred at the downstream monitoring sites in September 2007 with additional recruitment pulses occurring in the spring and summer (Figure 11). These data suggest oyster recruitment peaked in the spring and summer in the Loxahatchee River. These findings are consistent with those obtained by Bill Arnold's team from the Florida Fish & Wildlife Research Institute who monitors recruitment at a location between LRD's upstream and downstream sampling sites (Bill Arnold, pers. comm.). These recruitment results suggest oyster reefs in the Loxahatchee River are likely limited by suitable substrate availability and predation.

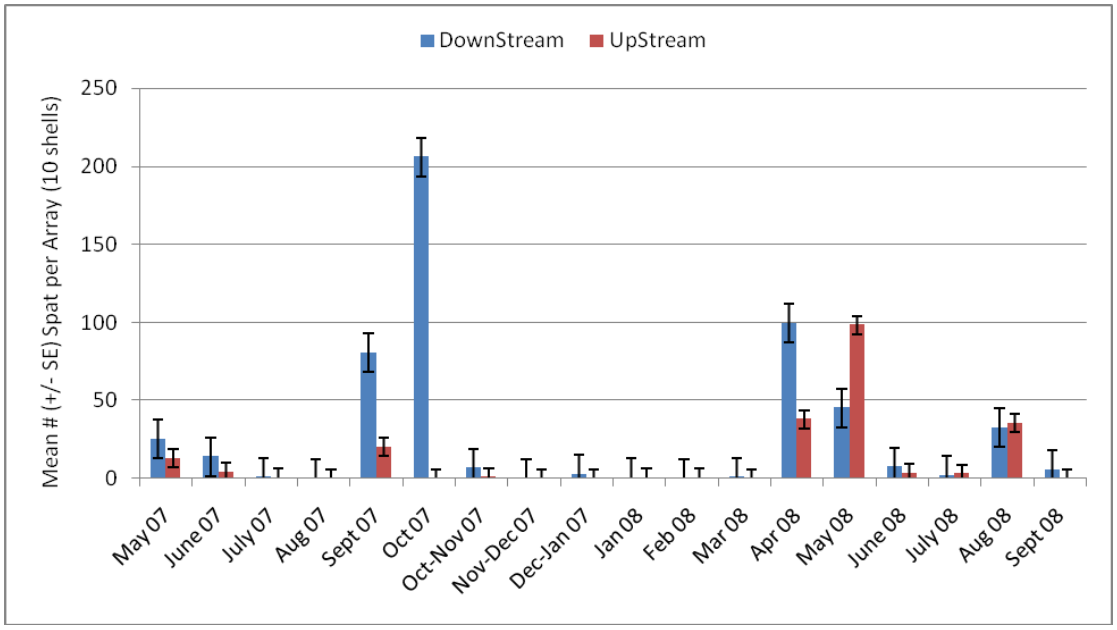

Figure 11. Summary of the monthly oyster spat monitoring in the Northwest Fork of the Loxahatchee River, Jupiter, Florida.

To investigate the potential relationship to river flow and river temperature, we performed some simple correlation analysis on monthly river flows with the monthly recruitment but no relationship was evident. Figure 12 shows recruitment (the mean number of spat per array) as a function of either (a) cumulative river flow or (b) average water temperature. While no obvious relationship is evident, there might be a data "dilution" issue with computing the cumulative water flow and average temperature over roughly 30 days of array deployment. We suspect further inquiry into these data will facilitate our understanding of oyster recruitment dynamics in the Loxahatchee River.

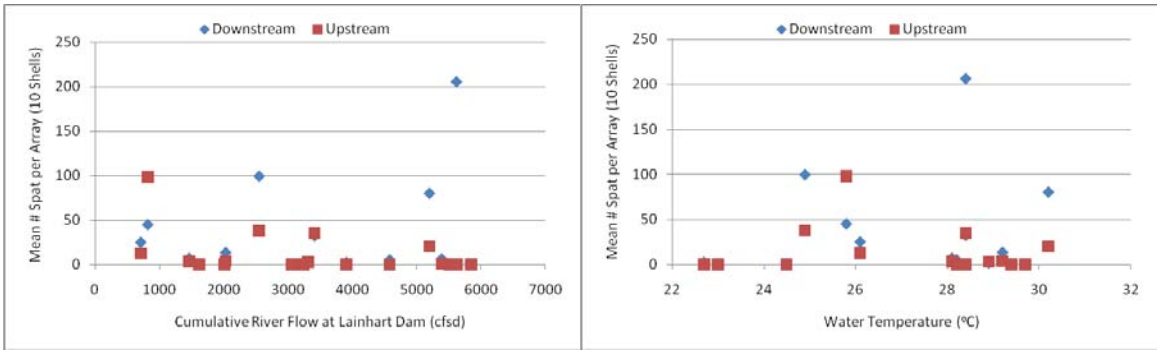

Figure 12. Oyster recruitment with cumulative river flow over Lainhart Dam (Left) and average water temperature measured at Pennock Point (Right), Loxahatchee River, Jupiter, Florida.

With respect to oyster disease, Darryl Hondorp, a Postdoctoral Fellow at the Smithsonian Environmental Research Center, found approximately 35 % of oysters in the Southwest Fork tested positive for *Perkinsus marinus* (a parasite), with those infected showing a relatively light infection (Darryl Hondorp, personal communication).

Summary

Like the various water quality, seagrass, and stormwater monitoring programs that LRD and their partners perform, this oyster monitoring program provides valuable insight into the health and ecological function of the Loxahatchee River. These documented changes in the spatial extent of oyster reefs, the assessment of density and shell size, and the insight into the recruitment patters of oysters throughout the river provide managers with critical information for assessing this resource throughout the ongoing restoration efforts. LRD looks forward to our continued partnerships with the SFWMD and Loxahatchee River Preservation Initiative to improve our understanding, protection, and restoration of these vital resources.

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