Deepwater Horizon
NRDA Early Restoration Project Comprehensive Final Monitoring Report:

Louisiana Oyster Cultch Project

Prepared by: Louisiana Natural Resource Trustees

May 2016

Introduction

The Louisiana Natural Resource Trustees (Trustees) selected the Louisiana Oyster Cultch Project (project) as a Phase I *Deepwater Horizon* (DWH) early restoration project to compensate the public for injury to oysters (*Deepwater Horizon* Oil Spill Natural Resource Trustees, 2012). The project involves (1) placing oyster cultch onto public oyster areas at six locations in coastal Louisiana, (2) monitoring oyster recruitment and production in restored areas to assess performance against specific criteria, and (3) constructing an oyster hatchery facility to improve existing oyster hatchery operations and produce supplemental larvae and seed to help facilitate success of the cultch plantings, if necessary. This document provides the status and performance of this project based on project-specific monitoring activities conducted through May 2015.

This document describes cultch placement activities in detail. This includes a summary of the Louisiana Department of Wildlife and Fisheries (LDWF)-led project-specific sampling methods to monitor the cultch plant sites, followed by project-specific monitoring data results of oyster recruitment and production at project cultch sites. A description of the oyster hatchery facility is also included.

Project Summary and Background

The project is intended to compensate the public for injury to oysters by (1) placing cultch material onto Louisiana public oyster areas, including public oyster seed grounds (POSGs) and public oyster seed reservations (POSRs); and (2) constructing an oyster hatchery facility (*Deepwater Horizon* Oil Spill Natural Resource Trustees, 2012).

Cultch material consists of limestone rock, crushed concrete, oyster shell, and other similar material. Cultch material in oyster-spawning areas provides a substrate on which free-swimming oyster larvae can attach as spat (less than 25-mm long), then grow first into "seed" oysters (25–74 mm), then adult sack-sized oysters (≥ 75 mm; LDWF, 2012b). Over time, cultch material degrades, gets buried, or is removed during oyster harvest and new cultch needs to be added. New cultch material is an excellent substrate for larval oyster spat settlement and harbors fewer oyster predators. Under ideal conditions, oyster spat that settle on cultch can survive and grow into seed oysters within one year (Soniat et al., 2012). In Louisiana, oysters can grow to sack size by approximately 2 years of age (Eastern Oyster Biological Review Team, 2007).

Successful oyster larvae colonization onto planted cultch material requires adult oysters on nearby reefs, natural oyster spawning events, and favorable environmental conditions. When natural larval oyster production is limited, oyster production in a hatchery has the potential to expedite recruitment success in project cultch sites. Once oyster larvae reach the proper age and size in the hatchery, personnel can broadcast the larvae directly over underperforming cultch sites. A hatchery can also be used to grow oyster spat (newly-settled oyster larvae) on small pieces of shell (or "micro-cultch") or on whole oyster shell. Personnel can place hatchery-produced spat on project cultch sites, where the young oysters grow into seed- and sack-sized oysters. Finally, spat can be reared in the hatchery or in a similar nursery area, such as the LDWF remote setting facility in Buras, Louisiana. Personnel can then place hatchery-produced spat oysters in locations where they are expected to grow successfully into seed and sack-sized oysters.

Cultch Site Identification and Cultch Placement

LDWF identified candidate cultch placement sites at six public oyster areas across coastal Louisiana with known current or historical oyster production. The sites were chosen to maximize diversity of habitat conditions in an effort to optimize the potential for success. Because oyster production throughout the region is spatially and temporally variable, diverse site placement helped increase the likelihood of project success compared to an approach of placing all the cultch in one area or areas with similar conditions. Before approving cultch placement in specific locations, the Trustees evaluated proposed oyster cultch areas for the presence/ongoing impacts from contaminants that would preclude successful cultivation. The Trustees also considered proximity to areas of cultural significance, oil and gas operations, and other infrastructure as additional factors when selecting final cultch placement sites (LDWF, 2012a). After considering the results of these investigations, the Trustees identified six sites that were suitable for cultch deployment.

LDWF initiated contracts for oyster cultch material placement in May 2012; contractors completed placement activities at all six sites by June 2013. Planted cultch material consisted of limestone rock and crushed concrete. Contractors deployed cultch over a total of 1,421 acres (Table 1) of existing public oyster areas at six sites: Hackberry Bay, Sister Lake, Bay Crab, Lake Fortuna, 3-Mile Pass, and Drum Bay (Figure 1). The volume of cultch material deployed across all six sites was 171,384 cubic yards. Depending on water-bottom characteristics at the time of implementation, cultch-planting density ranged from 91 cubic yards per acre at Drum Bay to 255 cubic yards per acre at 3-Mile Pass (Table 1).

Lower planting densities occurred at project sites that contained older cultch materials from existing natural reef or previous cultch planting activities not associated with this project. LDWF required higher planting densities to achieve desired cultch thickness at sites with little or no basement substrate. LDWF monitored the contractors' cultch placement during deployment and verified coverage over planned-upon acreage using onsite poling.

Table 1. Summary of Louisiana Oyster Cultch Project cultch placement sites.

Cultch site name	Date completed	Cultch material	Area of cultch plant (acres)	Volume of cultch planted (cubic yards)	Cultch-planting density (cubic yards/acre)
Hackberry Bay	05/21/2012	Limestone	201	26,086	130
Sister Lake	06/02/2012	Limestone	358	37,681	105
Bay Crab	10/06/2012	Limestone	201	20,172	100
Lake Fortuna	11/19/2012	Concrete	301	28,630	95
3-Mile Pass	05/09/2013	Limestone	159	40,504	255
Drum Bay	06/02/2013	Limestone	201	18,311	91
		Totals:	1,421	171,384	

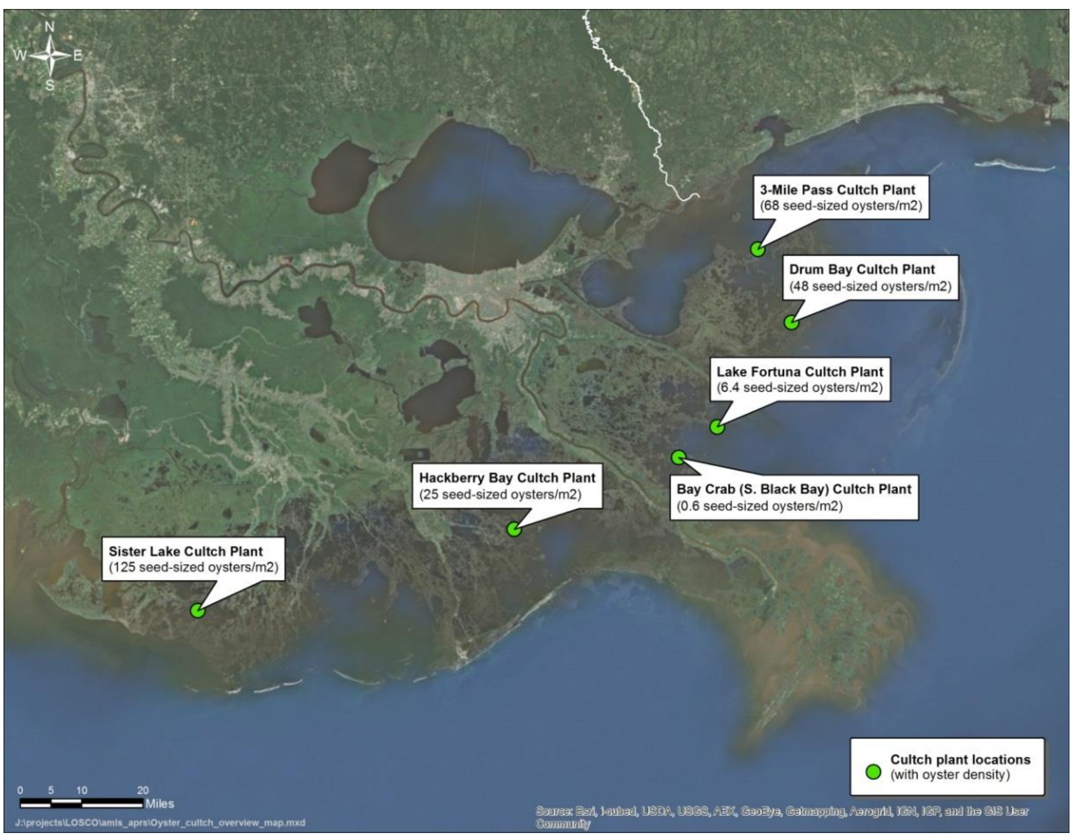

Figure 1. Location of cultch plants and mean density of seed-sized oysters from summer 2014 project-specific sampling.

Project-Specific Monitoring

Project-specific (performance) monitoring began during the summer of 2014, with each site sampled in either June or July 2014 using quantitative quadrat surveys, and again in October 2014, January/February 2015, and April/May 2015 using semi-quantitative oyster dredge as detailed in Louisiana Natural Resource Trustees (2014) cultch project monitoring plan. Trustees used project-specific monitoring data obtained from quadrat surveys to quantitatively estimate oyster settlement and densities at each cultch plant site. Project-specific dredge surveys were used to monitor oyster mortality and growth after quadrat sampling.

Prior to summer 2014, LDWF conducted precursory monitoring at each site using standard LDWF protocols for new cultch plants (LDWF, 2012a). LDWF used standard monitoring results to guide the development of project-specific monitoring protocols (Louisiana Natural Resource Trustees, 2014).

Project-specific quadrat survey methods consisted of dividing each site into equally sized, consecutively numbered grid squares and randomly selecting 20 grids for sampling. Within each randomly selected grid, field crews tossed one 0.25-square-meter polyvinyl chloride (PVC) pipe quadrat off of the sampling vessel onto the cultch plant site bottom. Scuba divers collected all oysters, surficial shell/cultch, and associated reef organisms from the quadrat area for enumeration and analysis. Field crews counted and measured all live and recently dead oysters within each sample before returning them to the water. Crew members also recorded observations of cultch condition.

Given that cultch plants were found to be non-homogeneous, a stratified random design was considered once data from the first quadrat sampling was collected. However, because the first quadrat sampling event clearly showed that density goals were met, there was no need to revise the experimental design and continue sampling. Had additional sampling been needed, selection of sampling locations would have been stratified.

Project-specific dredge survey methods also consisted of dividing each site into equally sized, consecutively numbered grid squares and randomly selecting 20 grids for sampling. Within each randomly selected grid, field crews collected bottom samples using a 24-inch-wide oyster dredge with 10 teeth that was deployed for 3 minutes. The dredge collected oysters, fouling organisms, and other sessile marine organisms. Dredge samples were evaluated in a manner similar to the quadrats: all oysters within each sample were measured and counted prior to returning all organisms to the water. However, oyster-density estimates were not derived from dredge samples, because dredges do not sample a defined area. Even without density data, the dredge sampling data provided important information on oyster recruitment, mortality, growth, and the presence or absence of reef-associated animals after quadrat sampling events.

Performance Criteria

This section provides a summary of the performance of the project with reference to the established performance criteria [see Louisiana Natural Resource Trustees (2014) for a discussion of the performance criteria]. The data used as the basis for this summary evaluation are presented for each cultch plant site in the subsequent section.

- Cultch Plant Construction and Maintenance: Cover a minimum of 850 acres of public oyster areas with suitable cultch material among 6 separate cultch placement sites.
  - Status: Achieved. To date, all six proposed cultch placement sites have been constructed. Cultch plant construction monitoring results indicate that cultch material covered 1,421 acres of water bottom (see Table 1).
- Oyster Resource Development: Achieve average oyster density at or above 20 seed oysters/m^2 across 850 acres of cultch at project sites within 3 years of cultch placement.
  - Status: Achieved. To develop a density estimate across all sites, the density at each site was multiplied by its area, summed to attain the number of seed-sized oysters present across all sites, and divided by the area of all sites combined. The area-weighted average density of seed oysters across all project sites was 51 seed-sized oysters/m^2 (Table 2), with a weighted 95th percentile confidence interval of 32 to 70 oysters/m^2 (Table 2), which exceeds the performance criteria of 20 oysters/m^2. Four of the six cultch sites, covering a total of 919 acres, had mean densities substantially higher than 20 oysters/m^2 (Table 2). The fall 2014, winter 2015, and spring 2015 dredge survey results confirmed that the oyster populations at the cultch sites have remained stable (see subsequent sections). In summer 2015, project cultch plants were between 2 and 3 years old (post-cultch placement). Given the achievement of stated performance criteria, LDWF opened the project cultch sites for harvest during the 2015 oyster harvest season. Details on individual cultch plant performance are provided in the next section.
- Hatchery Construction and Operation: Design, construct, and operate an oyster hatchery capable of producing oyster larvae as needed during project implementation.
  - Status: Achieved. As of summer 2015, the project hatchery construction has been completed and larval production systems are being tested. To date, none of the project cultch plants have received supplemental oyster larvae or been stocked with hatchery-reared oysters.

Table 2. Comparison of summer 2014 project-specific monitoring results to performance criterion for oyster resource development.

Site (see Figure 1)	Cultch area (acres)	Density of live seed-sized oysters (#/m^2)	
		Mean	Std. dev. (SD)
Hackberry Bay	201	25.4	38.39
Sister Lake	358	125.2	149.50
Bay Crab	201	0.6	1.47
Lake Fortuna	301	6.4	9.39
3-Mile Pass	159	68.2	61.93
Drum Bay	201	48.0	145.39
Total	1,421[b]	51.0 (31.6, 70.4)[a,b]	

a. Seed-sized oyster density across all sites (area-weighted mean and 95% confidence interval).
b. Achieve average oyster density at or above 20 seed oysters/m^2 across 850 acres of cultch at project sites within 3 years of cultch placement.

- Upon meeting or exceeding stated performance criteria specified in the Louisiana Natural Resource Trustees (2014) monitoring plan, a comprehensive final monitoring report will be developed and all project-specific performance monitoring would cease.
    - Status: Achieved. As of July 2014, all performance criteria have been met and/or exceeded; this document serves as the final comprehensive monitoring report; and project-specific performance monitoring has ended. The spring 2015 monitoring surveys described in this report were the final project-specific surveys conducted for this project.

Status of Cultch Placement Sites

This section provides a summary of project-specific monitoring data, including oyster density, size, and mortality, that LDWF collected at each cultch plant site.

Hackberry Bay

The Hackberry Bay cultch plant site is located in Barataria Bay within Louisiana's Coastal Study Area 3 (CSA 3; Figure 2). This CSA includes three public oyster areas. The oldest, Hackberry Bay, became a POSR in 1944 (LDWF, 2012b). LDWF has conducted cultch plantings in this area since 1943 to bolster oyster production. Little natural reef exists in the Hackberry Bay POSR; production depends on when and where cultch plants were placed in the bay. The addition of the Hackberry Bay cultch plant restoration project in May 2012 effectively tripled the available oyster reef acreage of the Hackberry Bay POSR from 99.7 to 299.7 acres (Louisiana Natural Resource Trustees, 2014).

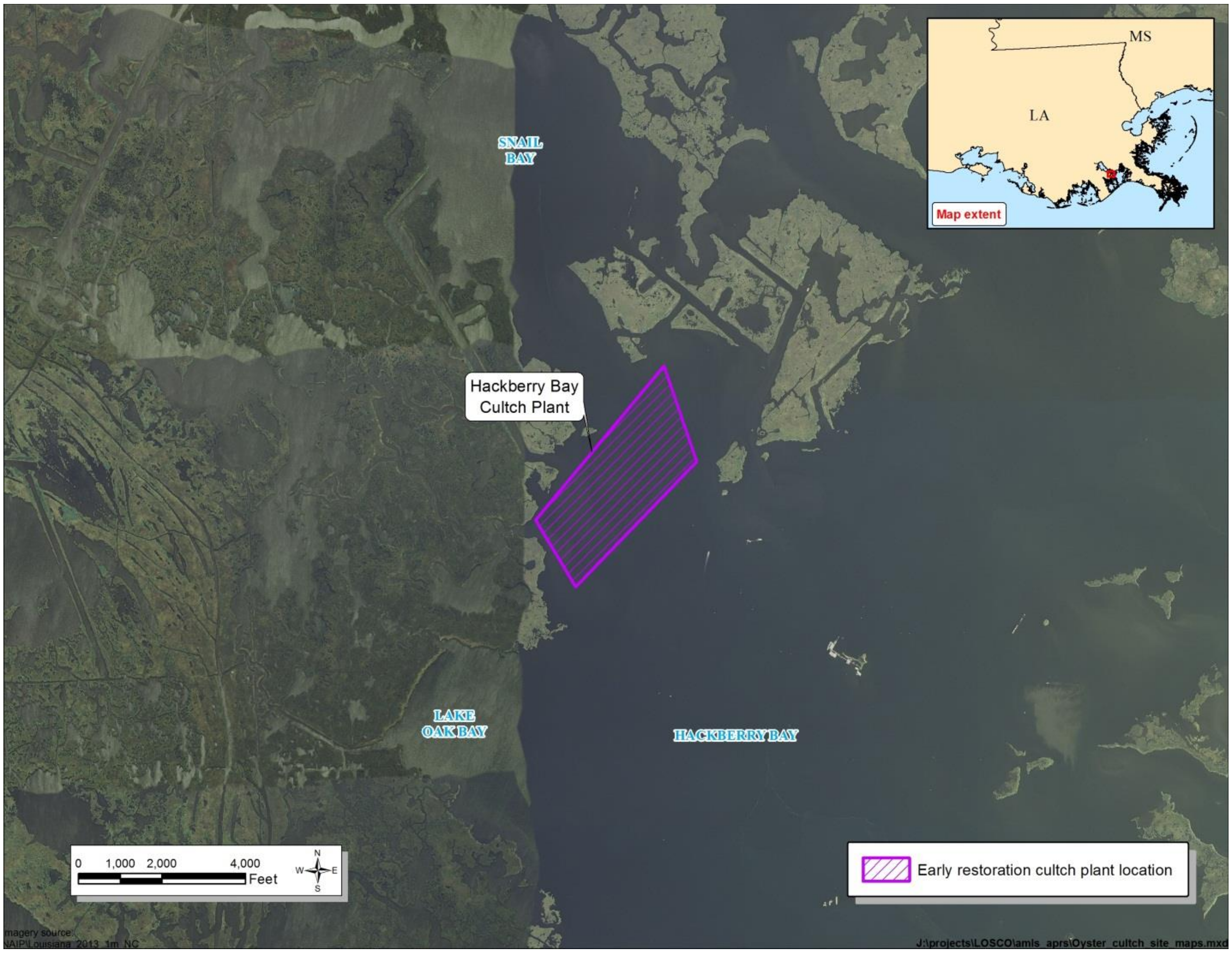

Figure 2. Hackberry Bay cultch plant placement site.

Project-specific sampling conducted in summer and fall 2014 showed good recruitment of seed oysters with low mortality throughout the project cultch site. At 26 months post-cultch placement, the average density of seed oysters on the cultch plant was 25.4 seed-sized oysters/m^2 (Table 3). Oysters were evenly distributed throughout most of the Hackberry Bay cultch plant. LDWF conducted the first project-specific dredge sampling event at this site in October 2014 at 29 months post-placement. Live oysters were observed in 13 of the 20 replicates. A large cohort of live seed- and sack-sized oysters and a few dead oysters were observed (Table 3). The majority of live seed oysters ranged from 42.5 to 72.5 mm in shell length. The majority of sack-sized oysters were just over the 75-mm sack-size classification threshold.

Although mortality estimates remained low, the number of live seed- and sack-sized oysters decreased in the January 2015 dredge sampling compared to October 2014. Sack-sized oyster counts subsequently increased in May 2015, while seed-sized oyster counts were similar in January and May 2015 (Table 3).

Table 3. Hackberry Bay cultch site project-specific monitoring results. Note that dredge surveys do not provide oyster-density estimates.

Survey month/year (survey method)	July 2014 (quadrat)	October 2014 (dredge)	January 2015 (dredge)	May 2015 (dredge)
Live spat density (#/m^2)	3.2	–	–	–
Live spat count[a]	16	12	3	2
Spat mortality	30.4%	14.0%	0.0%	0.0%
Live seed density (#/m^2)	25.4	–	–	–
Live seed count[a]	127	1,270	290	296
Seed mortality	10.6%	0.5%	1.4%	8.4%
Live sack density (#/m^2)	0.2	–	–	–
Live sack count[a]	1	159	33	181
Sack mortality	0.0%	1.2%	0.0%	3.7%

a. Counts refer to the total number of live oysters sampled in 20 replicate samples.

Overall, the Hackberry Bay cultch site had achieved the density performance criterion in July 2014 at approximately 26 months post-cultch placement. Over the following winter and spring, these seed-sized oysters likely grew and contributed to a strong cohort of sack-sized oysters observed in spring 2015. Moderate numbers of seed-sized oysters were also observed in spring 2015, indicating ongoing oyster production.

Sister Lake

The Sister Lake cultch site is in Terrebonne Bay in Louisiana's CSA 5. Similar to Hackberry Bay, Sister Lake is in a State POSR established in 1940. Historically, Sister Lake is the most productive public oyster area in the Terrebonne basin, with successful cultch plants dating back to the early 1900s (LDWF, 2012b).

Sister Lake is the largest project cultch plant site, totaling 358 acres. Before cultch placement, side-scan sonar surveys of the Sister Lake POSR area showed that the reef covered approximately 2,280 acres in 2012 (LDWF, 2012b). The estimated total reef covered in the Sister Lake POSR after project cultch placement increased by approximately 100 acres to 2,375 acres, indicating that the majority of project cultch was placed atop existing reef (LDWF, 2013). The project cultch plant site is in the middle of the Sister Lake POSR (Figure 3).

LDWF conducted the first project-specific quadrat sampling event approximately 26 months after cultch placement and observed high densities of seed-sized oysters (125 seed-sized oysters/m^2; Table 4). Moderate densities of sack-sized oysters were also observed (approximately 6 sack-sized oysters/m^2; Table 4). These sack-sized oysters may have grown from spat settlement on the project cultch in the two years after cultch placement, or they may have grown from the functioning cultch that existed within the footprint of the site prior to project cultch placement activities.

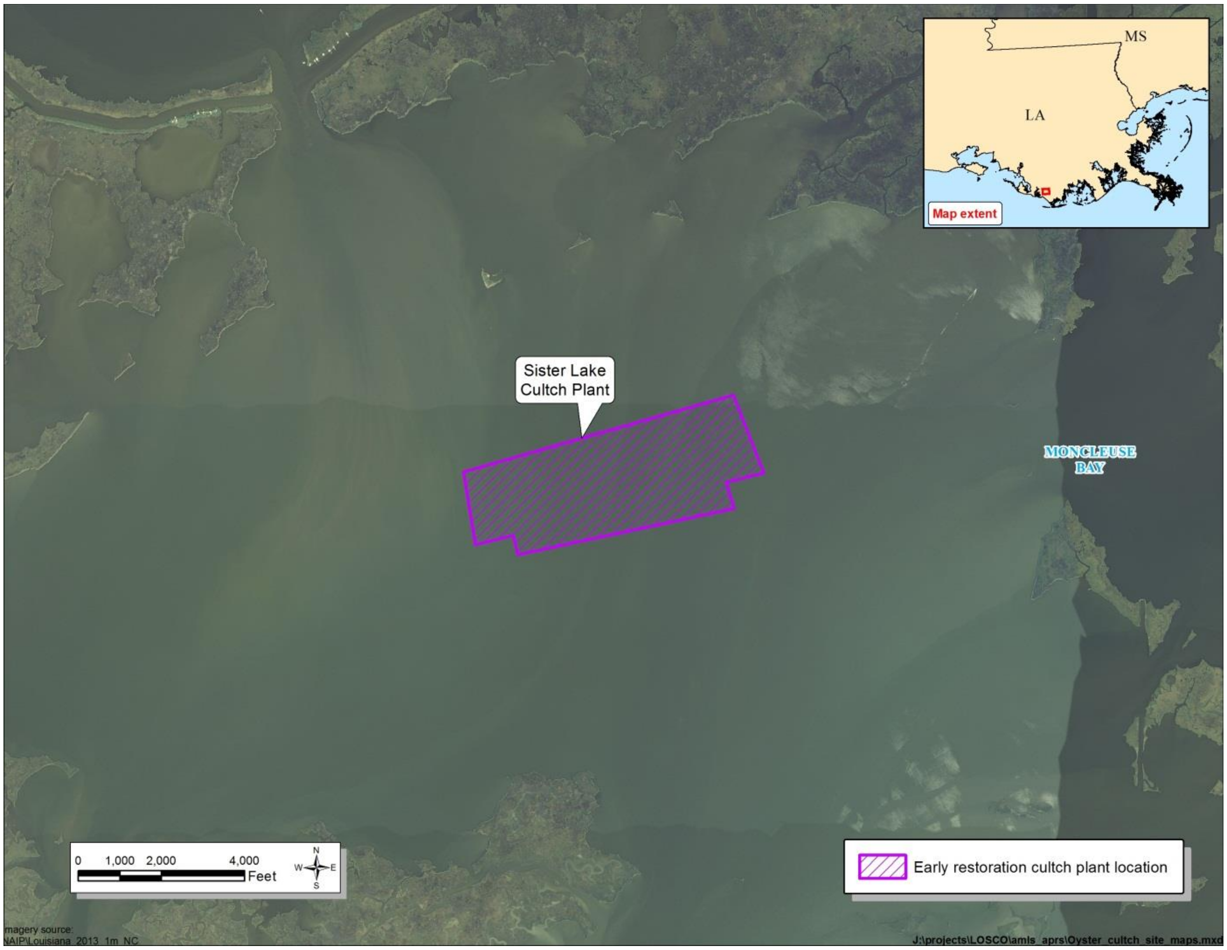

Figure 3. Sister Lake cultch plant placement site.

Table 4. Sister Lake cultch site project-specific monitoring results. Note that dredge surveys do not provide oyster-density estimates.

Survey month/year (survey method)	July 2014 (quadrat)	October 2014 (dredge)	February 2015 (dredge)	April 2015 (dredge)
Live spat density (#/m^2)	2.4	–	–	–
Live spat count[a]	12	341	434	353
Spat mortality	0.0%	4.7%	7.1%	6.4%
Live seed density (#/m^2)	125	–	–	–
Live seed count[a]	626	1,090	2,710	1,602
Seed mortality	0.2%	0.5%	0.7%	0.5%
Live sack density (#/m^2)	5.8	–	–	–
Live sack count[a]	29	252	803	671
Sack mortality	0.0%	0.0%	0.1%	0.3%

a. Counts refer to the total number of live oysters sampled in 20 replicate samples.

October 2014 dredge sampling results indicated that seed- and sack-sized oysters continued to survive and grow at this site. Additionally, a moderate number of live spat-sized oysters were evenly distributed throughout most of the Sister Lake cultch plant (Table 4). By February 2015, seed- and sack-sized oysters more than doubled over those seen in October 2014. The numbers of seed- and sack-sized oysters declined in April 2015 but were still abundant, with low mortality (Table 4).

In summary, Sister Lake has consistently been the most productive of all project cultch sites. Summer 2014 density estimates were five times greater than stated performance criteria. Since that time, seed- and sack-sized oyster numbers remained high and mortality low. This site will be approximately 3-years-old this summer and appears to be a mature cultch site.

Bay Crab

The Bay Crab (or South Black Bay) cultch plant is located in CSA 1 South Pontchartrain Basin POSG (Figure 4). LDWF has operated an active cultch planting program in this area since the early 1900s. In this CSA, oyster recruitment and survival are heavily influenced by Mississippi River discharge via levee gaps, freshwater diversion structures, and main-stem distributaries (LDWF, 2012b). Previous stock assessments in this area, prior to the fall 2012 Bay Crab cultch placement, showed substantial declines of oyster abundance – down 95% to 98% compared to long-term averages. Experts attributed poor oyster performance in 2012 to salt-wedge-induced hypoxia, spring freshets that occurred during peak spawning times, sedimentation, subsidence, disintegration of extant cultch material, and abundant oyster predators and fouling organisms (LDWF, 2013). LDWF reported that oyster stocks in this POSG showed improvement in 2013 surveys compared to the extremely low abundance estimated in 2012 (LDWF, 2013).

LDWF observed low oyster densities during the first summer 2014 project-specific sampling event, roughly 20 months after cultch placement. In the 20 replicates that LDWF sampled throughout the entire Bay Crab cultch plant, only 3 replicates had 1 oyster seed each. In addition, LDWF did not observe any spat- or sack-sized oysters. LDWF observed similar trends of low oyster recruitment during the October 2014 dredge sampling (Table 5). However, live oysters were observed in 11 of the 20 replicate samples, which may indicate a slight improvement in oyster production from the previous sampling event.

Greater numbers of seed-sized oysters were observed in January 2015 than in October 2014. Numbers of seed-sized oysters continued to increase, as evident in April 2015 dredge survey results (Table 5). Although the oyster production has improved, the numbers of seed- and sack-sized oysters are low, and no spat have been found since October 2014. Lack of spat settlement indicates that there may be limited recruitment of seed oysters in the future.

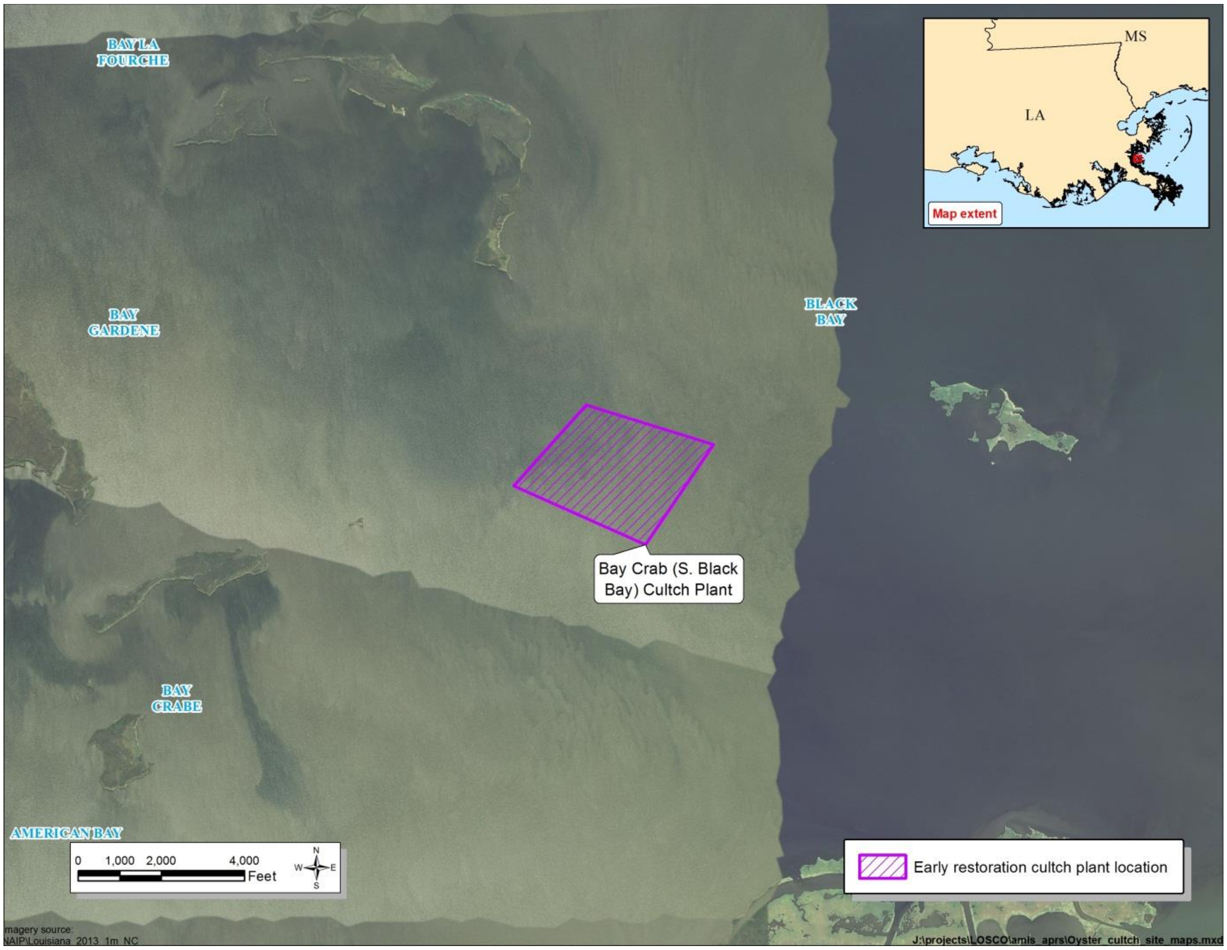

Figure 4. Bay Crab cultch plant placement site.

Table 5. Bay Crab cultch site project-specific monitoring results. Note that dredge surveys do not provide oyster-density estimates.

Survey month/year (survey method)	July 2014 (quadrat)	October 2014 (dredge)	January 2015 (dredge)	April 2015 (dredge)
Live spat density (#/m^2)	–	–	–	–
Live spat count[a]	0	1	0	0
Spat mortality	–	0.0%	–	–
Live seed density (#/m^2)	0.6	–	–	–
Live seed count[a]	3	15	28	40
Seed mortality	0.0%	0.0%	0.0%	0.0%
Live sack density (#/m^2)	–	–	–	–
Live sack count[a]	0	14	120	98
Sack mortality	–	0.0%	0.0%	0.0%

a. Counts refer to the total number of live oysters sampled in 20 replicate samples.

In summary, LDWF's monitoring indicates that oyster recruitment and productivity has been poor at the Bay Crab cultch plant. This observation is consistent with results from historical sampling on nearby natural reefs, which have also shown little to no spat settlement in the area since fall of 2009 (LDWF, 2013).

Lake Fortuna

Similar to Bay Crab, the Lake Fortuna cultch plant (Figure 5) is in the Pontchartrain Basin POSG (CSA 1 South), about eight miles northeast of the Bay Crab cultch plant. The same environmental stressors and recent declines in oyster stocks that LDWF has observed near Bay Crab may influence oyster performance in and near the Lake Fortuna cultch plant (LDWF, 2013).

Figure 5. Lake Fortuna cultch plant placement site.

LDWF conducted project-specific quadrat sampling at the Lake Fortuna cultch plant, approximately 20 months post-cultch placement. Although oysters in all size classes were observed, densities of spat (1.4 oysters/m^2), seed (6.4 oysters/m^2), and sack (0.2 oysters/m^2) oysters were low (Table 6). LDWF conducted the second round of project-specific sampling during the October 2014 dredge survey. Dredge survey results showed that spat-sized oysters were nearly nonexistent, with only 1 spat-sized oyster collected over 20 replicate sample locations. Relatively low numbers of seed- and sack-sized oysters were also observed during the October 2014 dredge survey (Table 6). January and April 2015 dredge surveys indicated a moderate improvement in seed- and sack-sized oysters at this cultch plant, with low mortality. However, few spat-sized oysters were observed during these surveys.

Table 6. Lake Fortuna cultch site project-specific monitoring results. Note that dredge surveys do not provide oyster-density estimates.

Survey month/year (survey method)	July 2014 (quadrat)	October 2014 (dredge)	January 2015 (dredge)	April 2015 (dredge)
Live spat density (#/m^2)	1.4	–	–	–
Live spat count[a]	7	1	4	0
Spat mortality	12.5%	0.0%	0.0%	–
Live seed density (#/m^2)	6.4	–	–	–
Live seed count[a]	32	20	106	66
Seed mortality	8.6%	9.1%	1.9%	0.0%
Live sack density (#/m^2)	0.2	–	–	–
Live sack count[a]	1	3	60	64
Sack mortality	0.0%	0.0%	1.6%	0.0%

a. Counts refer to the total number of live oysters sampled in 20 replicate samples.

In summary, the LDWF's monitoring indicates a lack of spat-sized oysters which may result in a delayed ability to achieve recruitment and production target densities for seed- and sack-sized oysters at the Lake Fortuna cultch plant.

3-Mile Pass

The 3-Mile Pass cultch plant is located in the North Pontchartrain Basin POSG (CSA 1 North; Figure 6). Unlike most other Louisiana CSAs, this area did not become a public oyster area until the late 1980s. The State of Louisiana has continually expanded and enhanced oyster reefs in this area through cultch placement activities. Historically, CSA 1 North has had high oyster production. However, similar to other nearby CSAs, oyster stocks near 3-Mile Pass have declined in recent years. The lowest recorded oyster stock sizes at CSA 1 North occurred in 2011 (LDWF, 2012b). While the 2012 stocks showed an increase in oyster production from 2011, stock sizes were still a fraction of historical averages and densities were highly variable. LDWF (2012b) attributed recently observed declines in seed and sack oysters to several years of heavy harvest, high recent mortalities, strong tropical storms, and impacts from the DWH spill and related response activities.

Figure 6. 3-Mile Pass cultch plant placement site.

Poor cultch condition was also noted as being a cause of poor spat settlement. For example, in 2012 LDWF noted that cultch was covered with silt and fouling organisms, and it had deteriorated into small "hash" particles in many areas within the CSA. As such, LDWF needed a greater volume and thickness of cultch material compared to other restoration sites to re-establish a functioning substrate for oyster recruitment. The 3-Mile Pass cultch plant covered approximately 160 acres of the CSA-1 North water bottom at a rate of 255 cubic yards of cultch per acre. Contractors completed the 3-Mile Pass cultch plant in May 2013, near the beginning of the 2013 oyster spawning season.

LDWF conducted project-specific monitoring in July 2014, approximately 14 months post-cultch placement. July 2014 quadrat sampling revealed high densities of seed-sized oysters (Table 7). LDWF observed oysters in almost all of the 20 randomly selected sampling replicates, with a generally even distribution across the entire cultch plant. Additionally, no dead oysters were found during the summer 2014 survey.

Table 7. 3-Mile Bay cultch site project-specific monitoring results. Note that dredge surveys do not provide oyster-density estimates.

Survey month/year (survey method)	July 2014 (quadrat)	October 2014 (dredge)	January 2015 (dredge)	April 2015 (dredge)
Live spat density (#/m^2)	3.8	–	–	–
Live spat count[a]	19	409	138	63
Spat mortality	0.0%	3.3%	0.0%	6.0%
Live seed density (#/m^2)	68.2	–	–	–
Live seed count[a]	341	886	2,382	1,505
Seed mortality	0.0%	0.4%	0.1%	1.0%
Live sack density (#/m^2)	0	–	–	–
Live sack count[a]	0	27	186	134
Sack mortality	–	0.0%	0.0%	0.0%

a. Counts refer to the total number of live oysters sampled in 20 replicate samples.

LDWF observed oyster growth in all size classes with low mortality during the October 2014 dredge survey (Table 7). Similar to the summer 2014 project-specific sampling, live oysters were observed in replicate samples collected throughout the entire site. This trend continued into 2015, including a substantial increase in both seed- and sack-sized oysters in the January 2015 dredge survey. These oysters likely originated from the large cohorts of spat- and seed-sized oysters observed in October 2014. In April 2015, the numbers of oysters in all size classes decreased, but mortality was low and oysters were still observed in moderate abundance.

The 3-Mile Bay site was one of the better performing sites among project cultch plants. July 2014 seed-sized oyster density was almost three times greater than the project performance criterion of at or above 20 seed-sized oysters/m^2. Subsequent dredge surveys consistently found high numbers of oysters in all size classes with low mortality. With high spat recruitment and low mortality, it is likely that high densities of seed- and sack-sized oysters will continue to be present at this site.

Drum Bay

The Drum Bay cultch site (Figure 7) is located in the North Pontchartrain Basin POSG (CSA 1 North), approximately 13 miles south of the 3-Mile Pass project cultch plant. The Drum Bay location experienced similar recent declines in oyster stocks, environmental stressors, and cultch condition as has occurred in other CSA 1 North locations.

Figure 7. Drum Bay cultch plant placement site.

In summer 2014, LDWF conducted the first of four project-specific monitoring events at the Drum Bay cultch plant site, approximately 13 months after cultch placement. LDWF observed relatively high densities of seed-sized oysters during this sampling event (48 seed oysters/m^2; Table 8) with high spatial variability. A single replicate sample accounted for 66% of the total oysters observed at the cultch plant site. Oysters were found in only 7 of the 20 replicates.

LDWF conducted a project-specific dredge sampling event in October 2014 approximately three months after the summer quadrat survey and observed moderate numbers of live seed- and sack-sized oysters (Table 8). They also observed little to no mortality, indicating that younger oysters were surviving and growing over the 2014 oyster growing season. Live oysters were sampled in 13 of the 20 replicate dredge locations, which was an improvement from the seemingly patchy distribution observed in the previous summer quadrat sampling event.

Table 8. Drum Bay cultch site project-specific monitoring results. Note that dredge surveys do not provide oyster-density estimates.

Survey month/year (survey method)	July 2014 (quadrat)	October 2014 (dredge)	January 2015 (dredge)	April 2015 (dredge)
Live spat density (#/m^2)	0.8	–	–	–
Live spat count[a]	4	17	69	51
Spat mortality	0.0%	0.0%	1.4%	0.0%
Live seed density (#/m^2)	48	–	–	–
Live seed count[a]	240	189	355	333
Seed mortality	0.4%	0.0%	0.6%	1.5%
Live sack density (#/m^2)	0.2	–	–	–
Live sack count[a]	1	92	482	322
Sack mortality	0.0%	1.1%	0.0%	0.3%

a. Counts refer to the total number of live oysters sampled in 20 replicate samples.

Dredge survey results from January 2015 showed that numbers of all size class oysters increased from the previous fall, with relatively low mortality. The April 2015 dredge survey results indicated that numbers of oysters remained stable, with little decrease from what was observed in January 2015 and continued low mortality (Table 8).

The Drum Bay cultch plant exceeded the 20 seed-sized oysters/m^2 performance criterion in July 2014. Subsequent dredge surveys indicate that oysters in all size classes are surviving and production may have increased throughout the site into the 2015 oyster growing season. With high spat recruitment and low mortality, it is likely that high densities of seed- and sack-sized oysters will continue to be present at this site.

Comparison to Pre-Project Conditions

Data collected during the regular oyster stock assessment sampling in July of 2011 and 2012 at nearby stations serves as an adequate baseline for comparison and is provided in Table 9 below. This data shows increased seed oyster densities compared to adjacent stations pre-project, indicating the provision of cultch material increased oyster recruitment and production. The reported increase in production is likely greater than what is shown in Table 9.

Table 9: Comparison of pre- and post- cultch plant production using densities (per square meter) at LDWF oyster stock assessment quadrat sampling stations at locations adjacent to cultch plants.

NRDA Cultch Plant	LDWF Stock Assessment Quadrat Samples						NRDA Cultch Plant Quadrat Samples	
	Station	2011		2012			2014	
		Seed	Sack	Seed	Sack		Seed	Sack
3-mile Pass	3-mile Pass	0.8	0.0	0.6	0.6		68.2	0.0
Drum Bay	Drum Bay	0.0	0.0	1.2	0.2		48.0	0.2
Lake Fortuna	Lake Fortuna	0.0	0.0	0.2	0.0		6.4	0.2
Bay Crab	East Bay Crab	0.0	0.2	0.0	0.0		0.6	0.0
Hackberry Bay	Middle	5.6	0.3	5.4	3.0		25.4	0.2
Sister Lake	217	5.0	2.6	0.4	0.0		125	5.8

Potential Economic Impacts

Using the densities of seed oysters found on cultch plants during the 2014 quadrat sampling, estimates of the potential availability of market oyster resource and associated value were determined using the conversion formula found in Melancon 1990 and a market price of $50 per sack (Table 10). It should be noted that there are several assumptions in this market value estimation that could cause these estimates to deviate from reality. These assumptions include: the number of seed oysters per sack, the growth and mortality of seed oysters that determines number of market sacks per seed sack, and a harvest efficiency of 100%.

Table 10: Potential market value for the observed cultch plant seed oyster resource.

NRDA Cultch Plant	Acreage	2014 Seed Density (sq m^{-1})	Total Seed Availability (number)	Total Seed Availability (Sacks)	Total Market Availability (Sacks)	Value
3-mile Pass	159	68.2	43,883,302	121,898	204,789	$10,239,437.06
Drum Bay	201	48	39,044,071	108,456	182,206	$9,110,283.18
Lake Fortuna	301	6.4	7,795,864	21,655	36,381	$1,819,034.98
Bay Crab	201	0.6	488,051	1,356	2,278	$113,878.54
HackBerry Bay	201	25.4	20,660,821	57,391	96,417	$4,820,858.18
Sister Lake	358	125	181,096,825	503,047	845,119	$42,255,925.81
Total	1,421	45.6	292,968,933	813,803	1,367,188	$68,359,417.75

Monitoring Summary

Across all the cultch sites, the following trends were observed based on project-specific monitoring data:

- Overall, cultch placement has increased oyster production and oyster recruitment from pre-project conditions.
- Oyster spat settlement, growth, seed production, and mortality were variable between project cultch sites. However, spatial trends in oyster performance are apparent. For example, cultch placement sites located in Terrebonne, Barataria, and North Pontchartrain basins are substantially outperforming sites located in the South Pontchartrain Basin. An analysis of spatial and temporal variability of oyster population dynamics is relevant to, but beyond the scope of this report.
- Project-specific monitoring was conducted during summer and fall 2014 and winter and spring 2015 using 20 randomly placed replicate samples. Observations of oysters in replicate samples provided more accurate estimates of density and spatial variability of oyster abundance, survival, and growth at each site than standard sampling methods with fewer replicates.
- Based on survey data from July 2014 to April 2015, the average area-weighted density of seed-sized oysters across all of the project cultch plant sites meets the performance criterion of 20 seed oysters/m^2. Results of the most recent dredge surveys indicate that oyster populations have had good survival and have increased from summer 2014 at the majority of the cultch placement sites.

Oyster Hatchery

The State of Louisiana started construction on the oyster hatchery for this project in 2013 and started hatchery testing operations in summer 2015. To date, no hatchery-reared oysters have been used to augment oyster production in any of the six cultch plant locations described in this report. Given that the project cultch plants have exceeded performance criteria within the stated timeframe and were opened for harvest during the 2015 oyster harvest season, the Trustees do not expect to extensively utilize hatchery-produced spat for this project. However, hatchery-produced oysters will be used to augment natural production on the State’s existing and future public seed grounds.

References

Deepwater Horizon Oil Spill Natural Resource Trustees. 2012. *Deepwater Horizon* Oil Spill Phase I Early Restoration Plan and Environmental Assessment. April. Available at: http://www.doi.gov/deepwaterhorizon/upload/Final-ERP-EA-041812-2.pdf. Access date: 5/22/2014.

Eastern Oyster Biological Review Team. 2007. Status review of the eastern oyster (Crassostrea virginica). Report to the National Marine Fisheries Service, Northeast Regional Office. February 16. NOAA Tech. Memo. NMFS F/SPO-88, 105 p. Available at: http://spo.nwr.noaa.gov/tm/TMSPO88.pdf. Access date: 12/16/2014.

LDWF. 2012a. Sampling Protocol for Projects in Public Oyster Areas. State of Louisiana, Department of Wildlife and Fisheries. Revised January 1, 2012, Effective Date March 1, 2012.

LDWF. 2012b. Oyster Stock Assessment Report of the Public Oyster Areas in Louisiana Seed Grounds and Seed Reservations. Oyster data report series No. 18. State of Louisiana, Department of Wildlife and Fisheries. July. Available at: http://www.wlf.louisiana.gov/sites/default/files/pdf/page_fishing/32695-Oyster%20Program/2012_oyster_stock_assessment.pdf. Access date: 5/22/2014.

LDWF. 2013. Oyster Stock Assessment Report of the Public Oyster Areas in Louisiana Seed Grounds and Seed Reservations. Oyster data report series No. 19. State of Louisiana, Department of Wildlife and Fisheries. August. Available at: http://www.wlf.louisiana.gov/sites/default/files/pdf/page_fishing/32695-Oyster%20Program/2013_oyster_stock_assessment_report.pdf. Access date: 9/25/2014.

Louisiana Natural Resource Trustees. 2014. Deepwater Horizon NRDA Monitoring Plan Phase I Early Restoration: Louisiana Oyster Cultch Project. Final Revised November 2014.

Melancon, E.J. 1990. Environmental and Economic Influences on the Oyster Fishery of Lower Barataria Bay, Louisiana. Dissertation. Louisiana State University. 310 pp.

Soniat, T.M., J.M. Klinck, E.N. Powell, N. Cooper, M. Abdelguerfi, E.E. Hofmann, J. Dahal, S. Tu, J. Finigan, B.S. Eberline, J.F. La Peyre, M.K. La Peyre, and F. Qaddoura. 2012. A shell-neutral modeling approach yields sustainable oyster harvest: A retrospective analysis of the Louisiana state primary seed grounds. *Journal of Shellfish Research* 31(4). Available at: http://www.oystersentinel.org/sites/default/files/docs/SoniatEtAl2012Model.pdf. Access date: 9/25/2014.