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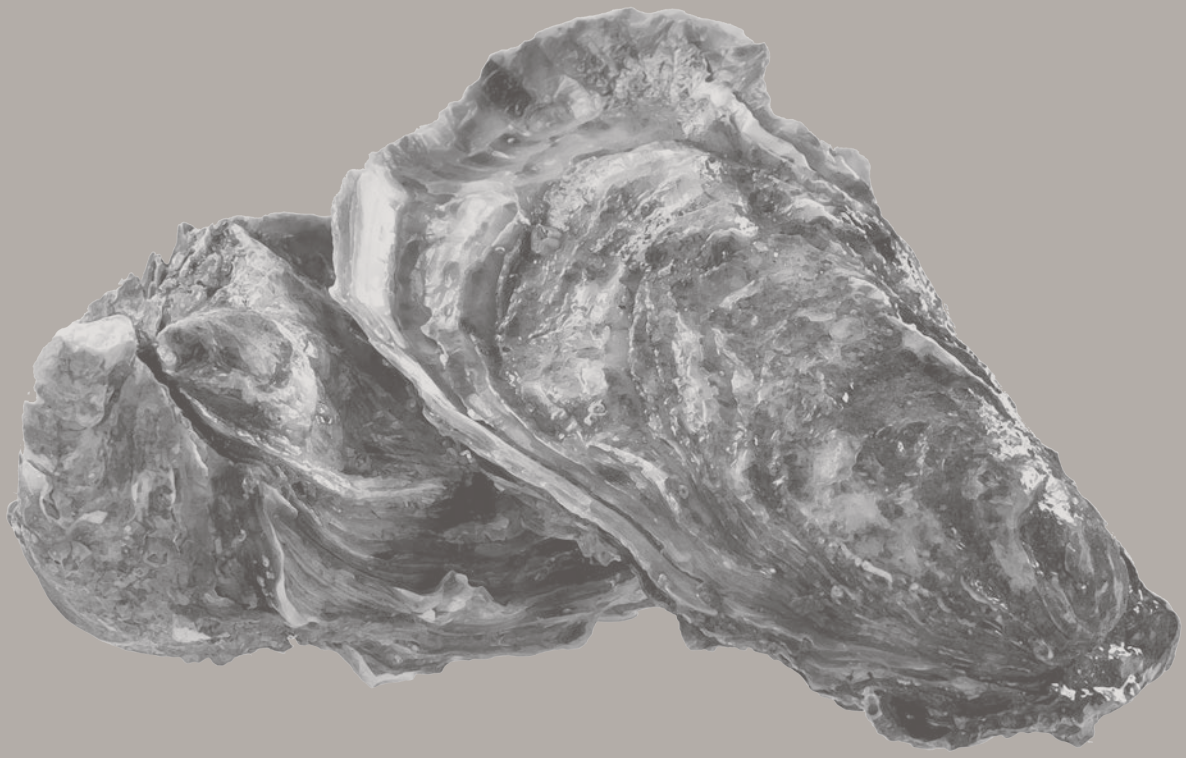

LOUISIANA OYSTER

2019 Stock Assessment Report of the Public Oyster Seed Grounds and Reservations of Louisiana

Oyster Data Report Series No. 25

LOUISIANA DEPARTMENT OF WILDLIFE & FISHERIES

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TABLE OF CONTENTS

LIST OF TABLES & FIGURES

TABLES

FIGURES

STATEWIDE OVERVIEW

OYSTERS TRANSPLANTED AND PLACED IN MODIFIED CRAB CAGES FOR EXPERIMENTAL PURPOSES AFTER THE 2019 UNPRECEDENTED FLOOD EVENT THAT CAUSED EXTENSIVE OYSTER MORTALITY ACROSS ALL THE BASINS IN LOUISIANA.

Introduction

Louisiana's vast coastal wetlands provide ample habitat where Eastern oysters (*Crassostrea virginica*) thrive under a variety of environmental conditions. Louisiana's Eastern oyster stock is one of the largest oyster stocks in the nation, supporting one of state's largest and most valuable fisheries, and providing important ecological services to the state. The Louisiana Department of Wildlife and Fisheries (LDWF) is charged with managing the state's oyster resource by closely monitoring the size and health of oyster populations on nearly 1.7 million acres of public oyster areas (*Figure 1*) as well as setting oyster seasons, monitoring harvest levels, and enhancing habitat (e.g., cultch planting, reef building, etc.).

The oyster industry has historically used Louisiana's public oyster areas as a source of seed oysters (less than 3 inches in length) to transplant to private oyster leases and grow out to market size. In Louisiana, there are approximately 404,000 acres of private oyster leases that are managed by leaseholders. The public oyster areas also yield a supply of market-size oysters (greater than or equal to 3 inches length), which may be taken directly to market. Louisiana leads the nation in oyster production largely due to this public/private oyster production system. Annual dockside sales have reached as much as $85 million in recent years.

LDWF manages public oyster areas to balance the economic opportunity of the fishery with the biological sustainability of the resource. Management depends on obtaining the best fishery dependent and independent data available through monitoring harvest and resource availability throughout the oyster season and performing yearly stock assessments. The annual individual Coastal Study Area (CSA) oyster stock assessment reports help fulfill these data needs as they provide estimates of the current stock size of the oyster resource within each CSA. The information these data provide allow resource managers to implement management changes to both effectively use the current resource and protect its long-term viability.

Oysters also play an important ecological role in the estuarine ecosystem. Oyster reefs provide the majority of hard substrate required by other sessile invertebrate species such as barnacles, bryozoans, tunicates, and anemones. Many species of invertebrates and fish also use oyster reefs as shelter and forage habitat. The oyster's filter-feeding activities enhance estuarine water quality, and reefs can also help stabilize shorelines.

FIGURE 1. Public oyster areas of Louisiana. The Louisiana Wildlife and Fisheries Commission designates Public Oyster Seed Grounds. The Louisiana Legislature designates Public Oyster Seed Reservations and Calcasieu and Sabine Lakes. Public Oyster Seed Grounds include Lake Borgne, Chandeleur/Breton Sound (primary Public Oyster Seed Grounds), Barataria Bay, Little Lake, Deep Lake, Lake Chien, Lake Felicity, Lake Tambour, Lake Mechant, and Vermilion/Cote Blanche/Atchafalaya Bays. Public Oyster Seed Reservations include Bay Gardene, Hackberry Bay, Sister (Caillou) Lake, and Bay Junop. Other public oyster areas include Calcasieu and Sabine Lakes.

Louisiana Oyster Landings

Oysters have been part of the Louisiana economy since the 1800s. Louisiana regularly leads the nation in the production of oysters and continues to account for approximately 50% of the nation's oyster landings by weight. Among Gulf of Mexico states, Louisiana consistently ranks first in landings (pounds of meat). (*Figure 2*). Additionally, Louisiana has averaged 43% of the annual landings (market value) of all oysters nationally from 1999-2018 (*Figure 3*). *Figures 2 and 3* also show that the value of landed oysters follows differing regional trends. After diminished oyster landings in 2010 totaling under 7 million pounds, Louisiana has harvested approximately 11 million pounds every year since, including 13.9 million pounds in 2015. Public oyster reef landings totaled approximately 247 thousand pounds and had a dockside value of approximately $1.8 million. Private oyster reef landings totaled approximately 10.8 million pounds (*Figure 4*) and had a dockside value of approximately $75 million (Source: LDWF Trip Ticket data).

Historically, public oyster areas were considered the backbone of the Louisiana oyster resource. In the past, these areas were a valuable contributor to overall Louisiana oyster landings each year, while also supplying seed oysters transplanted to private leases for grow-out purposes. The trend from 1970-1992 showed the majority of Louisiana oyster landings came from private reefs. From 1992 to 2001, the public ground stock size generally increased, and landings from the public grounds increased as well. In 2009, harvest levels significantly decreased on the public grounds from 2008 levels, with the public grounds producing only 22% of all oyster landings for the calendar year. Reliance on the public grounds has not recovered since 2009, and harvest data showed that only 2.0% of all oysters landed in Louisiana came from public grounds in 2018 (*Figure 4*).

Stock Assessment Methods

Management of the public oyster grounds and reservations relies heavily upon data gathered through a comprehensive biological

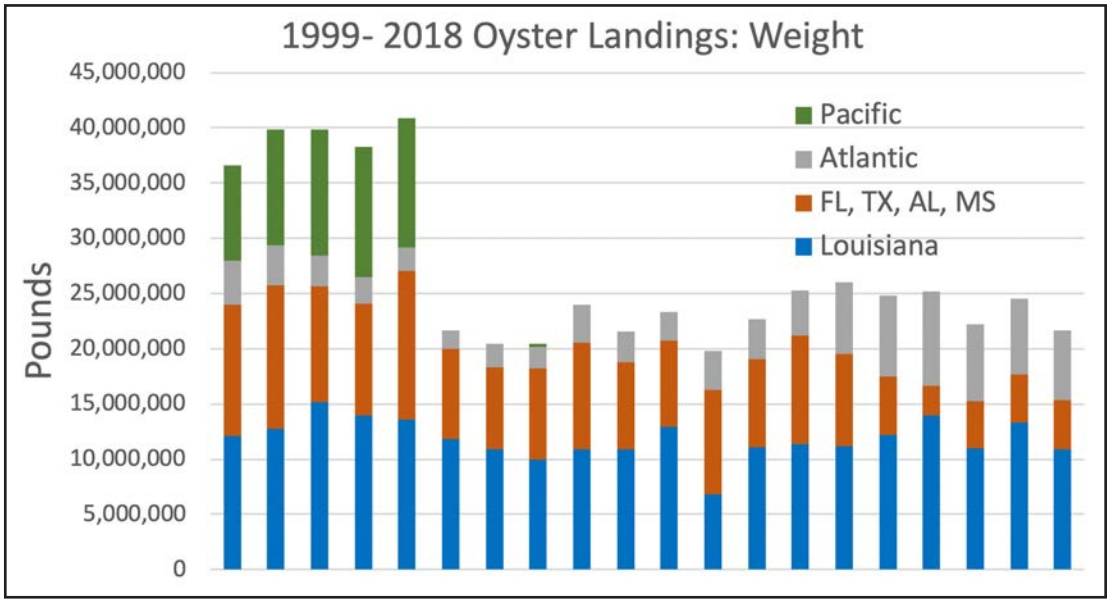

FIGURE 2. Annual oyster landings (pounds of meat) of regions of all oysters landings in the United States in 1999-2018. Louisiana regularly leads the nation in the production of oysters and continues to account for approximately 50% of the nation's oyster landings. Data provided by NOAA Fisheries. Pacific oyster landings data is not included in some years due to confidentiality.

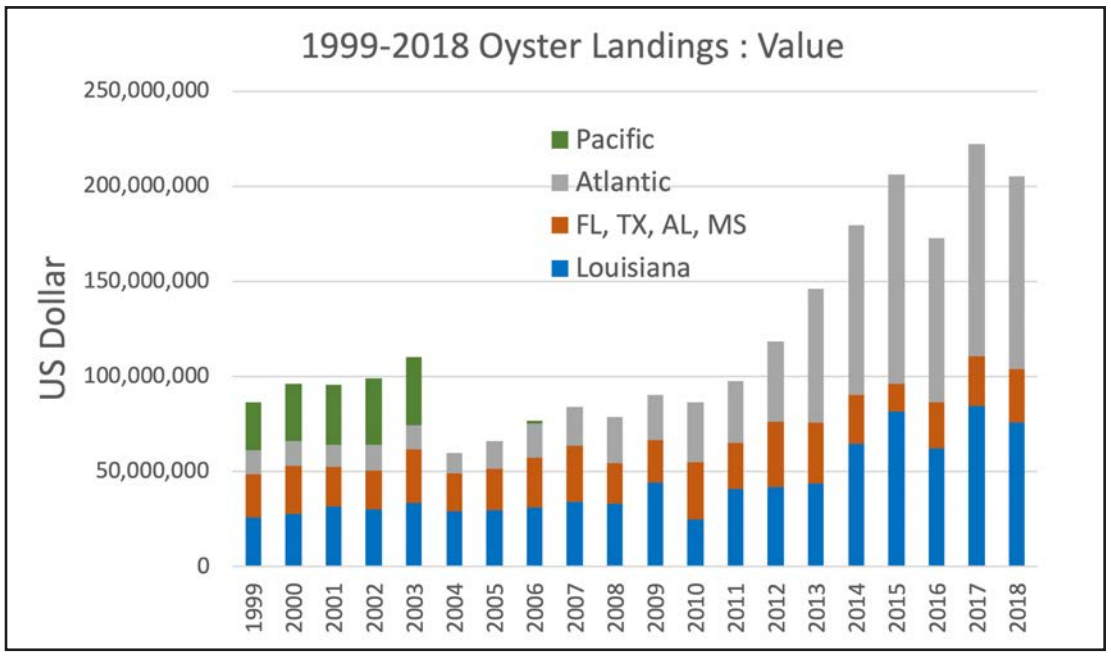

FIGURE 3. Percentage contribution of regions to average annual landings by value of all oysters in the United States, 1999-2018. Louisiana has averaged 43% of the annual landings of all oysters nationally from 1999-2018. Data provided by NOAA Fisheries. Pacific oyster value data is not included in some years due to confidentiality.

monitoring program. State biologists use two gear types (24-inch hand dredge and a square-meter [m^2] frame) when sampling the public reef areas, and analyze the data collected to determine overall health of the oyster resource throughout the year. Approximately 1,800 dredge samples are collected during each calendar year, and dredge data are used to monitor the overall health of the oyster stock during the year and to assess recruitment of new age classes of oysters into the population. Over 1,000 m^2 samples are collected per calendar year (including CPRA System-Wide Assessment and Monitoring Program), and data is used to measure the annual oyster stock size and for yearly oyster season recommendations by the Office of Fisheries. Additionally, field biologists routinely gather hydrological data on public oyster areas and develop harvest and fishing effort estimates by conducting boarding report surveys of oyster boats during open oyster seasons.

For annual stock assessments, LDWF biologists collect field samples in July from each CSA across Louisiana to perform a quantitative evaluation of the oyster stock on the state's public oyster areas (*Figure 5*). Biologists SCUBA dive on designated sampling stations within each CSA. At each sampling station, an aluminum m^2 frame (quadrat) is randomly placed on the oyster reef, and all live and dead oysters, reef-associated organisms, and exposed reef material are collected by hand from the upper portion of the substrate within the quadrat. This process is replicated five times at

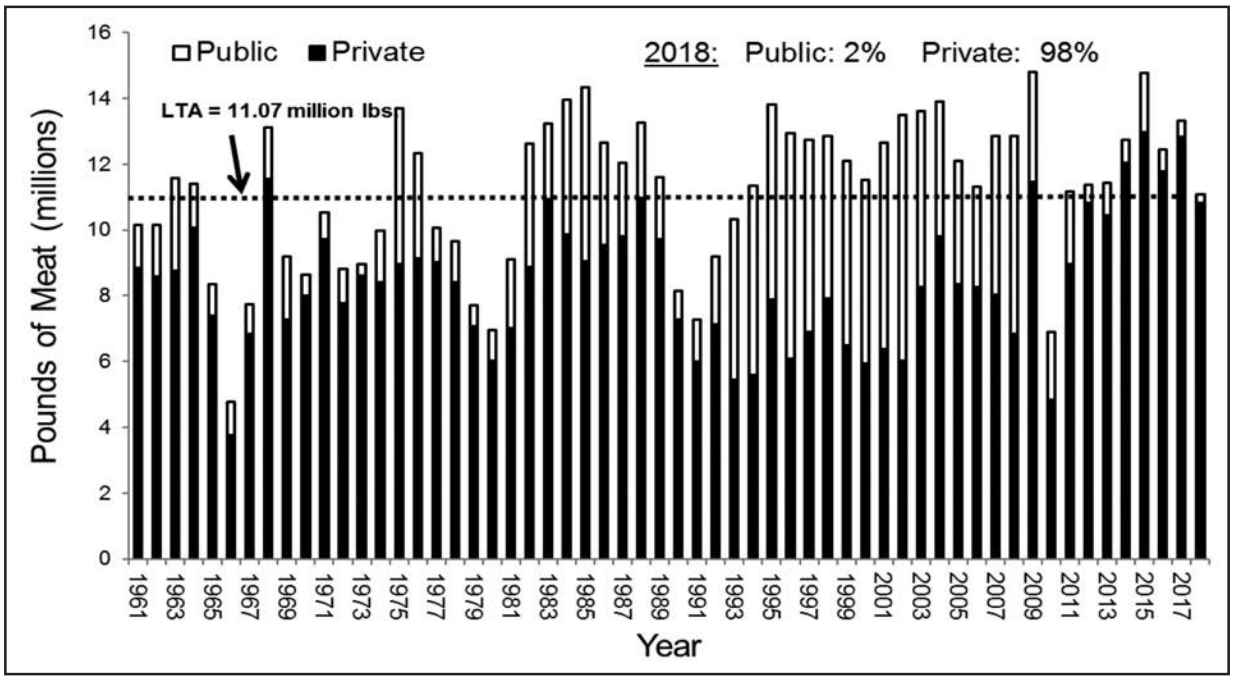

FIGURE 4. Historical Louisiana oyster landings for public oyster areas and private oyster leases, 1961-2018 (LDWF and NOAA Fisheries data).

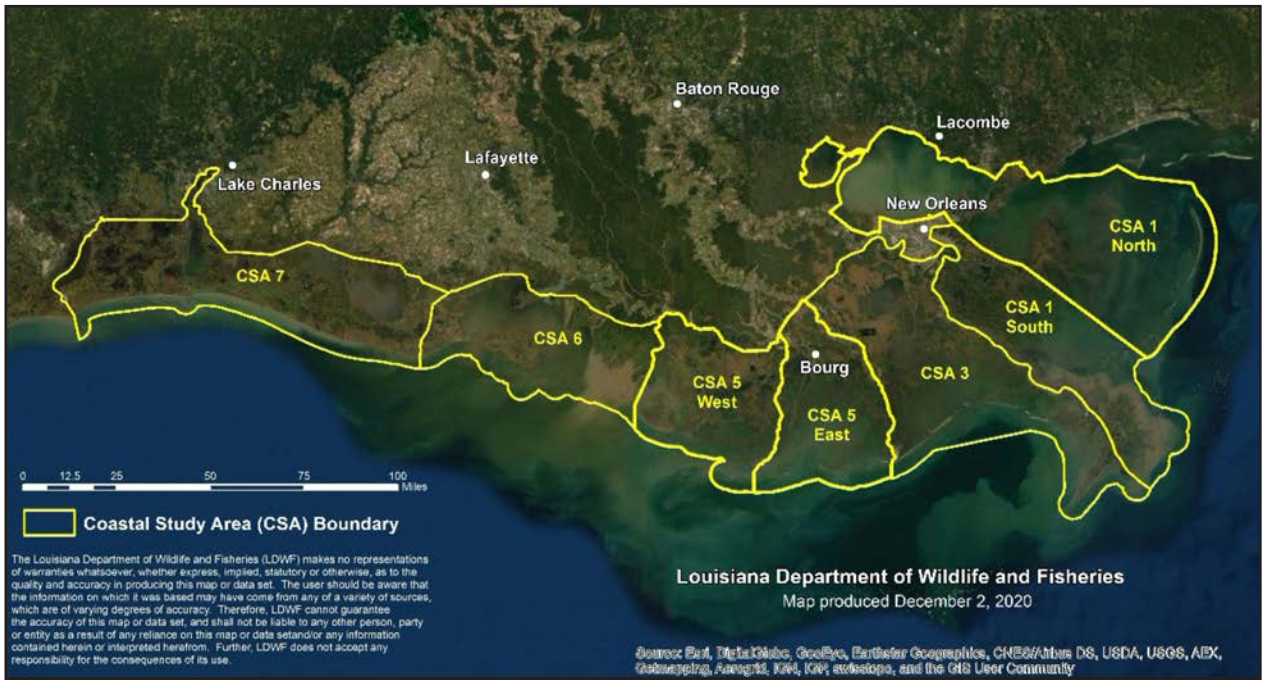

FIGURE 5. LDWF Coastal Study Areas (CSAs) boundaries and respective office locations.

each sampling station. Water temperature, dissolved oxygen, and salinity data are collected in conjunction with the m^2 samples, and cultch material types are identified and weighed.

LDWF biologists visited 105 sampling stations during the 2019 oyster stock assessment, gathering 525 individual samples. The assessment presents sampling data by CSA. During 2019 assessment sampling, CSA 1 South had the most sampling stations (26) while CSA 5 East had the fewest (3). There is a higher density of sampling in the Black Bay (CSA 1 South) and Sister Lake (CSA 5 West) areas due to their high level of oyster production in past years and historical importance to the oyster industry. Twenty-one of the 105 sampling stations were located on cultch plants constructed since 2004 by LDWF.

Sampling conducted as part of the annual oyster stock assessment plays a valuable role in predicting the success of the upcoming oyster season, which generally opens in early September and runs through April of the following year. However, the season may be closed or delayed if biological concerns or enforcement problems are encountered. LDWF uses oyster stock assessment information to make recommendations regarding setting the oyster season to the Louisiana Wildlife and Fisheries Commission (Commission).

In addition, Sustainable Oyster Shellstock Models (SOS), also called Shell Budget Models, are being improved and utilized to provide harvest thresholds for the public oyster areas of Louisiana. These models will help maintain reef material over the course of

time and were created in partnership with Dr. Thomas Soniat at UNO. This computerized model provides guidance for fisheries management with the goal of conserving the oyster reef base. Oyster stock assessment sampling provided model input data such as estimates of reef mass (grams per m^2) and size-frequency of oysters. Utilizing additional data on oyster growth, mortality, salinity and estimated commercial harvest rates, the model estimates the amount of oyster harvest that can be allowed on each individual reef while preserving the reef mass simulated based on three different conditions - low, medium, and high salinity patterns for each basin. The model was tested statewide and showed promising results. At this time SOS models are applied to reefs in CSA 1N, 1S, 3, 4, and 5. CSA6 has no known reef acreage to apply to model outputs, while CSA 7 is managed as a separate entity from the remainder of the State. That is due to the Sabine Basin being closed to oyster harvest by Act 159 (2018 Regular Legislative Session) and the only allowable method of harvest in the Calcasieu Basin is tonging.

Annual Stock Size

The 2019 estimated oyster stock on Louisiana's public oyster areas is approximately 249,800 barrels (bbls) of oysters (*Table 1*), an approximate decrease of 6% from the 2018 stock, and a 92% decrease from the long-term average (1982 through 2019; *Figure 6 and Table 1*). Similar to 2018, most of the live oyster stock is currently located in Calcasieu Lake (CSA 7; *Figure 7 and Table 1*). Calcasieu seed and market-size oysters account for 69% of 2019 estimated availability. An additional 178,951 bbls of oysters are located in Sabine Lake, but due to Act 159 (2018) that instituted a moratorium on oyster fishing in Sabine Lake, these totals are not reflected in overall statewide availability. Statewide, seed oysters increased by 12%, while market-size oysters decreased by 24% compared to 2018 (*Figure 6*). Only Calcasieu Lake showed increases in both seed and market-size oyster stocks. Sister Lake (CSA 5) also showed a 53% increase in seed oysters but overall availability in area on a decline from prior years. The estimated oyster stock in CSA 1 North and CSA 1 South - all water bottoms east of the Mississippi River - has decreased 86% from 2018 assessment and is at an all-time low of only 11,214 bbls availability.

Harvest Monitoring Methods

LDWF estimates harvest and associated activities by the commercial oyster industry during the oyster season by monitoring users to obtain fishery dependent data. To estimate harvest in a particular reef complex on a weekly basis, biologists conduct boarding surveys on portions of the Public Oyster Seed Grounds with an "OPEN" designation under the Louisiana Department of Health (LDH) classification system. They survey the entire area observing fishermen, recording locations, and making daily harvest estimates for each vessel. When biologists encounter fishermen working the seed grounds, they interview them regarding estimates of past and current catch rates as well as an estimate of future fishing effort. They summarize the data weekly to maintain a cumulative estimate of harvest for specific reef complexes. They project these harvest estimates over the amount of fishable days (winds less than 25 mph) for the week to determine a total harvest estimate of seed and market-size oysters for the week. Biologists often board vessels collecting seed oysters to determine if they are removing excessive amounts of cultch (non-living reef material) from area reefs.

LDWF also obtains harvest data via its trip ticket system. However, trip ticket data provide limited resolution as they are consolidated by geographic region and are considered preliminary until well after the season concludes.

LDWF collects fishery independent data via oyster dredging and visual census to assess the health and condition of the resource both prior to and during the final stages of the oyster season. Both fishery dependent and independent sources are subject to substantial uncertainties and should be used together to provide a better estimate of the available resource.

2018/2019 Oyster Season

The goal for the 2018/2019 oyster season was to delay opening to maximize potential oyster reproduction, avoid concentration of the fleet through uniform opening/closure dates, and close areas as recommended by the shell budget model thresholds; all of which should help minimize reef degradation. The 2018-2019 Oyster Season opened Oct. 29, 2018 and closed April 30, 2019. There were 2 special openings within LDH closed areas in CSA 1N - March 14-16 and March 19-21 - and one special opening in CSA 6 - March 14-16 - to allow for bedding relay transplants ahead of flood waters. Little to no resource was found (*Table 2*).

TABLE 1. Estimated statewide oyster stock size (in bbls) on Louisiana's public oyster areas by CSA. Seed percent, Market-size percent, and Total percent columns indicate percentage of statewide total percent change from prior year. Note that 1 bbl. equals two sacks. Green text indicates increases over 2018 levels; red text indicates decreases.

Area	Seed	Seed %	Market-Size	Market-Size %	Total	Total %
Lake Borgne/MS Sound	10,765	-78%	450	-99%	11,215	-86%
East of MS River, South of MRGO	0	0%	0	0%	0	0%
Hackberry Bay	3,108	53%	337	-77%	3,445	-1%
Lake Chien/Felicity	36	-92%	36	0%	72	-84%
Sister Lake/Bay Junop	55,229	14%	7,671	-65%	62,900	-11%
Calcasieu - East Side	15,209	72%	11,588	26%	26,797	49%
Calcasieu - West Cove	62,005	187%	83,367	16%	145,372	55%
Statewide Totals	*146,351*	*12%*	*103,449*	*-24%*	*249,800*	*-6%*

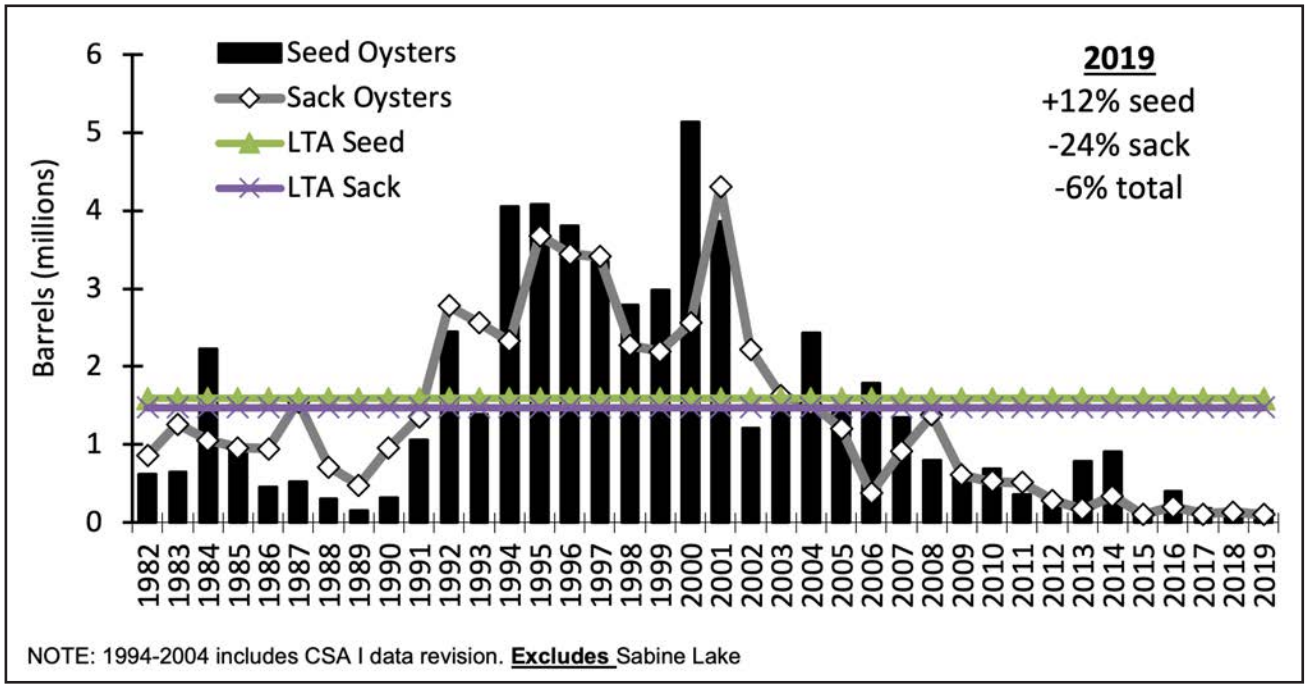

FIGURE 6. Historical seed and market-size oyster stock availability on Louisiana's public oyster areas. LTA denotes the long-term average from 1982 through 2019. Percentages indicate change from 2018.

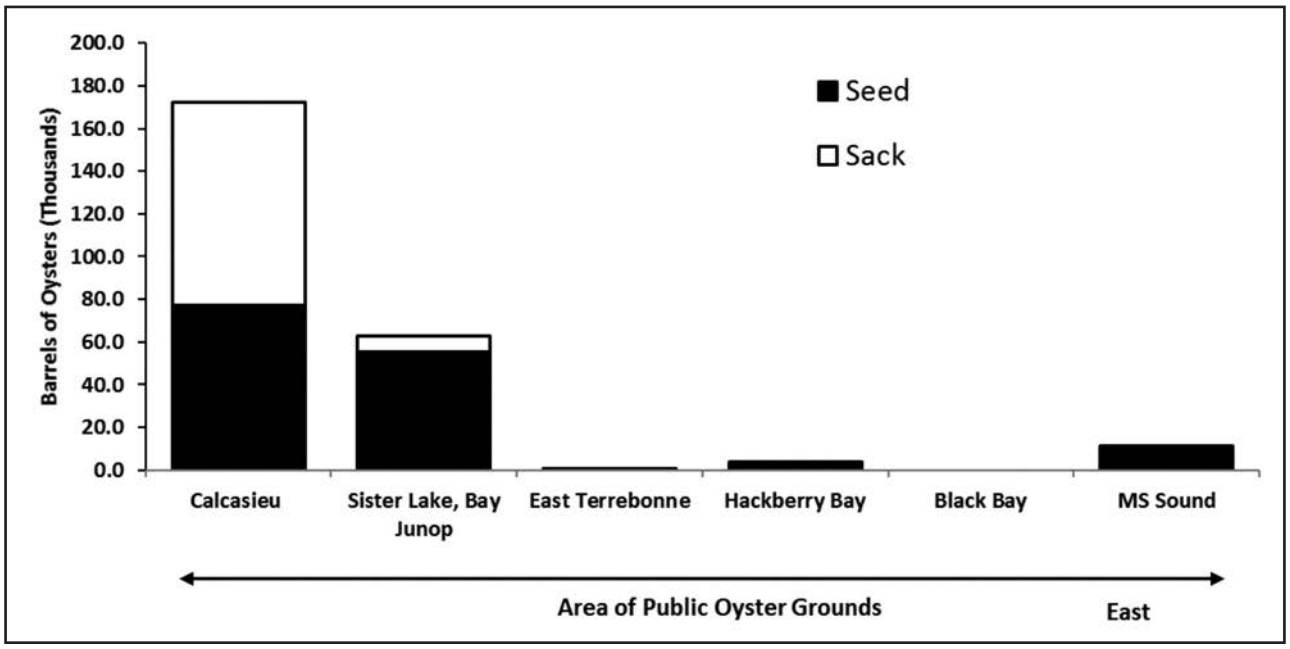

FIGURE 7. Statewide distribution of oyster stocks on Louisiana's public oyster areas in 2019.

Prior to the start of 2018/2019 oyster season, and to help mitigate reef loss and low recruitment issues, the following provision was incorporated into the seasonal rule passed by the Louisiana Wildlife and Fisheries Commission: "The harvest of seed oysters from a public oyster seed ground or reservation shall be for the purpose of moving the live oyster stock. The removal of more than 15% of non-living reef material in bedding loads is prohibited. All vessels shall allow on-board inspection and sampling of seed oyster loads by the LDWF biologists and/or agents". Additionally, the harvest of bedding material was allowed for just one day—Oct 29, 2018. In collaboration with Enforcement, LDWF biologists documented forty-five bedding vessels on opening day.

Estimated commercial harvest totaled 5,532 bbls of seed oysters and 28,761 sacks (14,381 bbls) market oysters for an overall total of 19,913 bbls oysters. This is a 70% decrease from the 2017/2018 oyster season (66,379 bbls). A decrease in both seed and market-size oyster harvest were observed statewide. The observed decline in availability of oysters in the Public Seed Grounds is not a result of any single event, but reflects the effects of a myriad of population stressors, including changes in hydrology, extreme weather events, the DWH oil spill/response activities, harvest pressure, lack of recruitment and most notably the 2018-2019 Mississippi River flooding event. Scarce oyster availability resulted in lowest harvests in CSA 1 North, CSA 5 West, and CSA 6 on record.

TABLE 2. Harvest estimates for the 2018/2019 oyster season on Louisiana's public oyster areas. Data derived from fishery dependent surveys of harvesting vessels rather than LDWF trip ticket data (bbls = barrels, 2 sacks = 1 barrel).

2018/2019 LDWF OYSTER SEASON SUMMARY						
Area	**Season Opening**	**Season Closure**	**Season/Type**	**Days Open to Date**	**Harvest to Date**	**CSA**
N of MRGO	Oct. 29	Oct. 29	1-day Seed Harvest	1	4,550 bbls	**1**
	Oct. 29	April 30	Market Oyster Harvest *LDH Area 3, Drum Day and 3-mile cultch plant CLOSED as of Jan. 20, 2019	183	18,669 sacks	
	March 14	March 16	Special opening for bedding purposes only due to flood event	3	0 bbls	
	March 19	March 21	Second special opening for bedding purposes only due to flood event	3	85 bbls	
All Public Seed Grounds East of Mississippi River and South of MRGO CLOSED						
Hackberry Little Lake	Oct. 29	Oct. 29	1-day Seed Harvest	1	877 bbls	**3**
	Oct. 29	Nov. 3	Market Oyster Harvest	6	186 sacks	
Barataria Bay, Deep Lake, Lake Chien, Lake Felicity and Lake Tambour CLOSED						
Lake Mechant	Oct. 29	Oct. 29	1-day Seed Harvest	1	20 bbls	**5**
	Oct. 29	April 30	Market Oyster Harvest	183	25 sacks	
Bay Junop	Oct. 29	Oct. 29	1-day Seed Harvest	1	0 bbls	
	Oct. 29	April 30	Market Oyster Harvest	183	500 sacks	
Sister Lake CLOSED						
Vermilion Bay	Oct. 29	Oct. 29	1-day Seed Harvest	1	0 bbls	**6**
	Oct. 29	April 30	Market Oyster Harvest	183	8 sacks	
	March 14	March 16	Special opening for bedding purposes only due to flood event	3	0 bbls	
Calcasieu Lake	Oct. 29	April 30	*East Cove:* Market Oyster Harvest ** closed between Dec. 31, 2018 and Jan. 20, 2019	**162	3,062 sacks	**7**
	Oct. 29	April 30	*West Cove:* Market Oyster Harvest	183	6,311 sacks	

2019 Flood Impacts to Louisiana Oyster Industry

Based on days at or above flood stage at Baton Rouge, LA, the 2018-19 Mississippi River flood is the longest lasting flood on record since 1900 (when records became available), surpassing the flood of 1927 in duration. The extreme duration of high Mississippi River levels since December 2018 has necessitated unprecedented efforts by the U.S. Corps of Engineers to mitigate the threat of levee failures in Louisiana. Such efforts included the opening of the Bonnet Carré Spillway twice in 2019; first in late February and again in early May. The Bonnet Carré Spillway opened for an unprecedented total of 123 days in 2019. The extreme influx of freshwater greatly reduced salinity levels in the coastal waters of Louisiana and disrupted the delicate balance of estuarine productivity. Significant, prolonged flood events also occurred in local river systems from Alabama through Louisiana, impacting regions at least as far west as the Sabine River Basin in Louisiana. As a result, the 2019 flood event was considered a statewide disaster with the most severe impacts occurring in the eastern half of Louisiana.

While freshets in winter and early spring can often benefit the reef system, either by reducing disease or predation, there are often other cumulative impacts that may affect recovery from such event. The impacts and subsequent recovery are also modified by not only the magnitude of a freshet, but perhaps also by the duration and timing (e.g., a combination of warm waters and low salinities can result in higher oyster mortalities).

The Louisiana Department of Wildlife and Fisheries (LDWF) investigated oyster impacts from the increased freshwater flows in the spring and summer of 2019 via standard and enhanced fisheries independent sampling (extra dredge sampling) on public oyster areas. LDWF biologists started collecting extra weekly dredge samples starting in March of 2019, in addition to the regular monthly scheduled dredge samples, collecting mortality data in the POSGs. Percent calculated losses were obtained from using the density of oysters and reef acreage from the 2018 oyster stock assessment and the current mortality estimates collected during the 2019 dredge samples. The values were then extrapolated using the following:

Mortality: The number of dead oysters were determined by adding the number of single

valves, and the number of boxes. Percent mortality was calculated as below:

recent dead / (# recent dead + # live) X 100 = Percent Mortality

TABLE 3. Total oyster loss in the Public Oyster Seed Grounds in Louisiana by basin.

Basin	Acreage Affected	Sacks Lost	Total Loss Value
Pontchartrain	25,981	182,876	$10,972,542
Barataria	370	546	$32,744
Terrebonne	2640	49,417	$2,965,042
Vermilion-Teche and Atchafalaya	570	36,753	$2,205,175
Calcasieu and Sabine	6,467	62,795	$3,767,674
Lake Fortuna Remote Setting	50	8,555	$513,328
Totals	*36,078*	*340,942*	*$20,456,505*

Density: The number of marketable or "sack" oysters that measure 75 mm and above converted to sacks by dividing by 180. The number of "seed" oysters that measure 25-74mm converted to sacks of future marketable oysters by dividing the number of seed oysters by 360 and by utilizing a conversion factor of 1.68 (Melancon 1990). For instance, 1000 seed oysters + 360 = 2.78 sacks of seed oysters. 2.78 sacks of seed oysters X 1.68 = 4.67 sacks of marketable oysters. Therefore, 1000 seed oysters grow into 4.67 sacks of marketable oysters.

As a result of the 2019 flood event, oyster mortality on public oyster areas in St. Bernard Parish ranged from 75-100% (*Table 3*). Mortality from LDWF samples on private leases near Lake Borgne and Mississippi Sound was also observed to be over 75%. Observed mortality in the Atchafalaya basin ranged from 32-100%. Sabine Lake saw significantly high mortality as well, concentrated in the northern part of the lake. Louisiana's oyster resource is one of the largest and most valuable oyster resources in the nation. While beyond the scope of the current assessment of fishery harvest value losses, losses to the resource will continue to affect the oyster industry for years to come.

Identifiable dockside losses using Trip Ticket data from oyster fisheries in Louisiana, as a result of the 2019 flood event as reported in LDWF's fisheries disaster request in November of 2019, was identified as $17,332,018, while identifiable resource and future losses from the oyster fisheries in Louisiana, as a result of the 2019 flood event, was estimated as $122,611,776. It should be noted that these are dockside (revenue) losses which do not incorporate in any way additional costs associated with longer travel times, increased fuel costs, etc. that would be included in increased costs to those harvesters or boat operators.

In addition, losses within the POSG were calculated using the average 2018-2019 price for a sack of oysters ($60), estimated at $19,943,177. Additionally, 100% mortality was observed on the recently established spat on fossilized shell/remote setting project in the Pontchartrain Basin (Lake Fortuna). That project is intended to help re-establish oysters in historic reef areas. The cost of that project was $513,328. While beyond the scope of the fishery impacts associated with the flood event, those costs are real costs to the state toward re-establishing oyster resources and habitats. The total oyster loss in the POSG was calculated at $20,456,505.

Oyster leases account for most of the commercial landings in Louisiana (*Figure 4*) and were significantly impacted by 2019 flooding event as well. Landing numbers; however, may not reflect the mortalities on those leases for several reasons. Many harvesters, in anticipation of oncoming flood waters, were able to increase harvest to remove available product prior to mortality events. The loss of living reef to sustain future growth will be felt and seen more so in upcoming years. LDWF estimated loss to the fishery resource through surveys and fishery-provided data, and the overall mortality in the private leases statewide, was estimated at 44.35%.

Louisiana statewide oyster landings have typically ranged from about 11 million to 14 million pounds annually for many years. In recent years, the vast majority of the oysters have come from leased water bottoms, not public seed grounds. Prior to this flood event, oyster landings have maintained productivity for at least a few generations of oysters. Thus, it was assumed that any mortality, at a minimum, would account for an equivalent fraction of the typical harvest. Taking into account the estimated time of three years for an oyster to grow and be brought to market, it is estimated is that 2,486,286 sacks of oysters were lost on leased waterbottoms, or an estimated loss of 5,362,089 pounds of meat and $34,051,757 (based on average dockside price) for a single year's worth of landings. It is possible that total biomass and potential productivity were significantly higher than what it would take to sustain that mean harvest level, as there are limits on what markets can receive, but we have no basis to provide any estimate of that additional biomass that could have sustained mortality.

Losses will be felt by the industry for at least three years, assuming that conditions are conducive for growth. Therefore, the estimated lost landings of 2,486,286 sacks of oysters, with a value of $102,155,271 based on dockside values from base years, will be distributed over that time. Due to recent price increases, the current annual market value of those oysters is significantly higher at $49,725,709 compared to $34,051,757.

Special Oyster Management Projects

LDWF biologists continue to participate in several important projects aimed at increasing oyster production on the POSG. Cultch planting is a reef rehabilitation method employed by LDWF since 1917. Two cultch plant projects have been completed in recent years. A new 100-acre limestone cultch plant in Calcasieu Lake was completed in the fall of 2017. In 2018, the Lake Fortuna cultch plant was constructed, on which LDWF worked with St. Bernard Parish Government to place additional cultch material onto 100 acres of the existing 2012 Lake Fortuna cultch plant. This process was performed in order to increase reef height, minimizing the chances of sedimentation and hypoxia-induced mortality. In April 2018, an additional 16,000 cubic yards of dry oyster shell was deposited. Funding for this project came from NRDA early

restoration oyster funds. An additional six acres within the 100-acre 2018 Lake Fortuna cultch plant was supplemented with spat on shell (SOS) sourced from a private hatchery. This restoration strategy was chosen due to the lack of natural spat setting in the area over the last 10 years, even though suitable hydrology for oyster growth and reproduction was prevalent. Early sampling showed promise; however, the freshwater input from the 2019 flood event, including the opening of the Bonnet Carré Spillway, caused 100% oyster mortality in the Lake Fortuna area.

Since the 2010 *Deepwater Horizon* oil spill/response activities, Louisiana's POSG have experienced significantly lower levels of successful oyster reproduction (oyster spat set). Spat set is a key indicator of the overall oyster population's stability because it illustrates the recruitment of young oysters into the population. In response, LDWF developed the Remote Setting Program to increase oyster production levels.

The Michael C. Voisin Oyster Hatchery, located in Grand Isle, Louisiana, is operated through a collaborative effort between LDWF and Louisiana Sea Grant (LSG). LSG assists with facility operations and provides recommendations to LDWF for hatchery operations. The hatchery produces diploid and triploid oyster larvae and seed for restoration projects and to incentivize the alternative oyster culture (AOC) industry. The hatchery also produces algae to feed oyster larvae, has a breeding program, and conducts research projects. The hatchery produced approximately 229 million oysters in 2018, and LDWF began managing larval and seed sales in January 2018 with the majority of orders received being for triploid larvae to be used by the AOC industry. In 2019, in collaboration with the Michael C. Voisin Oyster Hatchery, LDWF developed a spat on shell protocol to investigate and monitor survival and growth with hatchery-raised animals by following protocols developed in a 2014 remote setting pilot project. Diploid oyster larvae were produced and set on recycled oyster shells in a concerted effort to deploy to the public seed grounds across the state. To date (July 2019), there have been nine spat on shell deployments (1) Breton Sound, (1) Barataria Bay, (7) Hackberry Bay done by LDWF staff.

The recycled oyster shells used on the Remote Setting program are acquired in a partnership between LDWF and Coalition to Restore Coastal Louisiana (CRCL), and stockpiled at the Oyster Remote Setting Facility in Buras. Oyster shell is the material of choice for setting larval oysters. This program began during FY 2013-2014, when CRCL began delivering shell to the Buras site for storage. As of June 2019, approximately 3,971 tons of shell had been delivered to and cured at the site.

The Oyster Remote Setting Facility in Buras has been operational since November 2017. A trial run proved successful and the spat on shell were transported to and deployed in Lake Fortuna (Lake Machias) in late 2017. However, the status of future operations has yet to be determined and no further trials in Buras have been conducted due to water conditions on site, and remote location. LDWF started transporting recycled oyster shells from Buras to the Michael C. Voisin Oyster Hatchery in Grand Isle to continue smaller spat on shell trial runs that are more manageable, less remote, and able to be completed with staff.

Additionally, in the fall of 2018, LDWF conducted a small transplant study in Barataria POSG to research if oysters can survive and grow in the southern part of Barataria Bay ahead of any restoration projects planned for the area. Adult oysters were placed in modified crab traps to study survival, growth and reproduction. The project was deemed unsuccessful and terminated early due to continued loss of samples and containment devices (crab traps) which held oysters. Losses were associate to boat traffic in the area due to proximity to a major tidal pass to the Gulf. The area was also very prone to high salinities, promoting oyster drills which were observed attempting to eat the oysters through containment device.

Recent Legislation

The 2019 regular legislative session included one bill that was passed into law directly impacting the oyster industry. 'Act 142' was expanded to include hand tongs and oystering by hand to be legal methods of harvest on public oyster seed grounds as outlined within Oyster Seed Ground Vessel Permit. Both fishing methods are allowed with the possession of a single scraper or double scraper Oyster Seed Ground Vessel Permit.

Conclusion and Acknowledgments

The following report includes both the biological stock assessment and historical oyster landings data from each CSA in Louisiana, as well as a brief summary of the most recent oyster season in each area. Biological data were generated from quantitative square-meter sampling, while landings data were generated from boarding surveys and trip ticket information. This report was prepared by Carolina Bourque, Denise Kinsey, Carl Britt, Willie Cheramie, Jeff Marx, George Melancon, and Chris Schieble. Biologists from each CSA spent extensive time gathering samples and producing the report. Additionally, Bryan Alleman, Harry Blanchet, Becky Redmond-Chapman, Ty Lindsey, and Christian Winslow assisted with editorial review and preparation of this document. Efforts of both the field and office staff are greatly appreciated, as this report could not be produced without their hard work and dedication. Please direct questions and/or comments to Carolina Bourque, Oyster Program Manager, at 337-735-8726 or cbourque@wlf.la.gov.

CSA 1 NORTH

Introduction

The Public Oyster Seed Grounds in CSA 1 North (North Pontchartrain Basin) consist of approximately 690,000 acres of water bottom located within Lake Borgne, the Louisiana portion of Mississippi Sound, Chandeleur Sound, the Biloxi Marsh, and adjacent waters. Louisiana, Mississippi, and Texas fishermen harvest oysters from this area, which has historically been an area of high oyster production within the state of Louisiana. Although the state of Louisiana has managed this area as Public Oyster Seed Grounds for many decades, the Commission did not designate the majority of this area by rule until 1988. The Commission designated much of Lake Borgne as public oyster seed ground in 1995 and expanded the grounds in 2004. LDWF expands and enhances the public oyster reefs through the placement of cultch material (e.g. shell, limestone, crushed concrete) on suitable water bottoms. Most recently, LDWF completed cultch plants in Mississippi Sound (Round Island) in 2011 and Three Mile Pass and Drum Bay in 2013 as part of the 2010 *Deepwater Horizon* oil spill Natural Resource Damage Assessment (NRDA) Early Restoration Program.

Methods

LDWF biologists collected field samples for this oyster stock assessment between July 01 and July 10, 2019, from a total of 19 stations within CSA 1 North according to the methodology described in the Statewide Overview of this report. Sampling stations included 16 historical stations, as well as the 2011 cultch plant in Mississippi Sound (Round Island) and the two 2013 NRDA Early Restoration cultch plants in Three Mile Pass and Drum Bay (*Figure 1.1*).

Before the 2013 CSA 1 North oyster stock assessment, LDWF estimated acres of reef based upon water bottom surveys completed in the mid-1970s. To better locate and assess the oyster stock in the Public Oyster Seed Grounds, LDWF has conducted a number of side-scan sonar studies of water bottoms in these areas in recent years. These studies coupled with historical reef and cultch plant information resulted in a more up-to-date and realistic designation of productive water bottoms for use in the annual oyster stock assessment (*Table 1.1*). The 2019 CSA 1 North oyster stock assessment is based on the updated reef assessment of 22,427.2 acres of water bottom, which includes 649 acres of recent cultch plants. As those cultch plants are distinctly different from surrounding existing reef in terms of oyster productivity, LDWF assesses cultch plant acreages separately from the surrounding reef complex.

Only productive Public Oyster Seed Grounds for which an accurate acreage can be determined are included in the oyster stock assessment. For this reason, some areas, such as Public Oyster Seed Grounds located within Lake Borgne, are not included in this oyster stock assessment due to a lack of reef acreage information.

Results and Discussion

Seed and Market-Size Stock

The 2019 estimated oyster stock size for CSA 1 North is 10,765 bbls of seed oysters and 450 bbls of market-size oysters, for a total of 11,214.4 bbls of overall stock (*Table 1.2*). Compared to 2018, there was a 78.2% decrease in the seed estimate and a 98.5% decrease in the market-size estimate (*Table 1*). This year's assessed seed stock is down 94.6% from the previous 10 years' average, while assessed market-size stock is down 99.5% from the previous 10 years' average (*Figure 1.2*). Total assessed oyster stock for 2019 is down 86.0% from 2018 and is 96.2% below the previous 10 years' average. When compared to the long-term average (1996-2018), the total estimated oyster stock in CSA 1 North is down 98.5%. This year's stock estimate is driven by the oyster densities observed on the Drum Bay Reef Complex. The Drum Bay Reef Complex, accounted for all assessed oyster stock in CSA 1 North during this year's assessment. The Drum Bay reef held all observed seed stock, with a mean density of 1.2 seed oysters per square-meter, and a mean density of 0.2 market-size oysters per m^2.

It is important to note variability both within and among stations when comparing estimates. This variability is magnified when extrapolating small sample sizes to large areas. In short, changes between annual assessments can be dramatic on an individual reef basis, and only limited areas of significant resource availability are often identified.

Over the past 10 years, CSA 1 North has experienced heavy localized harvest, high mortality events, strong tropical events such as Hurricane Isaac in 2012 and Hurricane Nate in 2017, the 2010 *Deepwater Horizon* oil spill and related spill response activities, multiple. This decline combined with 2019's Mississippi River flooding event has severely reduced oyster resources and continues to limit recruitment needed for recovery. As a result, both the estimated seed and market-size oyster stocks continue to fall well below both the previous 10 years' average and the long-term average (1996- 2018; *Figure 1.2*).

Spat Production

Occurrence of spat oysters was nearly absent from this year's oyster stock assessment. Live spat were observed only at the Drum Bay reef sampling station with a mean density of 0.2 individuals per square-meter (m^2). Occurrence of spat oysters decreased from the previous year's assessment, which continues an observed lack of spat set over several of the reef areas during the spring spawning events. This could be attributed to several factors such as freshets, hypoxia, overburden or dissolution of cultch, or a combination of these stressors. It is noted that annual m^2 samples may occur between seasonal spawning events in some areas, and that spat numbers are somewhat biased by the amount of substrate collected in a given sample.

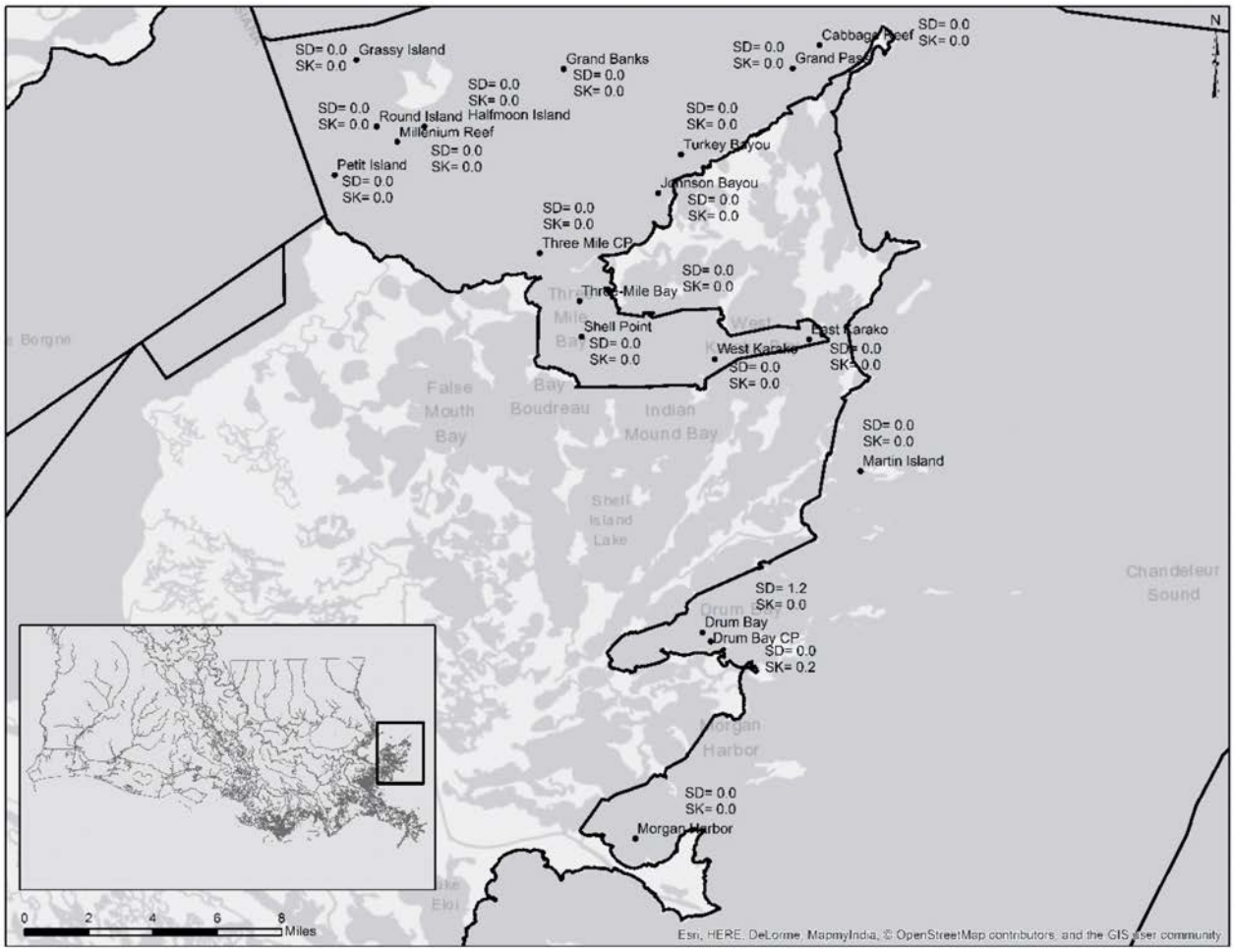

FIGURE 1.1. 2019 CSA 1 North oyster stock assessment sampling stations with average seed and sack sampling densities for the 2019 stock assessment, square-meter sampling.

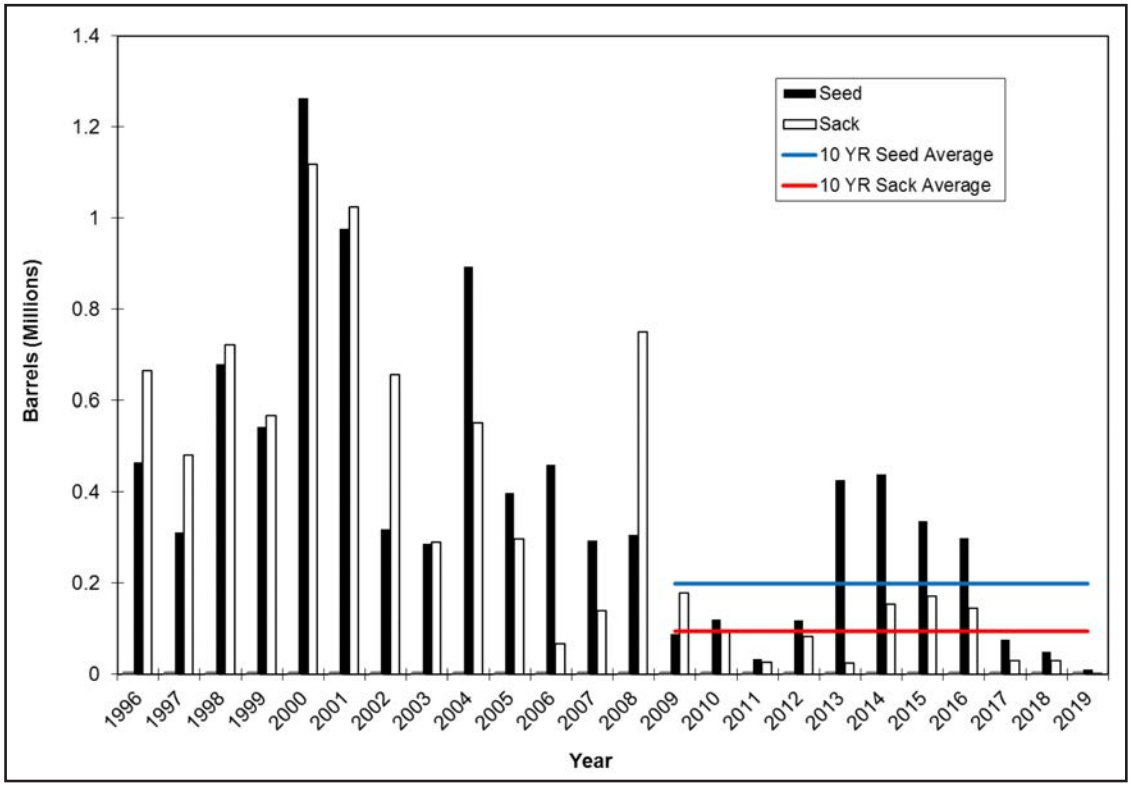

FIGURE 1.2. Current and historical seed and market-size stock size estimates in CSA 1 North. Horizontal lines represent the previous 10-year' seed and market-size stock size estimate averages.

TABLE 1.1. Mean densities of oysters collected at each sampling station in CSA 1 North.

Station Name	Station Number	Reef Acreage	Seed/ m^2	Market-Size/ m^2	Seed Oysters (bbls)	Market-Size Oysters (bbls)
Grassy Island	3005		0.0	0.0		
Halfmoon Island	3010		0.0	0.0		
Petit Island	3009	5,328.0	0.0	0.0	0	0
Grand Banks	3044		0.0	0.0		
Millennium Reef	3011		0.0	0.0		
Three Mile Bay	3008		0.0	0.0		
East Karako Bay	3041	3,058.7	0.0	0.0	0	0
West Karako Bay	3040		0.0	0.0		
Grand Pass	3007		0.0	0.0		
Cabbage Reef	3006	5,411.0	0.0	0.0	0	0
Turkey Bayou	3004		0.0	0.0		
Martin Island	3046	3,183.3	0.0	0.0	0	0
Shell Point	3052	47.2	0.0	0.0	0	0
Johnson Bayou	3051	200.0	0.0	0.0	0	0
Drum Bay	3049	1,596.0	1.2	0.0	10,764.7	0
Morgan Harbor	3050	2,954.0	0.0	0.0	0	0
Round Island	3056	291.0	0.0	0.0	0	0
Drum Bay Cultch		200.0	0.0	0.2	0	449.7
Three Mile Pass Cultch		158.0	0.0	0.0	0	0
2019 Total					***10,764.7***	***449.7***

Fouling Organisms

The hooked mussel, a sessile bivalve often associated with oyster reefs that likely competes with oysters for food and settlement surfaces, was observed at 3 of the 19 sampling stations during this sampling event. The highest density of mussels was 0.6/m^2 at the Drum Bay cultch plant. There was a marked decrease in hooked mussel densities across most of CSA 1 North when compared to the previous year's observations. It was noted that bryozoans were found on exposed substrate at several sampling stations, in addition to moderate to heavy barnacle fouling of oyster shells at a few sampling stations. All of these forms of fouling limit the ability of oyster larvae to attach to available cultch.

Oyster Predators and Disease

The southern oyster drill (*Stramonita haemastoma*) is a marine gastropod known to prey on oysters using a small tooth-like scraping organ called a radula to bore a hole through the oyster shell. During this year's sampling event, oyster drills were not observed at any sampling station, likely due to the extreme low salinity throughout the basin. No stone crabs, *Menippe adinia*, or blue crabs, *Callinectes spp.*, were collected in the m^2 samples. Other Xanthid crabs were noted in numerous samples that contained shell for substrate

Dermo, *Perkinsus marinus*, is a protozoan parasite that infects live oyster tissue and is known to cause extensive oyster mortalities especially in high salinities and water temperatures. Oyster tissue samples to be tested for presence of this parasite are collected annually from the Cabbage Reef and Three Mile Bay reef complexes in CSA 1 North. This year's Dermo samples were conducted in September of 2019, and results of the Dermo tests are presented in Appendix I.

Mortality

Overall, mortality estimates slightly increased from the previous year's stock assessment. There were no spat or market-size-sized oyster mortalities recorded during this sampling event. Round Island had the only seed mortality at 100%, representing an increase of 4.5% when compared to 2018 seed mortality. It is important to consider that mortality estimates are often based on an extremely small number of animals. Further, for some annual stock assessments, samples may be taken shortly after large mortality events that have either diminished or severely depleted abundances, so that neither the mortality nor the prior abundance is fully captured in the assessment sampling.

A massive mortality event, that was documented in the Introduction of this document, was observed through the four months preceding this sampling event in CSA 1 North sampling stations. Public Oyster Seed Grounds in Mississippi Sound and the adjacent Biloxi Marsh experienced tremendous oyster loss during this period. Weekly dredge samples collected in this area from March through June of 2019 have shown mortality rates up to 100% on most reefs. LDWF biologists have noted widespread low salinity rates brought on by introduction of Mississippi River water into the Basin through the Bonnet Carré Spillway, as well as from high discharge from the Pearl River as a result of extreme rain events and major spring flooding. Oysters, because of their sessile nature, are especially susceptible to such low salinity conditions.

The ramifications of the rate of resource loss during this mortality event are still being observed during this year's stock assessment, as evidenced by the 86% reduction of total available oyster stock across CSA 1 North.

Tropical and Climatic Events

As mentioned in previous section, spring 2019 has seen an unprecedented flooding event, driven by heavy winter snowfall and torrential rains across the mid-western United States, the Mississippi River approached flood stage by the end of February, elevating river stage and prompting the U. S. Army Corps of Engineers to begin operation of the Bonnet Carré Spillway on Feb. 27, 2019, for a total of 123 days opened. Forty-four days from Feb. 27 to April 11 during the first opening, and an additional 79 days from May 10 through July 27 during the second opening. Due to the duration of this flooding event, salinities on oyster growing areas throughout CSA 1 North decreased to below what is required for effective oyster growth and viability. Beyond the influx of fresh water through the Bonnet Carré Spillway, the low salinity conditions in CSA 1 North were further exacerbated by the rising of the Pearl River to above flood stage four different times between December 2018 and May 2019. Extensive mortalities caused by the 2019 flood event were recorded across CSA 1 North, including an estimated 100% mortality of the oyster stock in the eastern portion of Mississippi Sound, Grassy Island, Petit Island and Round Island, while in the western portion of Mississippi Sound and in Three Mile Bay, Grand Banks and the Three Mile Pass cultch plant were estimated to have 70 to 80% mortality. Further southeast in the Drum Bay area, losses were estimated to be 15 to 25%.

TABLE 1.2. Harvest estimates from the 2018/2019 public oyster season in CSA 1 North.

Station Name	Seed (bbls)	Market-size (sacks)
Grassy Island	0	50
Halfmoon Island	0	1,333
Petit Island	0	5,188
Lake Borgne	0	225
Millennium Reef	85	820
Grand Banks	0	0
Three Mile Bay	0	2,541
Turkey Bayou	0	0
Johnson Bayou	0	0
Grand Pass	0	0
Cabbage Reef	0	0
West Karako Bay	0	605
East Karako Bay	0	0
Drum Bay	0	247
Morgan Harbor	0	40
Bay Eloi	0	0
Shell Point	0	738
Round Island	1,350	4,278
Three Mile Pass Cultch Plant	3,050	1,452
Drum Bay Cultch Plant	150	1,151
Total	***4,635***	***18,668***

2018/2019 Oyster Season

The 2018/2019 oyster season in the CSA 1 North opened on Oct. 29, 2018, for both seed and market-size harvest, with a 25-sack per day limit levied across the entire State. All seed oyster harvest in CSA 1 North was suspended on Oct. 29, 2018, amounting to a one-day bedding season. During previous seasons, surveyed bedding loads contained large percentages of nonliving reef material, prompting LDWF to recommend limiting the amount of seed oyster harvest to maintain healthy levels of substrate on Public Oyster Seed Grounds.

On Jan. 20, 2019, harvest of market-size oysters was closed on public oyster grounds in the northern portion of LDH Harvest Zone 3, as well as from the Three Mile Pass and Drum Bay cultch plants to ensure these areas could withstand continued but limited harvest to maintain a sustainable harvest of the oyster resource. Two additional opportunities for seed oyster harvest were provided during March 2019 due to the opening of the Bonnet Carré Spillway. From March 14-16, 2019, all of LDH Harvest Area 1, in Lake Borgne was opened to allow the transplant of oysters that might be negatively impacted by Mississippi River water passing through the spillway. From March 19-21, 2019, transplant of oyster resource was allowed from all of LDH Harvest Areas 1 and 2. The 2018/2019 oyster season in CSA 1 North closed on April 30, 2019 (*Table 2*).

Harvest for the CSA 1 North during the 2018/2019 oyster season was estimated at 18,669 sacks of market-size oysters and 4,635 bbls of seed oysters. Compared with the 2018 oyster stock assessment, there was an estimated use of 30.1% of the market-size resource and 9.4% of the seed resource in 2019. In a general spatial context, this harvest was variable throughout CSA 1 North. The majority of the market-size oyster resource was harvested from Petit Island and Round Island. These two reefs combined accounted for 50.7% of harvested market-size oyster resource. There was also notable market-size resource harvest from Halfmoon Island, Three Mile Bay and the Drum Bay and Three Mile Pass cultch plants. The majority (65.8%) of the observed seed harvest came from the Three Mile Pass cultch plant, which is adjacent to the Three Mile Bay Reef Complex. An additional 29.1% of seed harvest came from Round Island. In terms of total productivity, the Three Mile Pass cultch plant and Round Island combined to yield 52% of all oysters harvested from CSA 1 North with 3,776 bbls and 3,489 bbls respectively.

While obtaining fishery dependent data, LDWF biologists routinely collect random samples of oyster seed loads from vessels working on the Public Oyster Seed Grounds to determine the percent of cultch (non-living material) being harvested within bedding loads. During the 2018/2019 oyster season, biologists collected samples from nine different vessels. Bedding loads on these vessels yielded cultch percentages ranging from 10.9 to 44.8%. These observations show a continuing trend of excessive cultch removal from public oyster areas by bedding vessels. Loss of adequate cultch material continues to be a major concern for Public Oyster Seed Grounds within CSA 1 North.

CSA 1 SOUTH

Introduction

The Public Oyster Seed Grounds in CSA 1 South (South Pontchartrain Basin), formerly CSA 2, consist of approximately 300,000 acres of water bottom located from the Mississippi River Gulf Outlet (MRGO) southward to South Pass in the Mississippi River delta and eastward from the eastern extent of private oyster leases east of the Mississippi River to the Breton National Wildlife Refuge. These Public Oyster Seed Grounds include Bay Gardene Public Oyster Seed Reservation, as well as areas designated as sacking only in Bay Long. Historically, this area has provided seed and market-size oysters for oyster fishermen from Louisiana, Mississippi, and Texas. Hydrology in the area is influenced at high Mississippi River stages by discharges through gaps in the Mississippi River levee south of Pointe a la Hache and through the Bohemia Spillway and Bohemia Spillway, discharge from the Caernarvon and Bayou Lamoque freshwater diversion structures, and main-stem river distributaries in the southern portion of the Basin (*Figure 2.1*).

LDWF continually expands and enhances public oyster reefs through the placement of cultch material (e.g. shell, limestone, crushed concrete) on suitable water bottoms. Numerous cultch plants have been constructed throughout CSA 1 South since 1917, including sites in Bay Gardene and Black Bay. Most recently, cultch plants were completed in California Bay in 2011 as well as in Bay Crabe and Lake Fortuna in 2012 as part of the 2010 *Deepwater Horizon* oil spill NRDA Early Restoration Program. Currently, LDWF, NOAA, and the St. Bernard Parish Government are working together to enhance a 100-acre portion of the 2012 Lake Fortuna cultch plant. To date, 16,154 cubic yards of oyster shell have been deployed on the site.

Methods

LDWF biologists collected field samples for this oyster stock assessment between July 1 and July 9, 2019, from a total of 26 stations within CSA 1 South according to the methodology described in the Statewide Overview. Sampling stations included 24 historical sampling stations, the 2009 Lonesome Island cultch plant, and the 2012 Lake Fortuna cultch plant (*Figure 2.1*). Biologists consider the 2012 Lake Fortuna cultch plant to be significantly different from surrounding water bottoms and assess this area separately as a result (*Table 2.1*).

To better locate and assess the oyster stock in the public oyster seed grounds, LDWF has conducted a number of side-scan sonar studies of water bottoms in CSA 1 South in recent years. These studies, coupled with historical reef and cultch plant information, have resulted in a more up-to-date and realistic designation of productive water bottoms for use in the annual oyster stock assessment. The 2018 oyster stock assessment is based on the updated reef acreage of 27,662.3 acres of water bottom.

Beginning with the 2013 oyster stock assessment, oyster reefs within CSA 1 South were grouped into reef complexes based on location, hydrology, oyster productivity, and response to environmental stressors. There were a total of 12 reef complexes, each with one to four representative m^2 sampling stations (*Table 2.1*). Recent water bottom assessments identified an additional 1,524 acres of oyster habitat (reef and scattered shell), but this acreage is not included in the annual oyster stock assessment acreage, as no current oyster sampling station adequately describes this acreage. Also not included in this year's stock assessment is the 100-acre portion of the 2012 Lake Fortuna cultch plant that underwent enhancement.

Results and Discussion

Seed and Market-Size Stock

The 2019 estimated oyster stock size for CSA 1 South was 'null'. Biologists observed no seed or market-size oysters during the 2019 oyster stock assessment (*Table 2.1*). Recent mortality was noted at only two sampling stations. However, this does not mean there was a complete absence of market-size oysters. As actual sampling stations are random and include only a small percentage of the total public oyster seed grounds, scattered oyster resource may be present in portions of the area that were not evaluated during this assessment. The results of this stock assessment point to an extremely low abundance of oyster stock across CSA 1 South, a trend that has persisted for a number of years. The 2019 estimate of available seed and market-size oysters was even lower than the 2018 assessment, with the lack of any live oysters: Additionally, twelve of the 26 stations sampled were found to not have any measurable reef material. A trend that has persisted for a number of years.

Over the past 10 years, CSA 1 South has experienced periods of heavy localized harvest, high mortality events, strong tropical events, the 2010 *Deepwater Horizon* oil spill and related spill response activities, and increasing freshwater influence from the Mississippi River. All of these appear to have severely reduced oyster abundance. As a result, the oyster stock size estimate continues to be critically below both the previous 10 years' and long-term (1985-2018) averages (*Figure 2.2*).

Spat Production

No live spat were found in the 2018 oyster stock assessment samples. Evidence of recent spat mortality was noted at just one sample sampling station. Although these sampling events may occur outside of the peak spawning period, it is evident that there has been only minimal spat catch on these reefs, marking a continuation of poor recruitment and survival within CSA 1 South. Inadequate cultch material for spat attachment is definitely a limiting factor for the Basin. Seven of the 26 stations sampled did not have any measurable reef material, and another five were noted to have material almost completely buried under sediments.

TABLE 2.1. Current reef complex acreages in CSA 1 South.

Complex Name	Station Name	Station Number	Current Acreage
East Black Bay	Jessie's Island	3013	549.9
	Bayou Lost	3016	
Bay Gardene	East Bay Gardene	3033	1,262.6
Bay Crabe	West Bay Crabe	3019	1,732.0
	East Bay Crabe	3032	
Elephant Pass	Elephant Pass	3022	202.2
California Bay	Sunrise Point	3027	3,692.8
	California Bay	3025	
	Bay Long	3001	
Mangrove	Mangrove	3000	2,889.11
	East Pelican	3028	
South Black Bay	Stone Island	3020	3,575.7
	South Black Bay	3021	
	Curfew Island	3023	
	Telegraph Island	3026	
Lonesome Island	Snake Island	3012	2,861.9
	2009 Lonesome Island CP	3086	
	Black Bay	3018	
Lake Fortuna	Lake Fortuna South	3036	3,453.85
	Lake Fortuna North	3003	
Horseshoe Reef	North Black Bay	3015	2,485.8
	Horseshoe Reef	3039	
	East Stone Island	3055	
Wreck	Wreck	3054	4,485.8
Battledore Reef	Battledore Reef	3035	270.6
Lake Fortuna CP (2012)			200.0
Total			***27,662.3***

Hydrological Data

Aside from occasional extreme event (oil spills, tropical storms), extended periods of low spring salinities and possibly periods of hypoxia in the summer and fall decrease spawning success and increase risk of mortality, inhibiting oyster production in this area. Past harvest pressure, combined with poor hydrology for oyster production, have largely degraded reef areas to shell hash and mud that is heavily fouled with mussels and other organisms; this lack of suitable substrate to enable spat settlement adds another stressor to the population in this area.

Fouling Organisms

The hooked mussel is a sessile bivalve often associated with oyster reefs that likely competes with oysters for food and settlement surfaces. During the 2018 oyster stock assessment, hooked mussels were present at 14 of the 26 sampling stations and ranged in density from 0.4 to 124.8 individuals per m^2. Overall, hooked mussel density was greatly decreased since the previous assessment with the largest decrease in density observed at the Jessie's Island station. Decreases in hooked mussel density were observed at fourteen sampling stations where mussels were observed during the 2018 assessment. There was, however, notably moderate to heavy barnacle fouling of oyster shells at sampling stations throughout CSA 1 South. All of these forms of fouling limit the attachment of oyster larvae to available substrate.

Oyster Predators and Disease

The southern oyster drill (*Stramonita haemastoma*) is a marine gastropod known to prey on oysters using a small tooth-like scraping organ called a radula to bore a hole through the oyster shell. No live oyster drills were found during this sampling effort. Recent extended periods of low salinity may have limited oyster drill abundance in the area. No stone crabs or blue crabs were observed in the samples.

Dermo, a protozoan parasite that infects oyster tissue known to cause extensive oyster mortalities especially in high salinities and high water temperatures. One dermo sample was collected from CSA 1 South in September 2019. Results of the Dermo tests are presented in Appendix I.

Mortality

During 2019 oyster stock assessment, biologists observed oyster mortality at two sampling stations. The North Lake Fortuna station was observed to have 100% mortality of spat oysters. On the Lake Fortuna cultch plant biologists noted 100% mortality of seed and market-size oysters. Under normal conditions, the lack of mortality could be interpreted as a sign of a healthy population with only minimal impacts from disease or predators, however, in this instance, low mortality can be attributed to the tremendous loss of oyster stock within CSA 1 South.

Tropical and Climatic Events

As mentioned in previous section, spring 2019 has seen an unprecedented flooding event, driven by heavy winter snowfall and torrential rains across the mid-western United States, the Mississippi River approached flood stage by the end of February, 2019. Due to the duration of this flooding event, salinities on oyster growing areas throughout CSA 1 South also decreased to below what is required for effective oyster growth and viability. The elevated river stage has greatly increased fresh water introduction from main stem river flow, as well through distributaries and levee breaches within the southern Basin. As a result of the intensity and duration of this flooding event, salinities on oyster growing areas throughout CSA 1 South decreased to below what is required for effective oyster growth and viability.

2018/2019 Oyster Season

No portion of CSA 1 South Public Oyster Seed Grounds was made available for commercial harvest during the 2018/2019 oyster season. This is the second consecutive season that public that public reefs south of the MRGO remained closed. The 2019 oyster stock assessment estimated there were no market-size oysters found in CSA 1 South.

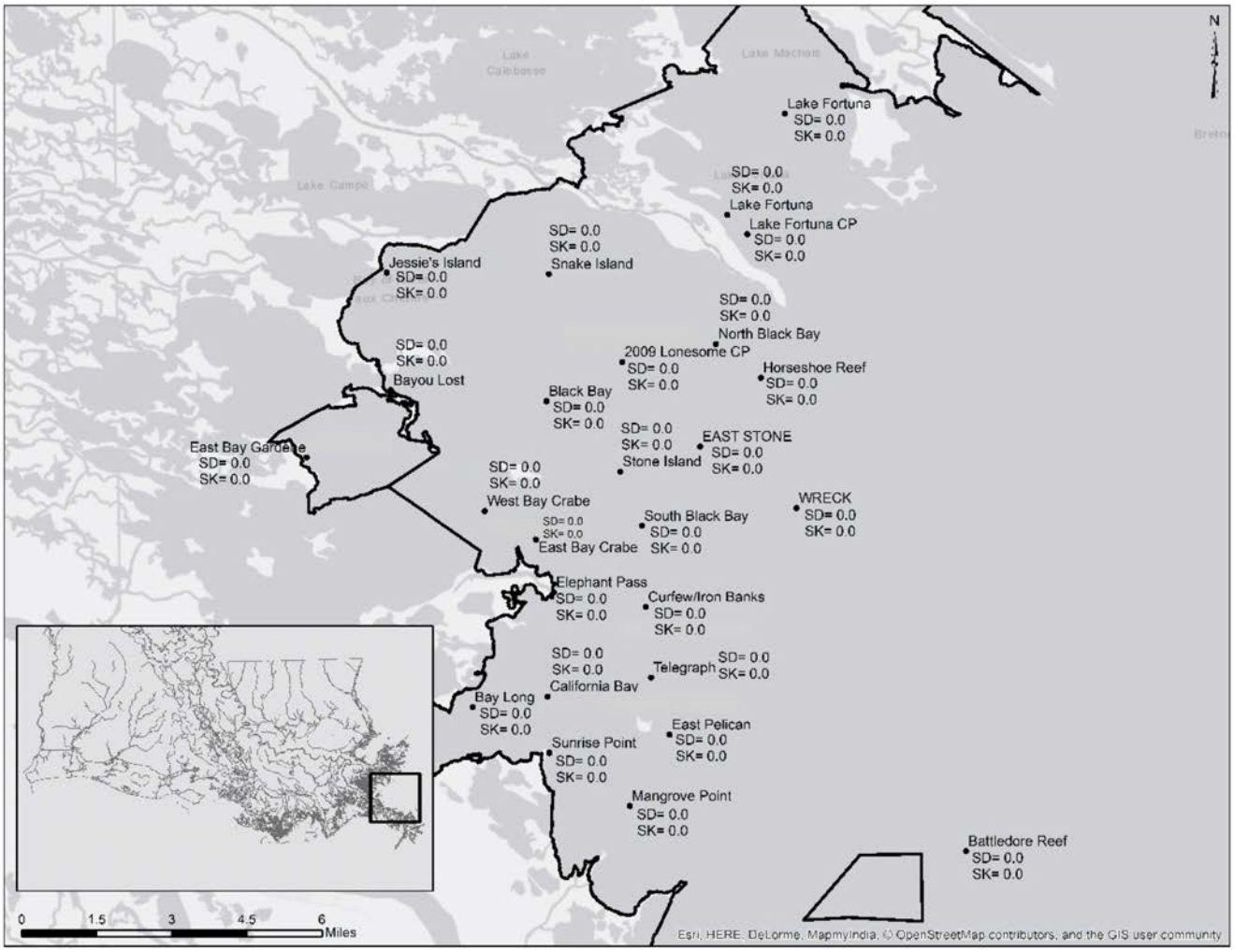

FIGURE 2.1. CSA 1 South oyster stock assessment sampling stations with average seed and sack sampling densities for the 2019 stock assessment, square-meter sampling.

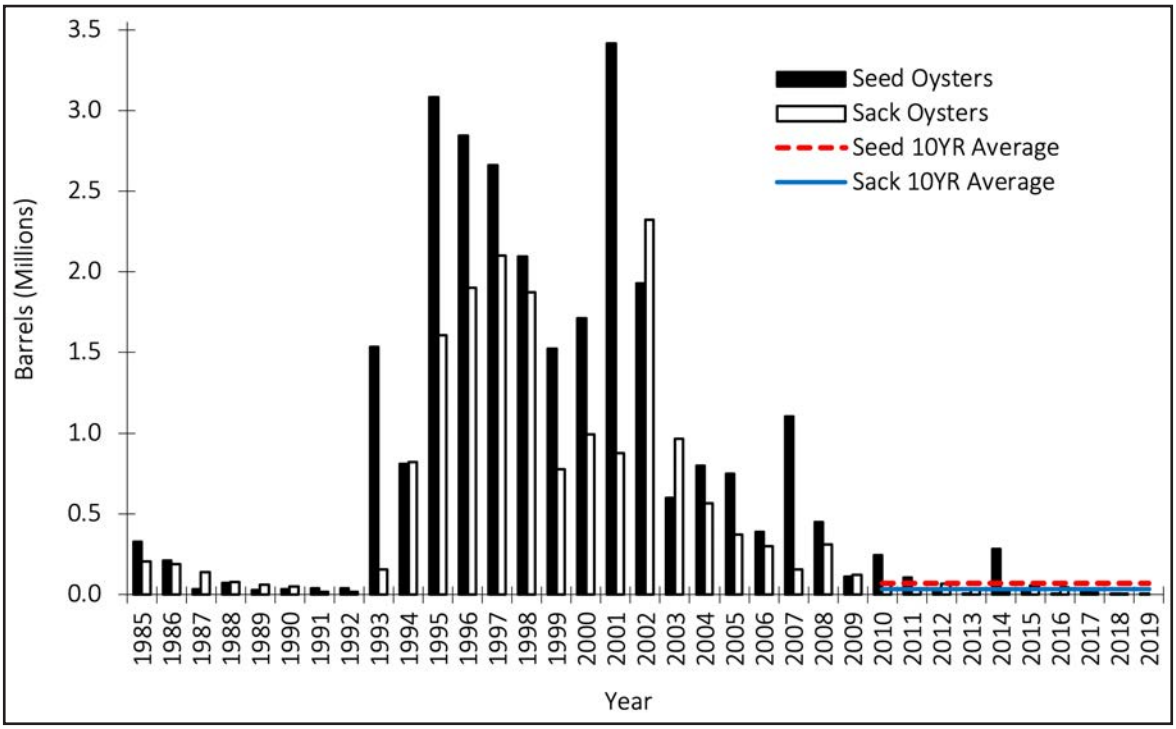

FIGURE 2.2. Current and historical seed and market-size stock size estimates in CSA 1 South. Horizontal lines represent the previous 10-year' seed (red) and market-size (blue) stock size estimate averages.

CSA 3

Introduction

CSA 3 consists of three public oyster areas distributed generally in a north-south direction within the Barataria Bay estuary (*Figure 3.1*):

1. Hackberry Bay Public Oyster Seed Reservation
2. Barataria Bay Public Oyster Seed Grounds
3. Little Lake Public Oyster Seed Grounds.

Hackberry Bay, in Jefferson and Lafourche parishes, is a 4,402-acre mesohaline embayment with a primarily soft silt and clay bottom of which only 14.7 acres is naturally occurring reef material. The three historical sampling stations within Hackberry Bay are the Upper, Middle, and Lower Hackberry sampling stations. The Middle Hackberry Bay station is the only sampling station located over existing natural reef, while the Upper and Lower stations are located over former cultch plants placed on top of historical reefs (*Figure 3.1*). The Upper Hackberry Bay station was the result of a 1994 cultch plant using federal disaster funds from Hurricane Andrew in 1992. The 1994 cultch plant totaled 145 acres and was comprised of six different sections of substrate including: crushed concrete, shucked shell, reef shell, clam shell, Kentucky limestone, and Bahamian limestone. This station was also the location of cultch plants in 1943 (140 acres), 1945 (70 acres), 1946 (92 acres), and 1981 (67 acres). The Lower Hackberry Bay station is on a reef that was part of a 450-acre 1973 cultch plant. Since very little natural reef exists on the Hackberry Bay Public Oyster Seed Reservation, production is highly dependent upon and reflective of when and where cultch plants are placed in the bay. It is unknown how much, if any, cultch material from the 1994 and earlier cultch plants remains exposed above the surface of the mud. Therefore, the acreage of these previous cultch plants is not factored into the annual oyster stock assessment.

Since 2004, LDWF has constructed five cultch plants in Hackberry Bay. LDWF constructed two cultch plants totaling 35 acres in 2004 and one of 50 acres in 2008. Two additional plants, a 2012 plant of approximately 200 acres, and a 2014 plant of 30 acres, combined with the other three, have increased the estimated reef acreage on the Hackberry Bay. These recent cultch plants have increased the estimated reef acreage on the Hackberry Bay Public Oyster Seed Reservation from 99.7 to 329.7 acres (*Table 3.1*).

The Commission designated the Barataria Bay Public Oyster Seed Grounds as such in response to possible changes in the salinity regime of the estuary stemming from the Davis Pond freshwater diversion project. Davis Pond is a large Mississippi River diversion that aims to reintroduce freshwater and nutrients into the Barataria Bay estuary to help restore the Louisiana coast. As this diversion was anticipated to reduce salinities in the estuary, LDWF estimated that additional public oyster seed grounds farther down-estuary may be productive during years with high freshwater input. The only known existing reef on the Barataria Bay Public Oyster Seed Grounds is a 40-acre cultch plant constructed of 7,536 cubic yards of crushed concrete in the northeast section of the area in May 2004. The reef is vulnerable to predators such as oyster drills and the protozoan parasite Dermo during periods of higher salinities. LDWF does not expect consistent production from this area until salinity regimes in the basin change due to natural forces or coastal restoration efforts.

The Little Lake Public Oyster Seed Grounds had previously been used as a temporary natural reef area and once contained private oyster leases. These leases all fell within the Davis Pond freshwater diversion impact area and were either purchased or moved by the state and federal government prior to the opening of the Davis Pond diversion. The Davis Pond diversion has not been consistently used to its maximum capacity since it first opened in 2002, and environmental conditions during some years have allowed oysters to continue to exist in Little Lake. Therefore, the Commission designated this area a public oyster ground so fishermen could harvest oysters from this area and LDWF could actively manage the reefs in this area. The location of the Little Lake Public Oyster Seed Grounds makes it vulnerable to depressed salinities from rainfall, inflow from the Intracoastal Waterway, and discharge from the Davis Pond diversion. Reduced salinities from increased freshwater input can negatively impact oyster survival and availability. However, when salinities are higher, the Little Lake Public Oyster Seed Grounds have provided the oyster industry with additional seed and market-size oysters in Barataria Basin. Although there is no information on the reef acreage on the Little Lake Public Oyster Seed Grounds, LDWF hopes to better survey the area in the future.

Methods

LDWF biologists collected field samples for the 2019 oyster stock assessment between July 1 and July 8, 2019, from a total of nine stations within CSA 3 according to the methodology described in the Statewide Overview of this report. Sampling stations included the recent cultch plants in Hackberry Bay (2012 and 2014; *Figure 3.1*). Biologists did not sample the Little Lake Public Oyster Seed Grounds due to lack of information on reef acreage.

Results and Discussion

Seed and Market-Size Stock

The 2019 oyster stock assessment estimated the stock on the Hackberry Bay Public Oyster Seed Reservation, including the productive cultch plants, at 3,108.0 bbls of seed oysters and 336.7 bbls of market-size oysters for a total of 3,444.7 bbls overall stock (*Table 3.1*). Seed oysters were not present at the 2004 Barataria Bay cultch plant, and the Lower Hackberry Bay sampling stations.

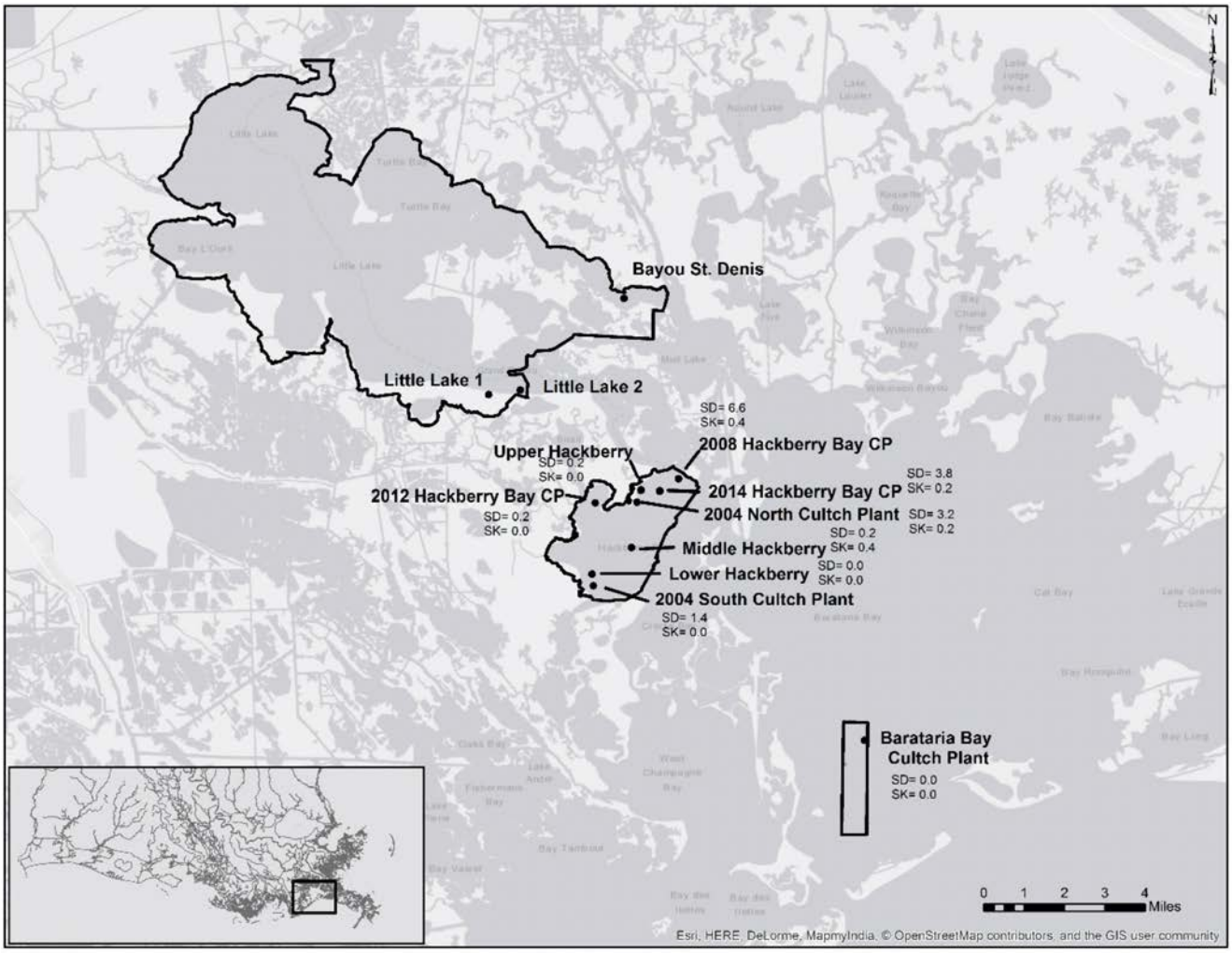

FIGURE 3.1. 2019 CSA 3 sampling stations with average seed and sack sampling densities for the 2019 stock assessment, square-meter sampling.

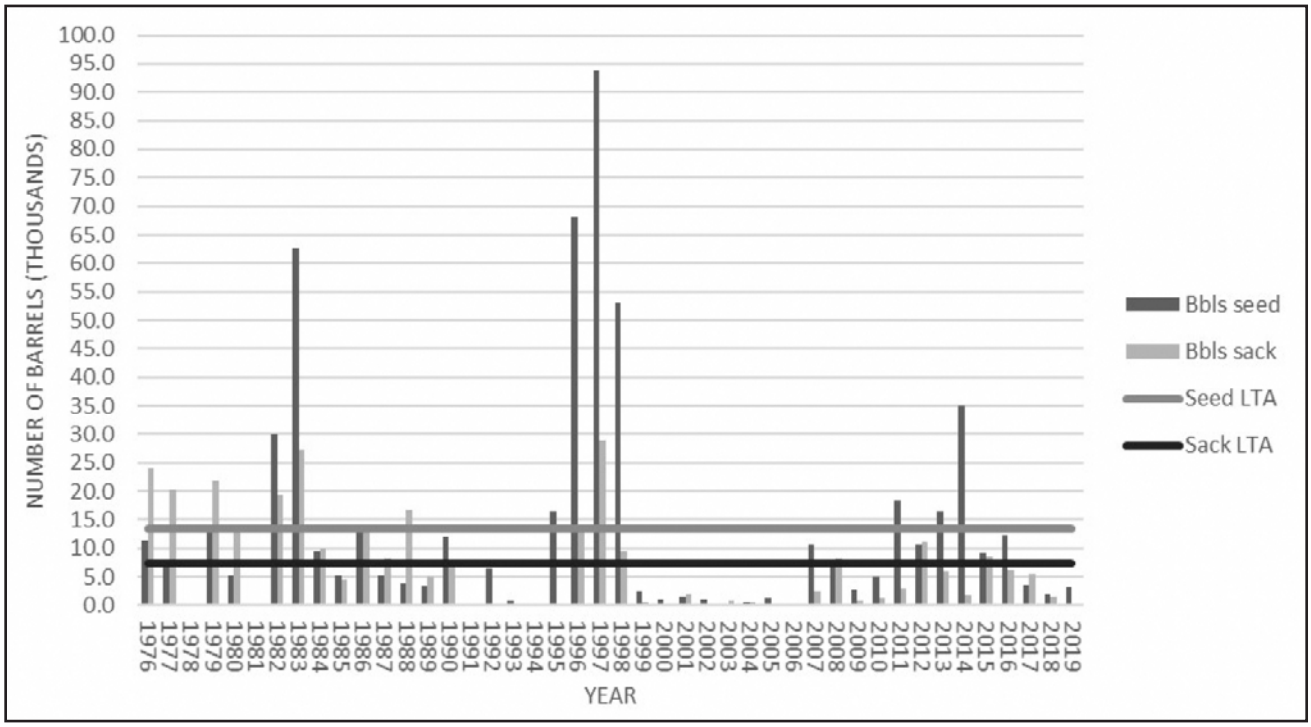

FIGURE 3.2. Estimated seed and market-size oyster availability on the Hackberry Bay Public Oyster Seed Reservation from 1976 to 2019 compared to long-term average seed and market-size abundance (LTA 1976-2018).

TABLE 3.1. 2019 square-meter sampling results for CSA 3.

Station Name	Station Number	Approx. Reef Acreage	Average Live Seed Oysters/ m^2	Average Live Market-Size Oysters/m^2	Bbls of Seed Oysters Available	Bbls of Market-Size Oysters Available	Oysters Spat/m^2
Hackberry Bay North Cultch Plant (2004)	6	10.0	3.2	0.2	179.9	22.5	0.8
Hackberry Bay South Cultch Plant (2004)	7	25.0	1.4	0.0	196.7	0.0	0.4
Hackberry Bay Cultch Plant (2008)	9	50.0	6.6	0.4	1,854.8	224.8	1.6
Hackberry Bay Cultch Plant (2012)	10	200.0	0.2	0.0	224.8	0.0	0.0
Hackberry Bay Cultch Plant (2014)	11	30.0	3.8	0.2	640.8	67.4	0.0
Lower Hackberry Bay	1	4.9	0.0	0.0	0.0	0.0	0.0
Middle Hackberry Bay	2	4.9	0.2	0.4	5.5	22.0	0.0
Upper Hackberry Bay	3	4.9	0.2	0.0	5.5	0.0	0.0
Barataria Bay Cultch Plant (2004)	8	40.0	0.0	0.0	0.0	0.0	0.0
Little Lake		Unknown	Unknown	Unknown	Unknown	Unknown	
Total		***369.7***			***3,108.0***	***336.8***	

There was an overall 52.8% increase in seed availability from July 2018. Seed availability is 74.2% below the 10-year average (3,108.00 bbls) and 76.8% below the long-term average from 1976-2018 (3,540.8 bbls; *Figure 3.2*).

Market-size oysters were present at three stations: Middle Hackberry Bay sampling station, the North Hackberry Bay cultch plant, and the 2008 Hackberry Bay cultch plant. The 2004 North Hackberry Bay cultch plant was the only station that had more market-size oysters available compared to 2018 (0.2 per m^2). The 2008 Hackberry Bay cultch plant had the highest density at 0.4 per m^2 (*Table 3.1*). Including the Hackberry Bay 2012 and 2014 cultch plants, the market-size oyster stock was down 76.9% from 2018, 93.5% from the previous 10-year average (336.7 bbls), and 95.3% from the long-term average (7,245.1 bbls; *Table 3.1, Figure 3.2*).

The combined stock of 3,444.7 bbls of seed and market-size oysters showed was 1.4% below the 2018 estimate (*Table 1*), 80.0% below the 10-year average, and 83.3% below the long-term average. There was an overall reduction in market-size oyster stock at all but two stations - the 2008 Hackberry Bay cultch plant and North Hackberry Cultch. The highest available bbls of market-size oyster were at the 2008 and 2014 Hackberry Bay cultch plants. There were 224.8 bbls of market-size oysters at the 2008 Hackberry Bay cultch plant and 67.4 bbls at the 2014 Hackberry Bay cultch plant. The progressive decline in available oyster stock over time appears to be an artifact of loss of production on ageing reefs within the Hackberry Bay Public Oyster Seed Reservation. Researching the potential for rehabilitating older reefs and cultch plants should be considered to augment production. No live seed or market-size oysters were observed on the Barataria Bay Public Oyster Seed Grounds (*Figure 3.1, Table 3.1*). Market-size oyster availability has not been documented on this area since it was created in 2004.

	2017	2018	% Change
Seed	2,033.8	3,108.0	+52.8%
Market-Size	1,459.1	336.8	-76.9%
Total	***3,492.9***	***3,444.8***	***-1.4%***

The July 2019 average size of seed and market-size oysters was 2.7 inches The overall average size, from combined dredge and m^2 samples, from July 2018 to July 2019 was 2.7 inches, ranging from 1.2 to 3.0 inches

The July 2019 average catch-per-unit-effort (CPUE) at the seven Hackberry Bay stations, for both seed and market-size oysters combined, as well as spat, seed, and market-size oysters combined, was lower than July 2018, and the CPUE was below the overall combined monthly average CPUE for dredge samples from August 2018 through June 2019.

Spat Production

There was a slight increase in spat m^2 compared to 2018 (0.3 spat per m^2 vs. 0.0 spat per m^2). Even though 16 total live spat were collected in 2019, spat abundance was still well below the long-term average (1976-2019) of 8.0 spat per m^2. The highest numbers of spat were found at the 2008 and North Hackberry Bay cultch plants (8 at 2008 and 4 at North); 75% of the 16 total spat came from these reefs. No spat were collected on the Barataria Bay Public Oyster Seed Grounds in 2019.

Hydrological Data

Oyster habitat suitability for area seed grounds are highly influenced by Mississippi River discharge and the Davis Pond diversion discharge. The United States Army Corps of Engineers (USACE) Tarbert gauge recorded Mississippi River discharge from January 2018 through June 2019 averaging 841,000 cubic feet per second (cfs), reaching a peak discharge for 2019 at 1,385,000 cfs in March. Discharge levels remained above the long-term average (1961-2015) of 594,000 cubic feet per second (cfs) (*Figure 3.4*).

The United States Geologic Survey (USGS) constant recorder located near Davis Pond diversion structure, recorded a monthly average discharge of 1,177 cfs from July 2018 through June 2019, which was below the long-term monthly average of 1,831 cfs. The maximum monthly average discharge over this time period was 1,548 cfs during August 2018 (*Figure 3.5*). Oyster habitat suitability for area seed grounds are highly influenced by Mississippi River discharge and the Davis Pond diversion discharge.

Hackberry Bay Public Oyster Seed Reservation salinities from January 2018 to June 2019 averaged 9.3 ppt with a range of 4.3 to 17.4 ppt (*Figures 3.4 and 3.5*). The average salinity for June 2019 was 4.3 ppt, which remained below the long-term (1996-2019) June monthly average of 9.9 ppt.

Using the Habitat Suitability Index (HSI) as outlined in Sustainable Oyster Shellstock Models (Soniat, *oystersentinel.org*), the average salinity values listed above, along with a potential 100% bottom covered with suitable cultch, yielded only an HSI value of 0.42, or "Fair" oyster habitat for Hackberry Bay Public Oyster Seed Reservation in 2019. The HSI value for Hackberry Bay was 0.32 from 2017 and 2018 and has been categorized as "Unsuitable" to "Fair" for the past five years, mostly because of suppressed salinity levels. Elevated Mississippi River discharge, combined with increased discharge from the Davis Pond structure, and above average rainfall over the previous four months, reduced salinity in Hackberry Bay below the long-term monthly average. These unsuitable oyster habitat conditions over such an extended period of time have likely negatively impacted the oyster population within the Hackberry Bay Public Oyster Seed Reservation leading to the decrease in market-size oyster availability over time as seen during the 2019 oyster stock assessment sampling.

Salinities in the Barataria Bay Public Oyster Seed Grounds from January 2018 to June 2019 averaged 16.2 ppt with a range of 8.1 to 28.4 ppt (*Figures 3.4 and 3.5*). Using the HSI model, the average salinity values listed above, along with a potential 100% bottom covered with suitable cultch, yielded a HSI value of 0.66 or "Fair" for the Barataria Bay Public Oyster Seed Grounds. Therefore, it would be expected that some level of oyster stock would be available on this area. One seed oyster was sampled during the 2018 assessment for the first time since development of the reef in 2004, however, no spat, seed, or market-size oysters have been sampled from this area since the 2018 oyster stock assessment sampling.

Salinities in the Little Lake Public Oyster Seed Grounds from January 2018 to June 2019 averaged 5.2 ppt with a range of 1.3 to 11.4 ppt (*Figures 3.4 and 3.5*). Using the HSI model, the average salinity values listed above, along with a potential 100% bottom covered with suitable cultch, yielded an HSI value of 0.0 or "Unsuitable Habitat" oyster habitat for the Little Lake Public Oyster Seed Grounds. This HSI value likely explains the high mortalities and low catch per effort seen for the replicate dredge samples conducted in Little Lake Public Oyster Seed Grounds during July 2019.

Fouling Organisms

The hooked mussel is a reef-associated, benthic bivalve species that competes with oysters for food and settlement surfaces. Hooked mussels were present at five of the nine sampling stations including the lower and middle Hackberry Bay historical sampling stations, the 2004 Hackberry Bay South cultch plants, and the 2008 and 2014 Hackberry Bay cultch plants. The highest density (3.6 mussels per m^2) was observed at the south Hackberry Bay historical sampling station. The average number of hooked mussels observed on the Hackberry Bay Public Oyster Seed Reservation was 1.1 per m^2, a decrease from last year's average of 3.1 per m^2.

Oyster Predators and Disease

The southern oyster drill is a marine snail that preys on oysters using a radula (a small tooth-like rasping organ) to bore a hole through the oyster shell. During sampling for the 2019 stock assessment, two oyster drills were collected from the Barataria Bay Public Oyster Seed Grounds, one collected at the Middle Hackberry station, and one oyster drill was collected at the 2012 Hackberry cultch plant. Since 2009, biologists have collected only 21 oyster drills during dredge and m^2 sampling; most of these have come from the Barataria Bay Public Oyster Seed Grounds. Mortalities of oyster drills have been reported from Mississippi Sound when salinities fell below 8-10 ppt; the absence of oyster drills from almost all 2019 samples is most likely due to the low overall average salinities throughout CSA 3.

Dermo, a protozoan parasite that infects live oyster tissue, is known to cause extensive oyster mortalities, especially in high salinities and water temperatures. Results of Dermo tests are presented in Appendix I.

Mortality

Spat mortality at each sampling station on the Hackberry Bay Public Oyster Seed Reservation averaged 11.1% overall, an increase from the 1.6% overall average in 2018. Seed oyster mortality at each station averaged 0.0%. Market-size oyster mortality was 0.0%. The combined overall spat, seed, and market-size mortality was 2.0%.

Monthly dredge samples also provided additional source of oyster mortality data. Dredge samples revealed an overall average monthly mortality of 2.7% for spat, seed, and market-size oysters combined between August 2018 and June 2019 (*Figure 3.3*). This was similar to the 2.6% overall monthly mortality observed during the same time period prior to the 2018 stock assessment sampling. Although the average monthly mortality for the past 12 months appears low, elevated spat mortalities were documented in November, February and April of 2019.

Tropical and Climatic Events

The 2019 flood event is discussed in the Introduction section of the Statewide Overview. No tropical systems have affected CSA 3 since Hurricane Isaac in 2012.

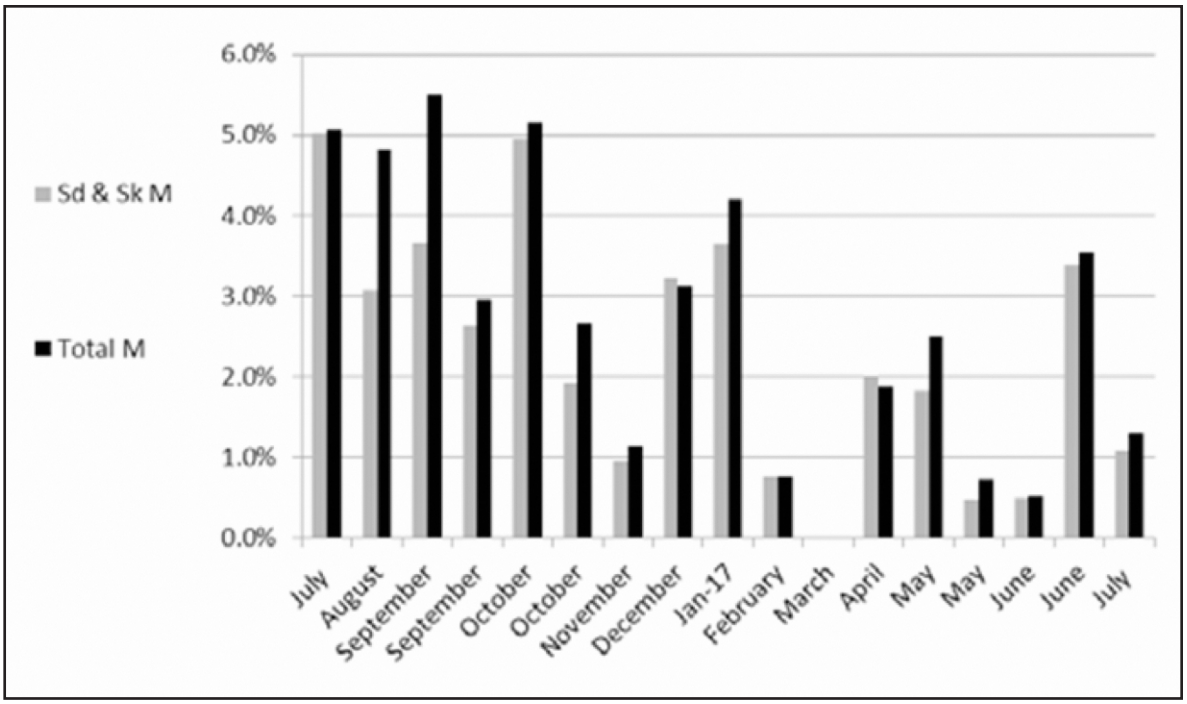

FIGURE 3.3. Total oyster mortality –spat, seed and sack oysters (Total M) and combined seed/market-size (Sd. & Sk. M) mortality in monthly dredge and annual (July) square-meter samples in CSA 3.

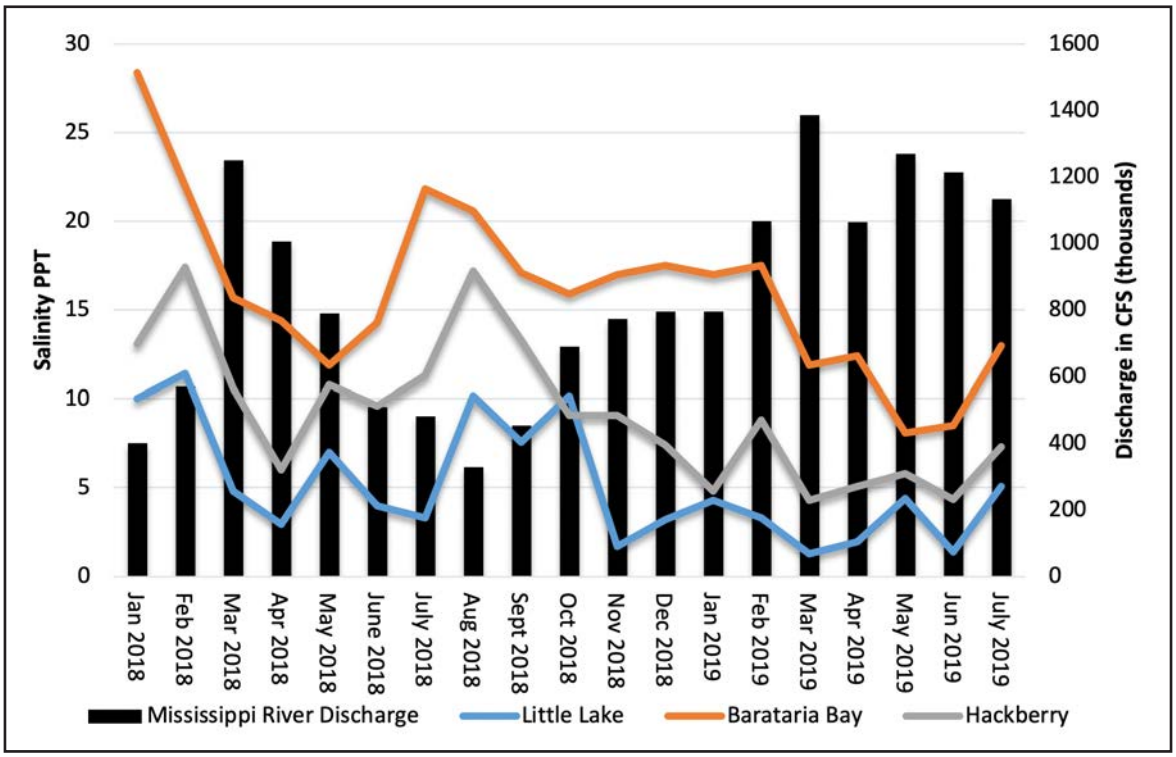

FIGURE 3.4. Mississippi River discharge vs. average monthly salinities in the Barataria Bay and Little Lake Public Oyster Seed Grounds and Hackberry Bay Public Oyster Seed Reservation. The U.S. Army Corps of Engineers supplied Mississippi River discharge data.

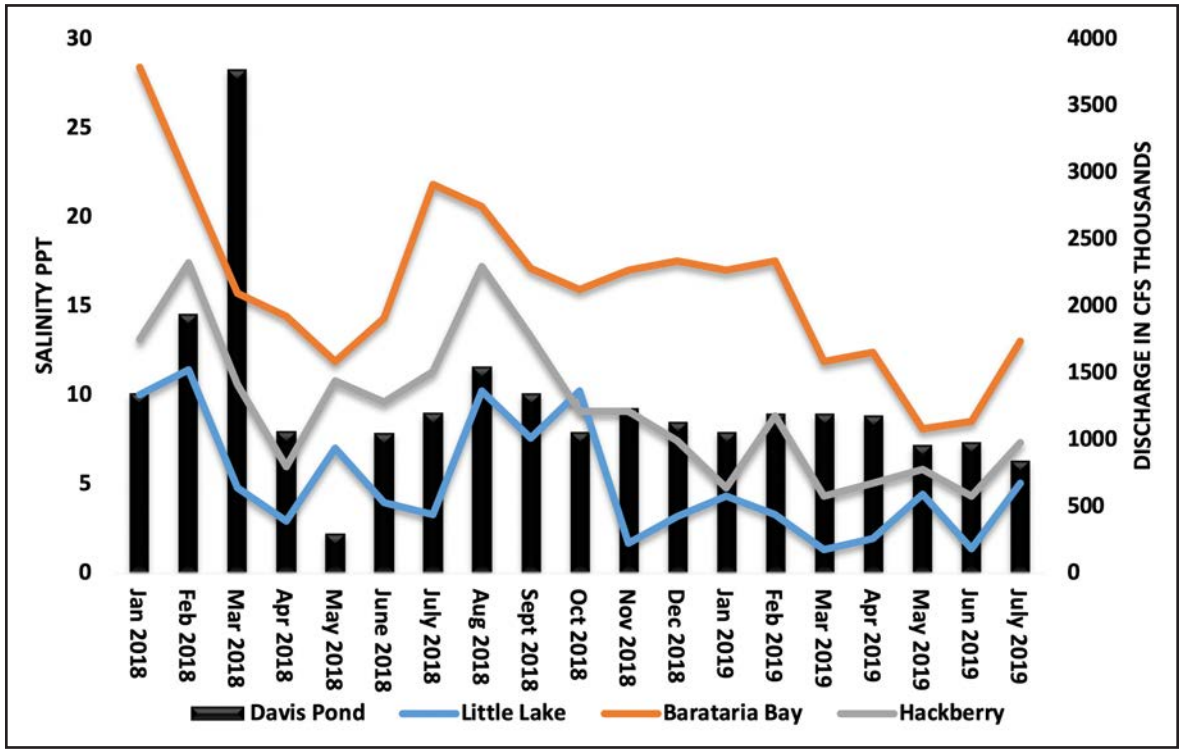

FIGURE 3.5. Davis Pond discharge vs. average monthly salinities in the Barataria Bay and Little Lake Public Oyster Seed Grounds and Hackberry Bay Public Oyster Seed Reservation. The Davis Pond discharge data are supplied by the U.S. Geological Survey constant data recorder located near the Davis Pond structure.

2018/2019 Oyster Season

The Little Lake and Barataria Bay Public Oyster Seed Grounds remained closed for the 2018/2019 oyster season. The Hackberry Bay Public Oyster Seed Reservation opened for one day on Oct. 29, 2018, for bedding purposes only. The market-size season opened from Oct. 30 through Nov. 3, 2018, with a 50 sack limit per vessel per day. Total harvest from public grounds in CSA 3 during the 2018/2019 season was estimated at 877 bbls of seed and 93 bbls of market-size oysters (*Table 2, Figure 3.6*).

While obtaining fishery dependent data, LDWF biologists routinely collect random samples of oyster seed loads from vessels working on the Public Oyster Seed Grounds to determine the percent of cultch (non-living material) being harvested within bedding loads. During the 2018/2019 oyster season, biologists collected samples from six different vessels from the Hackberry Bay Public Oyster Seed Reservation. Bedding loads on these vessels yielded cultch percentages ranging from 0 to 43%. These observations show a continuing trend of excessive cultch removal from public oyster areas by bedding vessels. Loss of adequate cultch material continues to be a major concern for Public Oyster Seed Grounds within CSA 3.

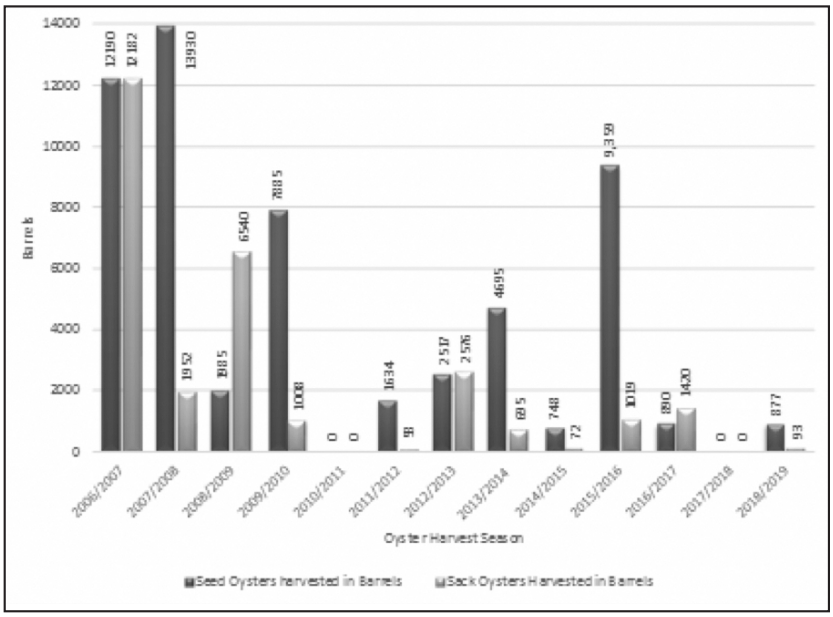

FIGURE 3.6. Estimated oyster harvest from the public oyster areas in CSA 3 for the past 13 oyster seasons based on boarding surveys. 2014/2015 estimates are for the Little Lake Public Oyster Seed Grounds only.

CSA 5

Introduction

CSA 5 is comprised of the Terrebonne Basin from Bayou Lafourche west to the Atchafalaya River, including Terrebonne Bay, Timbalier Bay, Sister Lake, Lake Mechant, and Caillou Bay. CSA 5 oyster stock assessments are divided into eastern and western portions of the Terrebonne Basin. There are currently seven different Public Oyster Seed Reservations (POSR) and Public Oyster Seed Grounds (POSG) within CSA 5:

1. Sister Lake (Caillou Lake) Public Oyster Seed Reservation
2. Bay Junop Public Oyster Seed Reservation
3. Lake Mechant Public Oyster Seed Grounds
4. Deep Lake Public Oyster Seed Grounds
5. Lake Felicity Public Oyster Seed Grounds
6. Lake Chien Public Oyster Seed Grounds
7. Lake Tambour Public Oyster Seed Grounds.

Sister Lake, Bay Junop, and Lake Mechant are located in the western Terrebonne Basin; Deep Lake, Lake Felicity, Lake Chien, and Lake Tambour are found in the eastern Terrebonne Basin (*Figures 5.1, 5.2 and 5.3*).

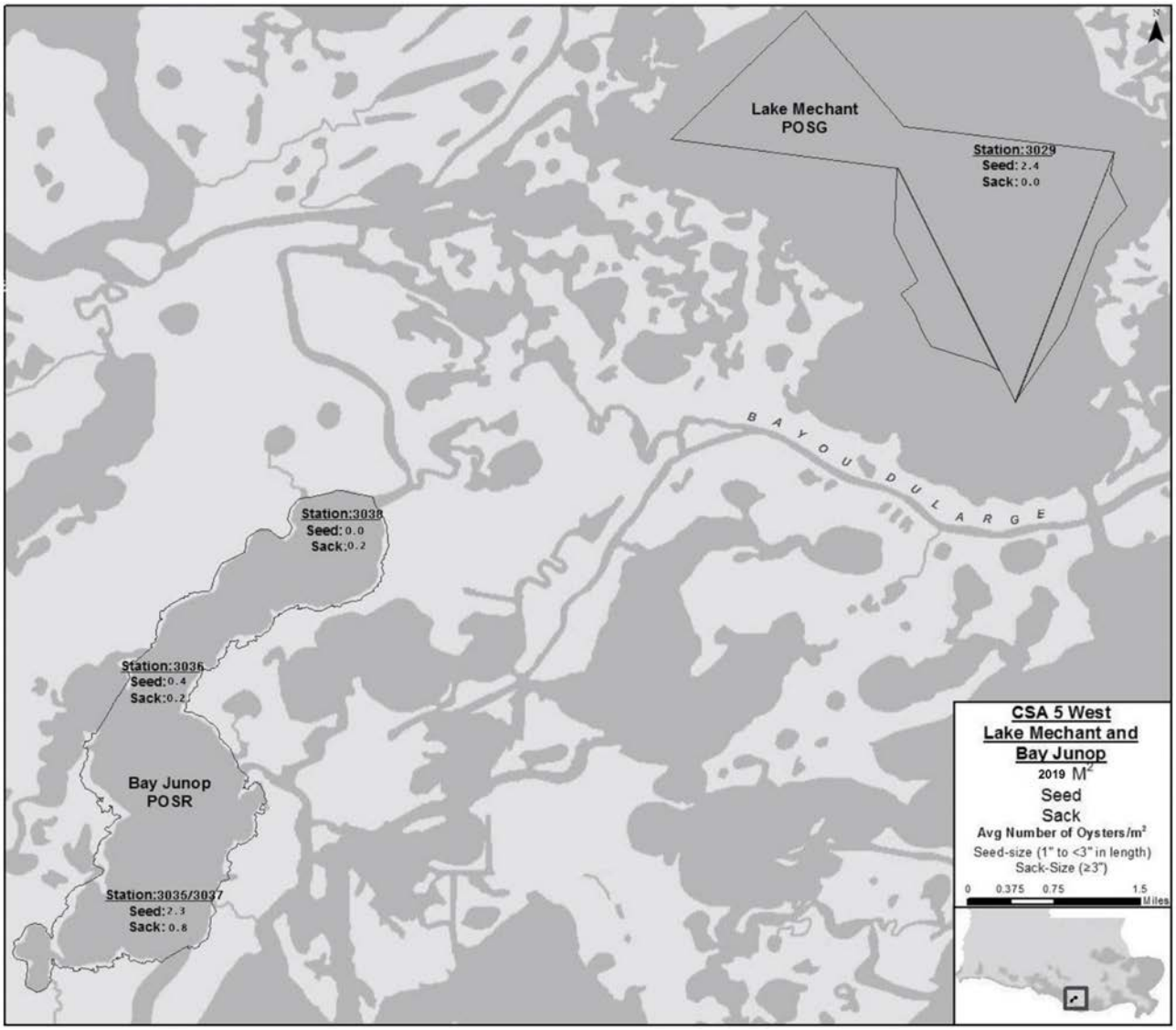

FIGURE 5.1. Bay Junop POSR and Lake Mechant POSG (western portion of CSA 5) with average seed and sack sampling densities for the 2019 stock assessment, square-meter sampling.

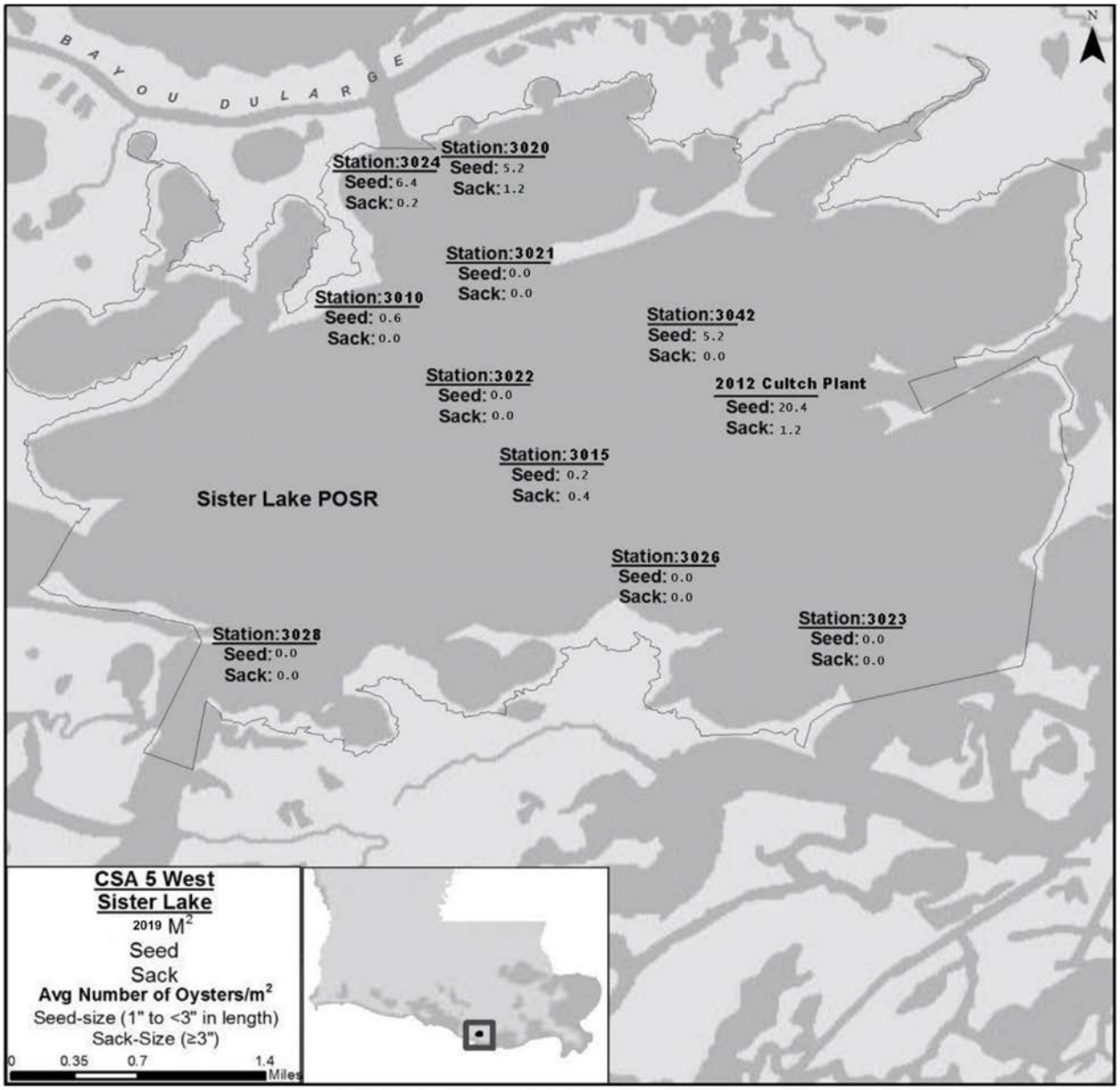

FIGURE 5.2. Sister Lake POSR with average seed and sack sampling densities for the 2019 stock assessment, square-meter sampling.

The Commission designated Sister Lake as a public oyster seed reservation in 1940; this area includes 9,150.5 acres of water bottom. (*Figure 5.2*). Recent Sister Lake cultch plants include a 67-acre site in 2004, a 156-acre site in 2009, and a 358-acre site in 2012. The most recent (2012) was funded as part of the 2010 *Deepwater Horizon* oil spill NRDA Early Restoration Program. For oyster stock assessment purposes, the current total reef acreage for Sister Lake is estimated to be 2,375.4 acres.

The Commission established the Bay Junop Public Oyster Seed Reservation (*Figure 5.1*) in 1948; it consists of approximately 2,646.5 acres of water bottom. Due to the shallow water depth of the bay and inability of barges and tugs to enter for cultch plants, LDWF has not been able to construct any reefs in this area to augment natural oyster reef production. Available public reef acreage in Bay Junop is estimated at approximately 252 acres.

The Commission established the Lake Mechant Public Oyster Seed Grounds (*Figure 5.1*) in 2001 with approximately 2,100 acres of water bottom and added unleased water bottoms between the designated public oyster seed grounds and private oyster leases in 2007. The addition increased water bottom acreage within the Lake Mechant Public Oyster Seed Grounds to 2,583 acres. The total reef acreage outside of the (2004) 30-acre cultch plant created within the seed grounds is unknown.

The Commission established the Lake Tambour, Lake Chien, Lake Felicity, and Deep Lake Public Oyster Seed Grounds (*Figure 5.3*) in 2001. The upper portion of Lake Felicity was used as a Public Oyster Seed Reservation during the 1940s and early 1950s, but this was discontinued because salinities were usually too high for oyster production. However, future planned coastal freshwater diversion projects may return the area to a salinity regime that is more favorable for oyster production.

There are three cultch plants between the Lake Chien and Lake Felicity Public Oyster Seed Grounds including a 16-acre cultch plant in Lake Chien completed in 2004, a 40-acre cultch plant in

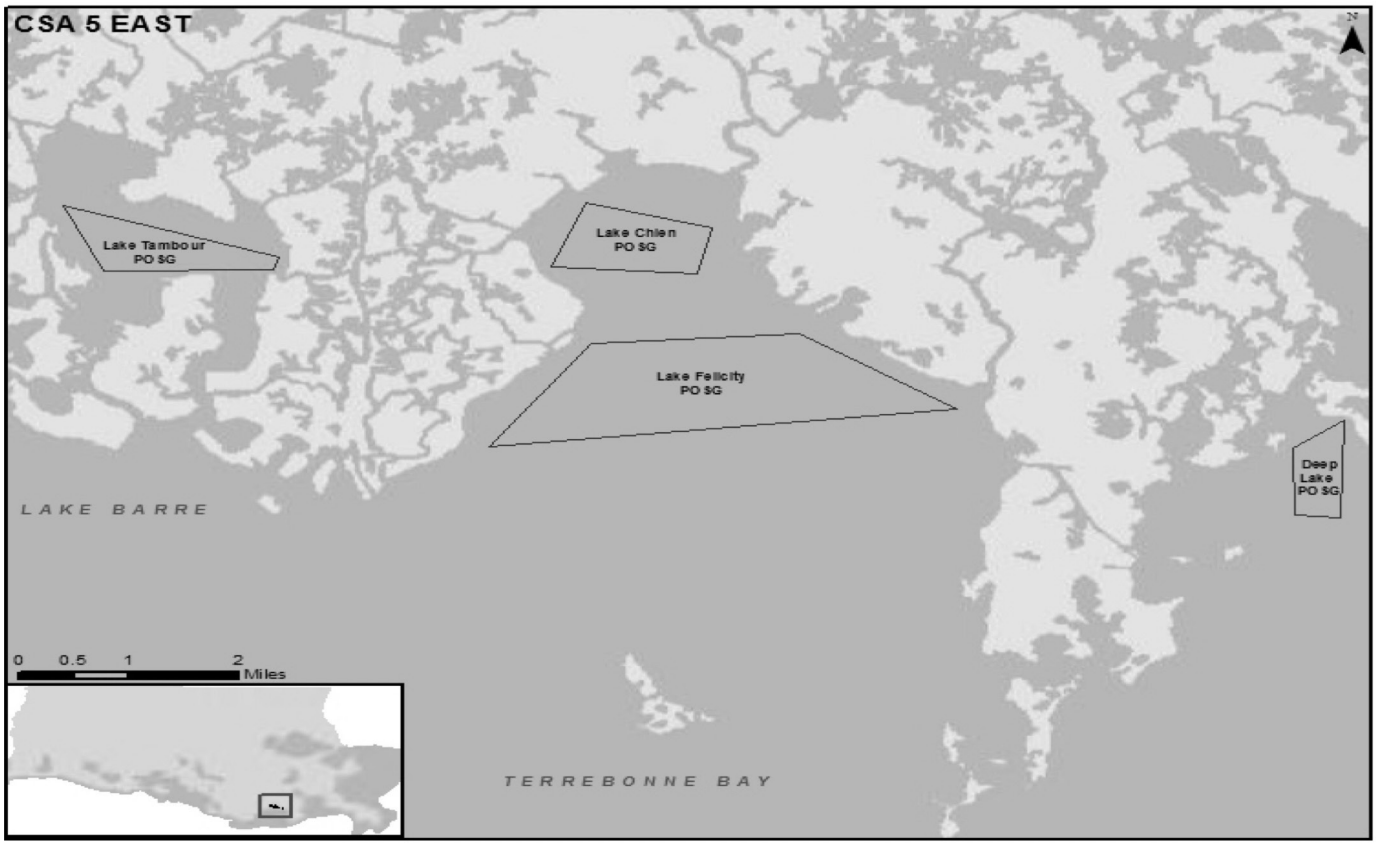

FIGURE 5.3. Public oyster areas within the eastern portion of CSA 5.

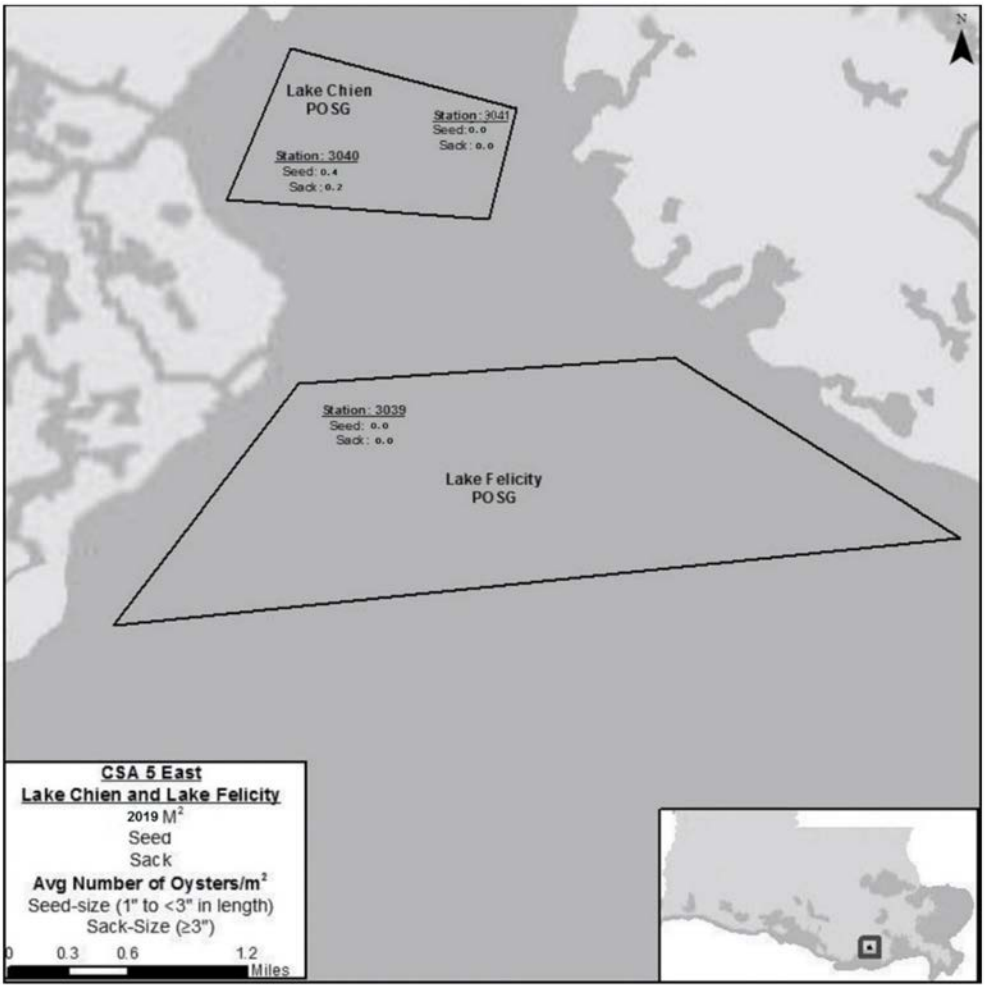

FIGURE 5.4. Lake Chien and Lake Felicity with average seed and sack sampling densities for the 2019 stock assessment, square-meter sampling.

Lake Felicity (completed in 2004, and a 22-acre cultch plant due east of the initial Lake Chien cultch plant completed in May 2009. Outside of these cultch plants, there is no known reef in between the Lake Chien and Lake Felicity Public Oyster Seed Grounds. LDWF has not developed any reefs in Lake Tambour or Deep Lake.

Methods

LDWF biologists collected field samples for the 2019 oyster stock assessment on July 1-3 2019, from a total of 19 stations within CSA 5 according to the methodology described in the Statewide Overview of this report. Sampling stations included existing oyster reefs in Lake Felicity, Lake Chien, Sister Lake, Bay Junop, and Lake Mechant.

The 2019 oyster stock assessment for CSA 5, reflects adjusted acreage in Sister Lake due to the footprint of the 2012 cultch plant and the combination of stations on overlapping reefs. They have maintained this adjustment for all assessments since that time. There are additional details on stations and reef complexes affected in the 2013 Oyster Stock Assessment Report.

Results and Discussion

Seed and Market-Size Stock

The 2019 oyster stock assessment estimated the stock for CSA 5 at 55,198 bbls of seed oysters and 7,661 bbls of market-size oysters in the western basin (Sister Lake, Bay Junop, and Lake Mechant), and 36 bbls of seed oysters and 36 bbls of market-size oysters in the eastern basin (Lake Felicity and Lake Chien; *Tables 5.1-5.4*).

In Sister Lake, the most productive oyster area in CSA 5, estimated seed and market-size oyster availability for 2019 were 62 and 94% below long-term averages (1980-2018), respectively. The 2019 oyster stock assessment estimated 53,758 bbls of seed and 6,852

TABLE 5.1. 2019 Sister Lake oyster availability by sampling station.

Station Number	Reef (Acres)	Reef (square-meters)	Average Number Seed Oysters/ m^2	Average Number Market-size Oysters/ m^2	Bbls Seed Oysters	Bbls Market-Size Oysters
3020	320	1,296,253	4.1	0.5	7,321.4	1,680.3
3028	140	568,302	0.0	0.0	0.0	0.0
3015	56	225,694	0.2	0.4	62.7	250.8
3021	191	773,114	0.0	0.0	0.0	0.0
3022	552	2,235,653	0.0	0.0	0.0	0.0
3023	513	2,075,194	0.0	0.0	0.0	0.0
3026	82	332,896	0.0	0.0	0.0	0.0
3042	156	629,369	5.2	0.0	4,545.4	0.0
Cultch Plant (2012)	365	1,476,298	20.4	1.2	41,828.4	4,921.0
Total	***2,375***	***9,612,773***	***29.9***	***2.1***	***53,757.9***	***6,852.1***

**Average of stations 3020/200, 3010/202, and 3024/216 to represent the Grand Pass reef complex.*

TABLE 5.2. 2019 Bay Junop/Lake Mechant oyster availability by sampling station.

Station Number	Reef (Acres)	Reef (square-meters)	Average Number Seed Oysters/ m^2	Average Number Market-size Oysters/ m^2	Bbls Seed Oysters	Bbls Market-Size Oysters
3038	17	69,606	0.0	0.2	0.0	38.7
3035	67	272,598	2.3	0.8	870.8	605.8
3036	73	296,474	0.4	0.2	164.7	164.7
3029	30	121,406	2.4	0.0	404.7	0.0
Total	***187***	***760,083***	***5.1***	***1.2***	***1,440.2***	***809.2***

**Average of stations 3035 and 3037 to represent the South Bay Junop reef complex.*

TABLE 5.3. 2019 Lake Chien/Lake Felicity oyster availability by sampling station.

Station Number	Reef (Acres)	Reef (square-meters)	Average Number Seed Oysters/ m^2	Average Number Market-size Oysters/ m^2	Bbls Seed Oysters	Bbls Market-Size Oysters
3040	16	64,750	0.4	0.2	36.0	36.0
3039	40	161,875	0.0	0.0	0.0	0.0
3041	22	90,245	0.0	0.0	0.0	0.0
Total	***78***	***316,870***	***0.4***	***0.2***	***36.0***	***36.0***

TABLE 5.4. Oyster availability and percent change from the 2018 to 2019 assessment for both regions of CSA 5.

Region	Area	Bbls of Seed Oysters			Bbls of Market-Size Oysters		
		2018	2019	Change	2018	2019	Change
Western Terrebonne Basin	Sister Lake	46,493.4	53,758.0	15.6%	21,788.6	6,852.1	-68.6%
	Bay Junop	380.8	1,035.5	171.9%	358.1	809.2	126.0%
	Lake Mechant	1,483.9	404.7	-72.7%	0.0	0.0	0.0%
Eastern Terrebonne Basin	Lake Chien	452.4	36.0	-92.0%	0.0	36.0	100.0%
	Lake Felicity	0.0	0.0	0.0%	0.0	0.0	0.0%

bbls of market-size oysters on the Sister Lake Public Oyster Seed Reservation, of which 78% (41,828 bbls) of available seed and 72% (4,921 bbls) of available market-size oysters were located on the 2012 cultch plant (*Figure 5.5, Table 5.1*).

Lake Mechant and the northern portion of Bay Junop, near Buckskin Bayou (Sampling station 3038), receive input from the Atchafalaya River via Blue Hammock Bayou on an annual basis. This continues to have a large influence on salinity levels, which inhibits and affects oyster growth and productivity in this area due to high Atchafalaya River levels in recent years (*Figures 5.1, 5.6 and 5.7*).

In Lakes Chien and Felicity in the eastern Terrebonne Basin, availability of seed oysters was 99% below the long-term average; availability of market-size oysters was 97% below the long-term average. Both cultch plants in Lake Chien showed a marked decrease in seed oyster availability, and one market-size oyster in the 2019 m^2 samples (*Figures 5.8 and 5.9; Tables 5.3 and 5.4*).

Continued marsh degradation in the eastern Terrebonne Basin allows salinities to fluctuate widely based on prevailing wind direction, and the constant erosion added sediment to the system, which can increase reef burial. The majority of the Lake Felicity cultch plant was covered with sediment and has shown zero productivity of market-size oysters in the last seven years.

Spat Production

Average number of oyster spat ranged from 0 to 6.6 per sampling station in 2019. Sister Lake 2012 cultch plant had the highest number per sample, with an average of 6.6. In the western Terrebonne Basin, most samples showed a slight increase in the number of spat present; in the eastern Terrebonne Basin, Lake Felicity remained with no recovered spat while Lake Chien had a slight increase in spat collection than in the previous year.

Hydrological Data

Average water temperatures for May and June 2019 (the two months prior to sampling) on each public oyster area in CSA 5 ranged from 27.6 to 28.4°C, close to the long-term mean (1996-2018). Average salinities for May and June 2019 were below the long-term averages for all areas. Biologists collected these data during dredge samples. Temperature and salinity measurements collected concurrently with square-meter sampling in July averaged 27.7°C and 14.3 ppt, respectively in the eastern Terrebonne Basin, and 27.8°C and 7.8 ppt in the western Terrebonne Basin.

Mortality

Biologists observed no market-size oyster mortality throughout CSA 5 during 2019 square-meter samples. Seed and spat mortality was only noted in Sister Lake. Overall seed mortality in Sister Lake was 3.2%; spat mortality 7.1%.

Fouling Organisms, Predators and Disease

Biologists collected four types of incidental species (hooked mussel, mud crab, oyster drill, and stone crab) during 2019 square-meter sampling. Hooked mussels were most abundant incidental species and were more prevalent in western Terrebonne Basin samples, with an overall average of 12.0 hooked mussels per sample. Of this overall average, Sister Lake had the highest occurrence with 35.1 hooked mussels per sample; Eastern Terrebonne Basin samples showed an average of 1.8 oyster drills per sample.

Scientific literature suggests that Dermo may cause extensive oyster mortalities in conditions of high salinities and water temperatures. Results of Dermo tests are presented in Appendix I.

Tropical and Climatic Events

The 2019 flood event is discussed in the Introduction section of the Statewide Overview. However, no other significant tropical or climatic activity affected CSA 5 for the period covered by this report.

2018/2019 Oyster Season

The commission opened Lake Mechant and Bay Junop for harvest of both seed and market-size oysters on Oct. 29, 2018, and closed on April 30, 2019. Seed harvest was only open for one day; with no report of seed harvest. A daily take and possession limit of 25 sacks was imposed during the 2018/2019 market-size season. An estimated yield of 500 sacks of market-size oyster were harvest in Bay Junop (*Table 2*).

The Commission did not open Sister Lake, Lake Chien or Felicity during the 2018/2019 season.

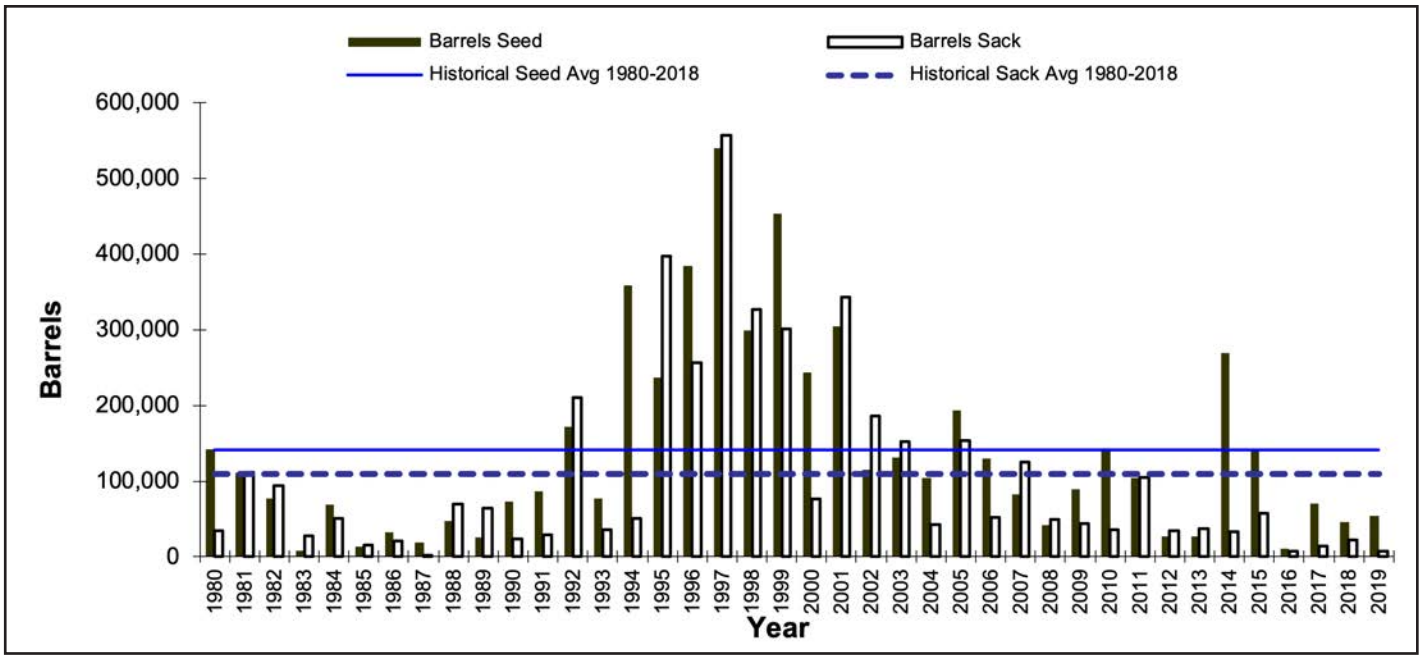

FIGURE 5.5. Sister Lake historical oyster stock availability.

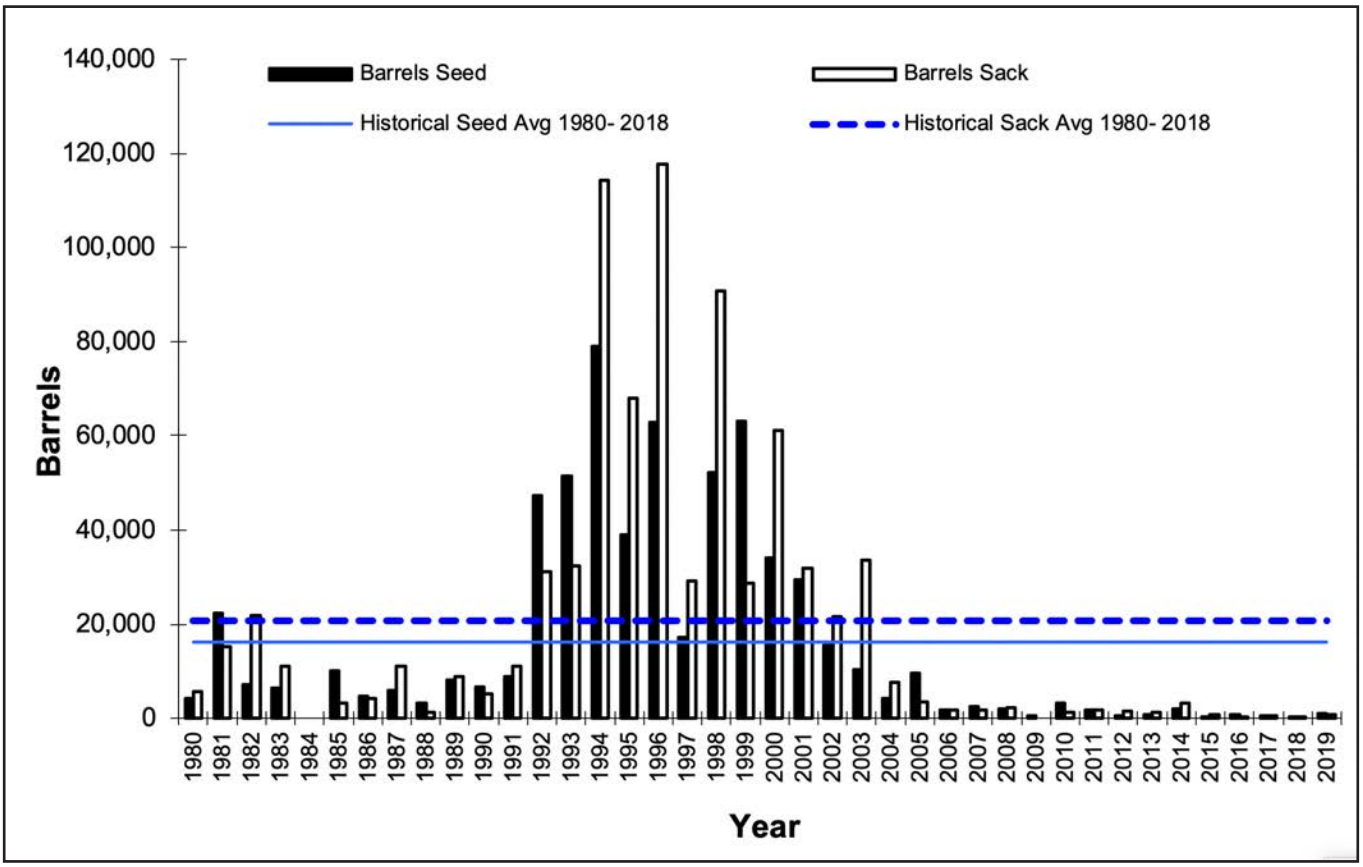

FIGURE 5.6. Bay Junop historical oyster stock availability.

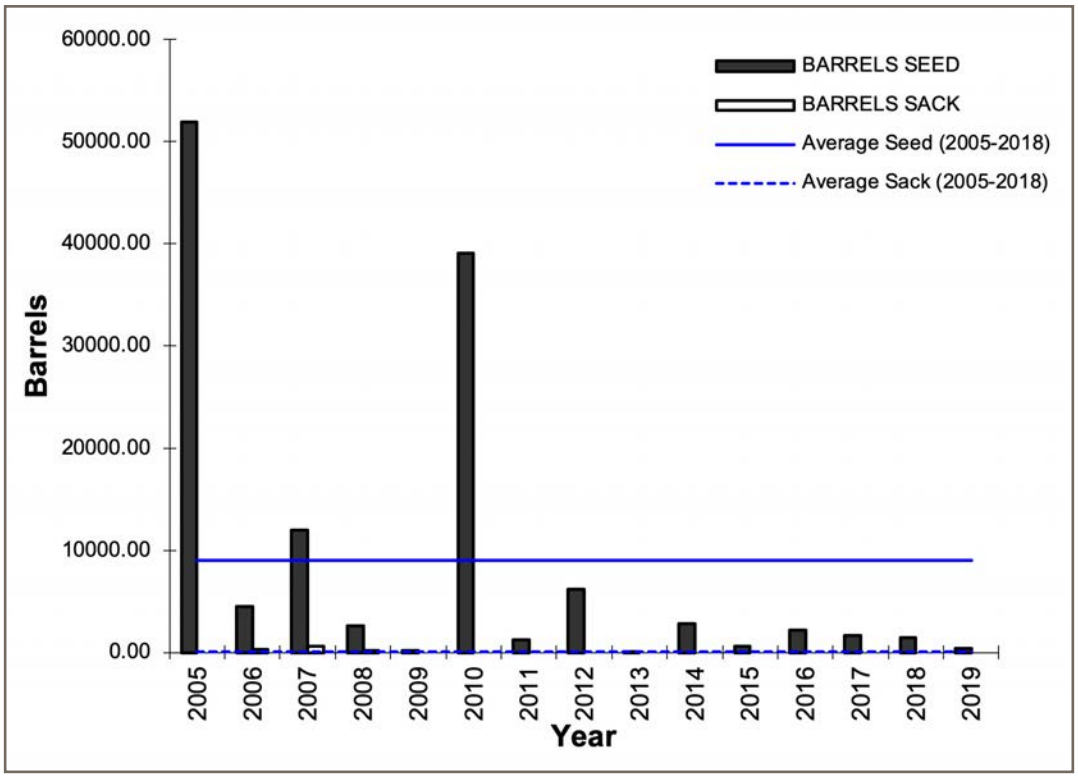

FIGURE 5.7. Lake Mechant historical oyster stock availability.

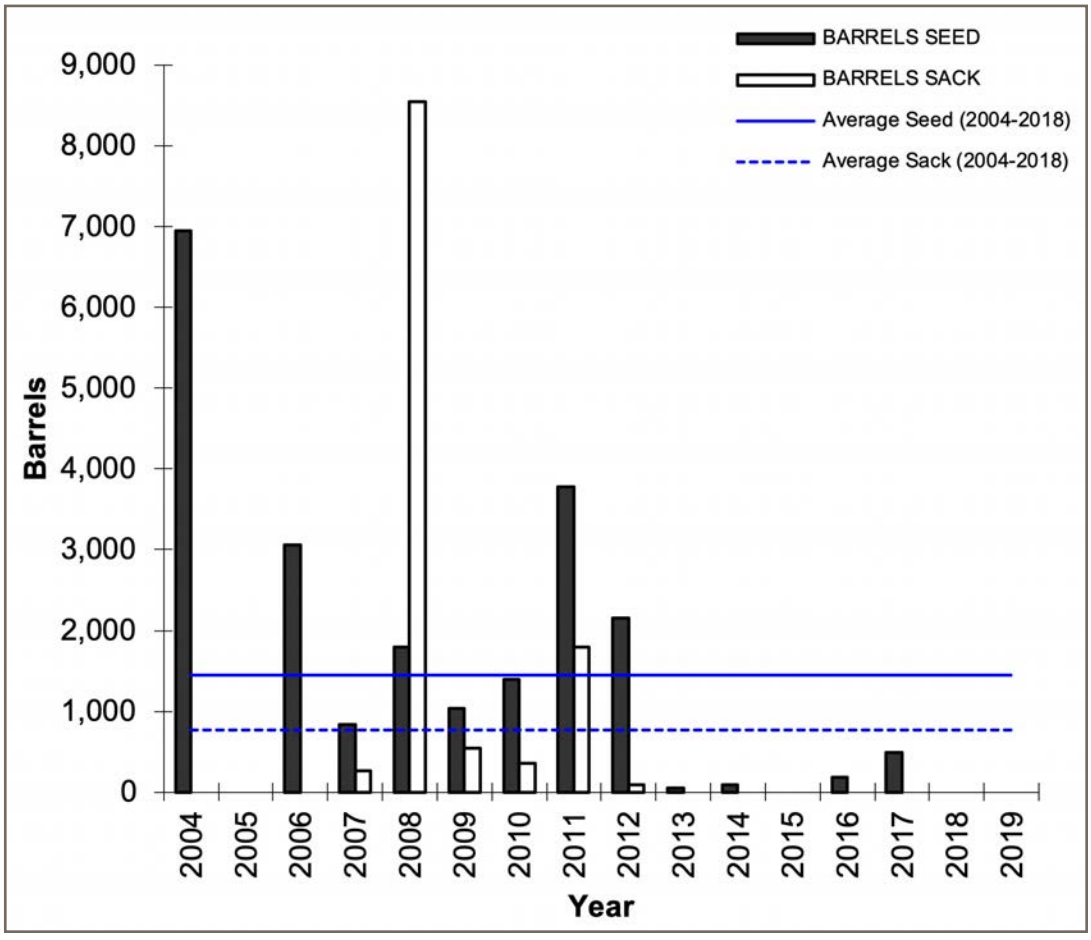

FIGURE 5.8. Lake Felicity historical oyster stock availability

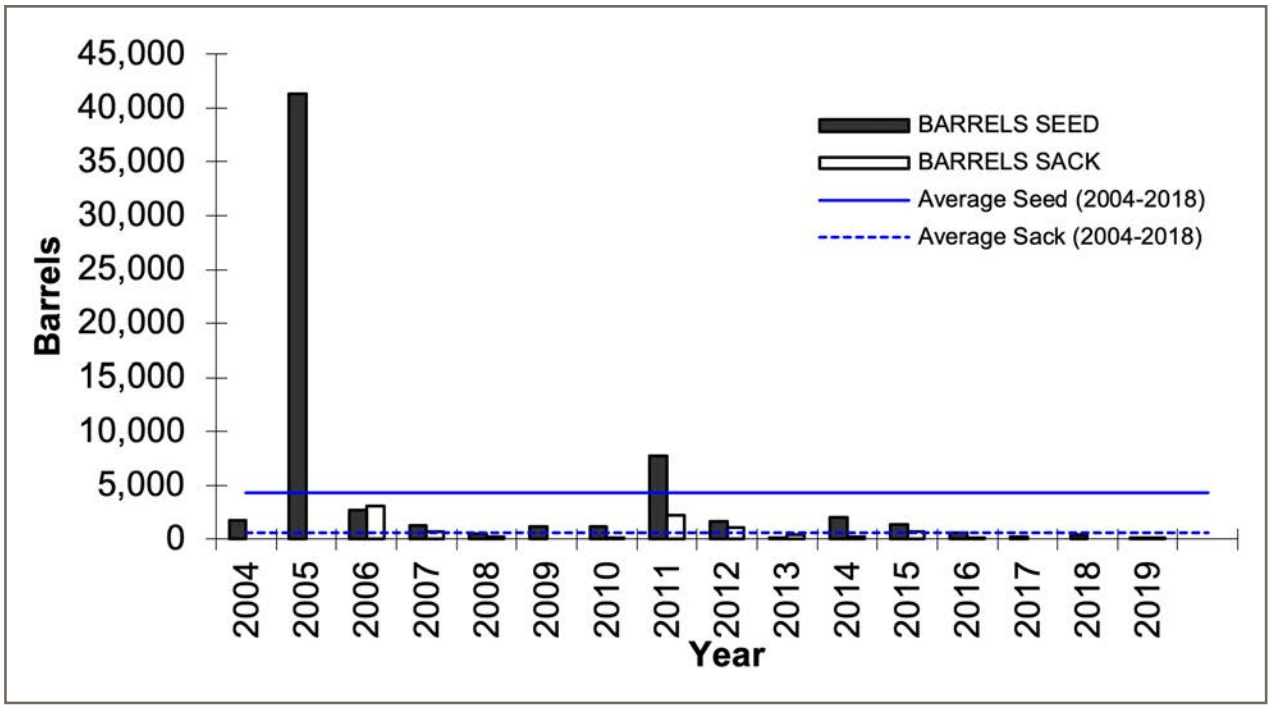

FIGURE 5.9. Lake Chien historical oyster stock availability.

CSA 6

Introduction

CSA 6 includes oyster reefs found in the Vermilion/East and West Cote Blanche/Atchafalaya Public Oyster Seed Grounds. The Commission established the inside portion of these Public Oyster Seed Grounds in 1990; this area consists of state water bottoms found generally north of a line from the western shore of Vermilion Bay and Southwest Pass eastward to Point Au Fer. The Commission established the outside portion of these Public Oyster Seed Grounds in 1988; this area consists of Louisiana State Territorial Waters from the private oyster lease boundary near Mound Point/ Marsh Island eastward to Point Au Fer. LDWF managed the oyster resources found on local state water bottoms in a manner similar to current management procedures for public oyster seed grounds. Management allowed limited harvest/relays from the Vermilion Bay area reefs when oyster abundance and distribution permitted.

The Vermilion/East and West Cote Blanche/Atchafalaya Bays complex is a large, primarily open-water brackish system; the Public Oyster Seed Grounds in this area consist of approximately 541,787 acres of water bottom (*Figure 6.1*). Primary influences on the bays' dynamic salinity regime are the Gulf of Mexico, Atchafalaya River and the adjacent Wax Lake Outlet, and the Vermilion River. In general, freshwater discharge from the Atchafalaya River highly influences the Public Oyster Seed Grounds within CSA 6. Independent of local rainfall, biologists have noted a historical negative correlation between increased Atchafalaya River flow and reduced salinity levels in the bay system. Typically, oyster reproduction occurs in the fall after the river stage abates, with oysters growing to seed size (1 inch to less than 3 inches) by the following spring. However, spring and early summer floodwaters depress salinities, placing extreme physiological stress on the organisms. These low salinities,

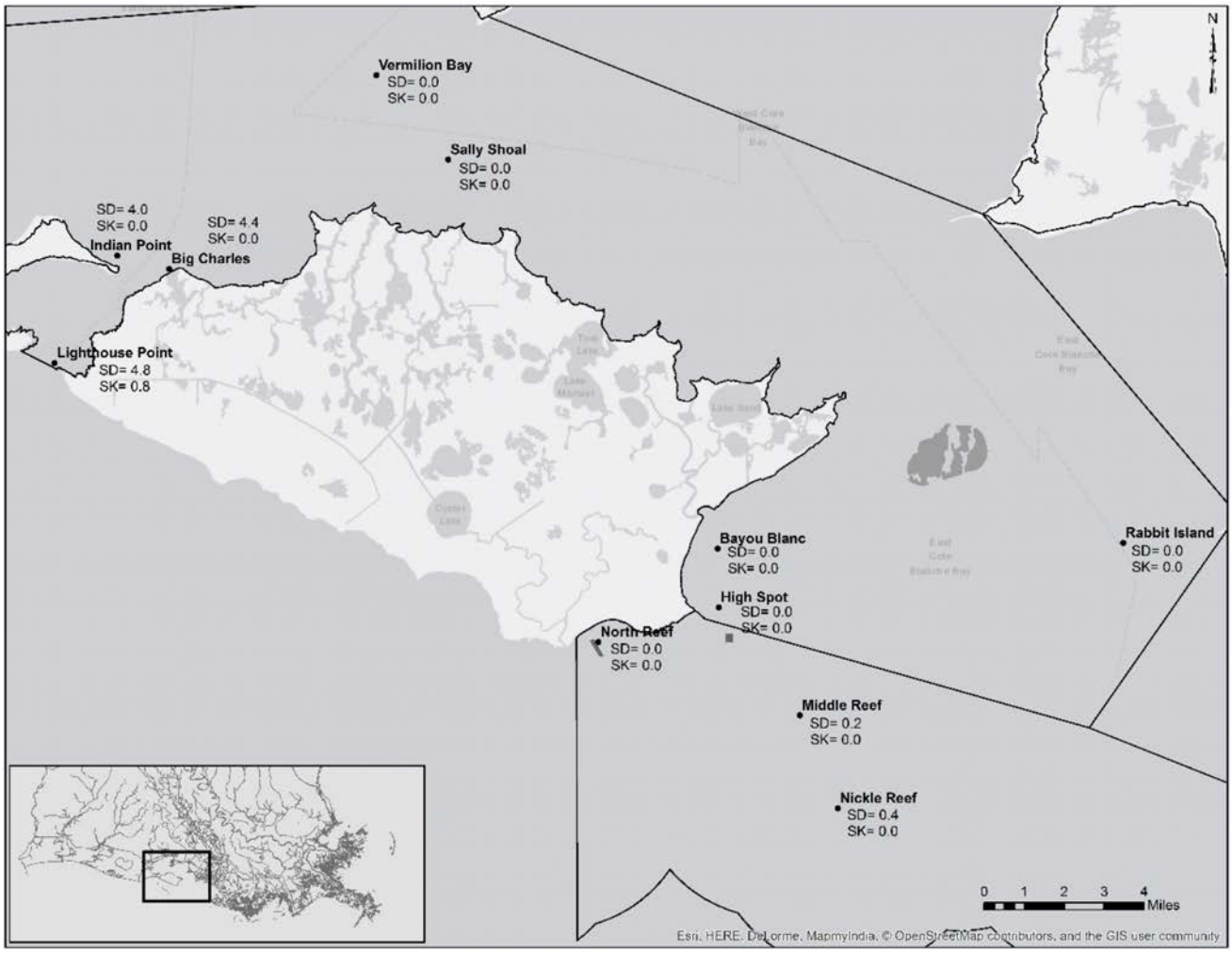

FIGURE 6.1. 2019 Coastal Study Area 6 oyster square-meter sampling stations of the Vermilion/East and West Cote Blanche/ Atchafalaya Bays Public Oyster Seed Grounds. Data displayed below station represent average seed (SD), and market-size (SK) oysters per square-meter sample.

coupled with high water temperatures through the summer months, typically result in extensive oyster mortalities on the public grounds. Occasionally, however, reduced freshwater inflow from the Atchafalaya River leads to higher-than-normal salinities, and the normal annual cycle of extensive oyster mortalities is broken, leading to a harvestable population of seed oysters during the following oyster season (September through April). Such was the case in 2000, 2001, 2005, 2006, 2007, 2013, 2014, and 2017 when sizable quantities of seed oysters were available for harvest. LDWF manages these seed grounds similar to other areas allowing limited harvest and relays when oysters are in abundance.

An overall oyster stock assessment for CSA 6 is not possible at this time, as figures relative to oyster reef sizes are not available. This report compares data collected from the 2019 oyster stock assessment sampling to previous years' sampling data, with a look at hydrologic conditions, marine fouling, and oyster predators on sampled reefs. In addition, the report also presents information regarding the 2018/2019 oyster season harvest on CSA 6 Public Oyster Seed Grounds.

Methods

LDWF biologists collected field samples for this report on July 8 and 9, 2019, from a total of 11 stations (*Figure 6.1*) within CSA 6 according to the methodology described in the Statewide Overview of this report.

Results and Discussion

Seed and Market-Size Stock

Biologists found live seed oysters at five of the 11 sampling stations (*Figure 6.1*). Densities of live seed ranged from 0.2 per replicate at Middle Reef to a high of 4.8 at Lighthouse Point. Biologists collected market-size oysters only at Lighthouse Point with a density of 0.8 oysters per replicate.

Low production years associated with extended periods of high Atchafalaya River output and depressed salinities are not uncommon on the seed grounds of this bay system; nine of the previous 11 years, biologists noted close to 100% oyster mortality on the grounds. In the first half of 2019, Atchafalaya River levels were high during warm weather months. The unfavorable saline conditions have reflected in the lowest density of oysters plus reflecting the extended low availability within the Vermilion Bay system occurring in the last 10 years. Due to the lack of water bottom assessments in CSA6, data is reported in density per sample shown in *Table 6.1* and *Figure 6.2*.

Spat Production

Despite the presence of suitable substrate at all sampling stations, biologists found live spat at only four of the 11 sampling stations. Densities of spat ranged from 0.2 at Nickle Reef to a high of 2.4 per replicate at Big Charles. Low spat productivity during periods of high Atchafalaya River flow (with associated low salinity conditions) are common in this bay system.

Fouling Organisms

Biologists documented an overall 75% decrease in hooked mussel abundance at the sampling stations compared to 2018 oyster stock assessment. They noted an increase in density at two stations while density decreased at six stations. Three stations experienced no change in hooked mussel abundance. The Bayou Blanc sample sampling station showed a large decrease in hooked mussel density dropping to an average of 2.4 per replicate in the 2019 oyster stock assessment compared to 68.8 per replicate in 2018 oyster stock assessment.

Oyster Predators

Biologists did not find any southern oyster drills during square-meter sampling. These marine snails are more often associated with high salinity waters where they are known to prey heavily on oysters and other bivalve species. The occurrence of mud crab on historically sampled reefs decreased by 90% compared to 2018 oyster stock assessment. Seven of the 11 sampled reefs had no mud crabs, but mud crab density reached a high of 0.4 crabs per replicate at High Spot and Indian Point. Biologists did not collect any blue or stone crabs during the 2019 square-meter sampling.

TABLE 6.1. Mean density of live seed and market-size oysters collected in Coastal Study Area 6 square-meter samples by year.

Year	Mean Density Seed/ Sample	Mean Density Market-Size/ Sample	Seed/Market-Size Ratio
2000	81.4	3.3	25:1
2001	28.8	4.8	61
2002	2.25	0.25	9:1
2003	1.2	0	No Market-size Oysters
2004	4.3	0	No Market-size Oysters
2005	14.8	0	No Market-size Oysters
2006	16.1	0.5	32:1
2007	11.6	0.8	15:1
2008	1.3	0	No Market-size Oysters
2009	3.4	0	No Market-size Oysters
2010	0.8	0.12	7:1
2011	0.32	0.02	16:1
2012	1.78	0.04	45:1
2013	0.3	0.02	15:1
2014	1.12	0.08	14:1
2015	0.44	0	No Market-size Oysters
2016	1.2	0.16	8:1
2017	0.58	0.11	5:1
2018	2.13	0.05	43:1
2019	1.25	0.07	18:1

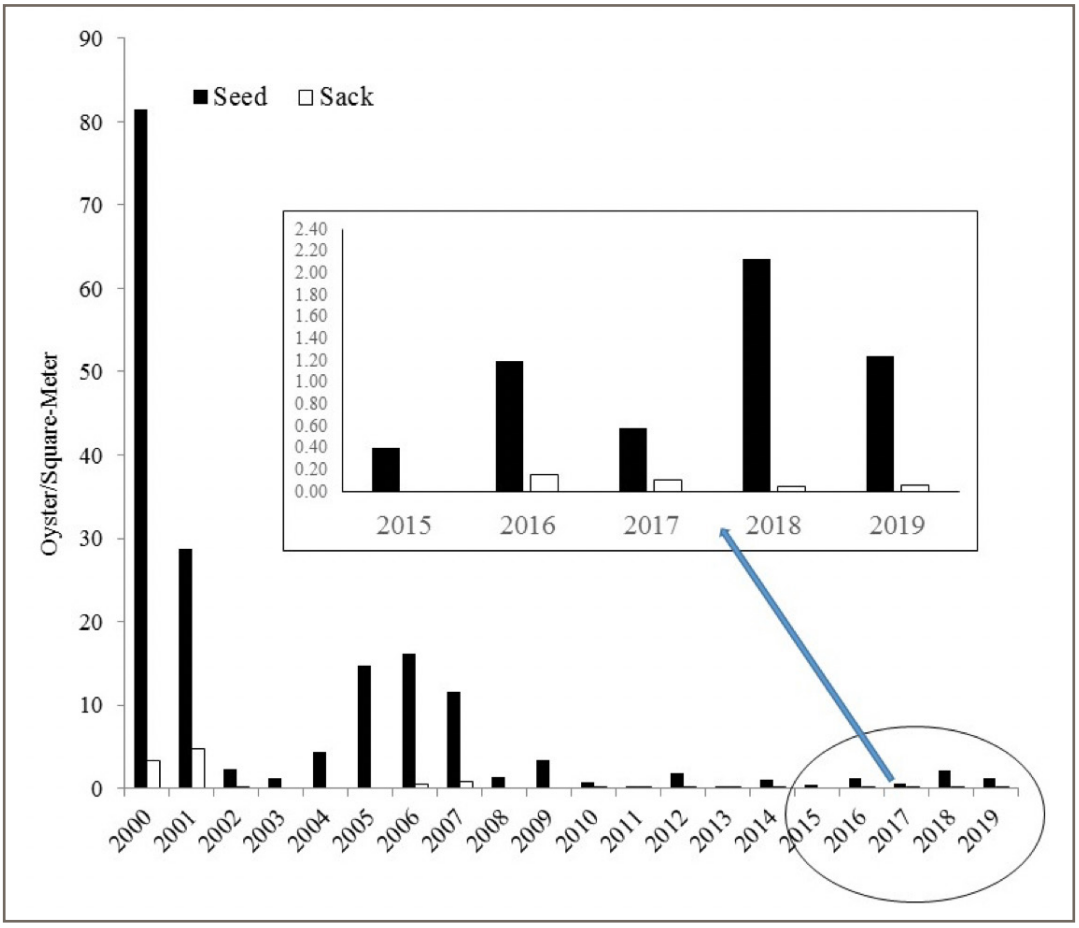

FIGURE 6.2. Mean density of live seed and market-size size oysters collected in Coastal Study Area 6 square-meter samples by year.

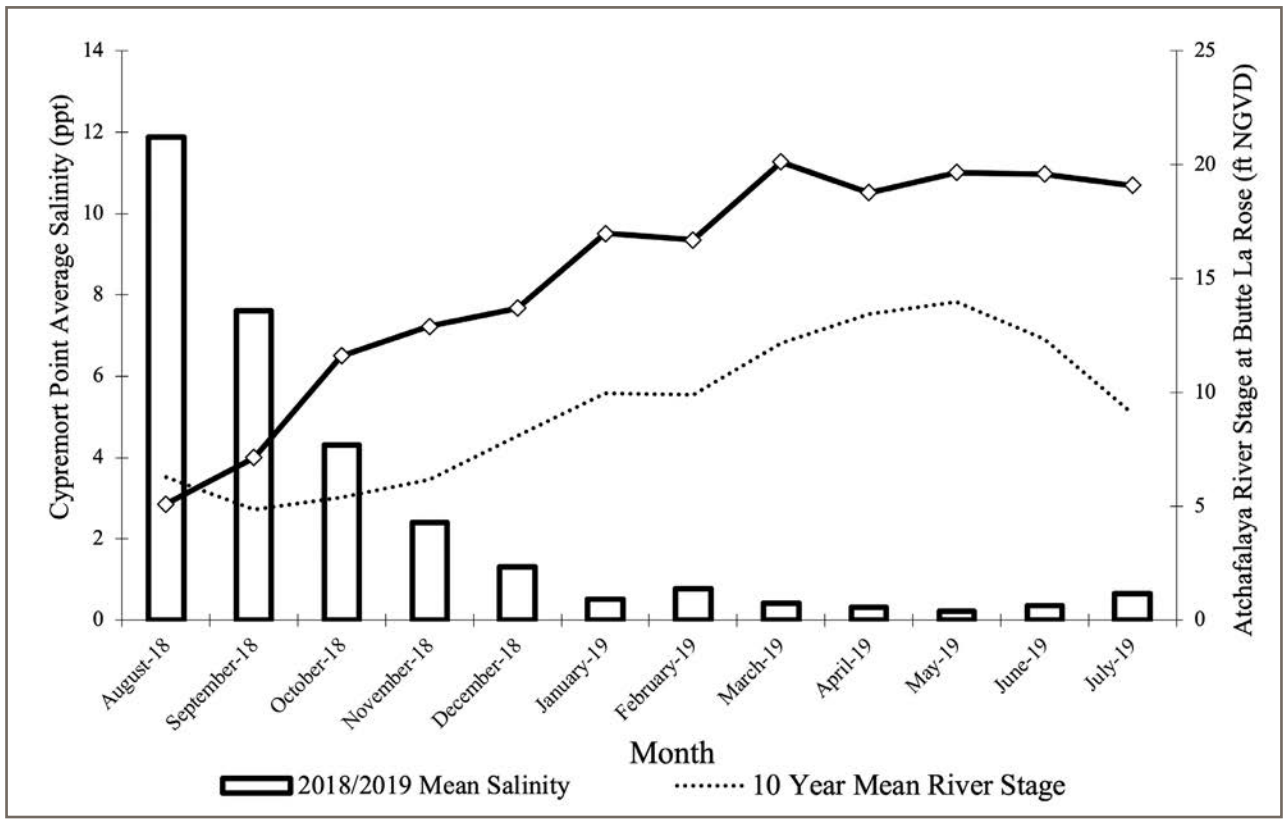

FIGURE 6.3. Atchafalaya River levels at Butte La Rose gauge and average salinity for Cypremort Point, LA during the period Aug. 1, 2018 through July 31, 2019. 10-year average monthly river stage at Butte La Rose is included.

Mortality

In the first half of 2019, there were significant numbers of seed size oysters at Nickle, Middle, Lighthouse Point, High Spot, Indian Point, and Big Charles reefs, as observed in monthly dredge samples collected throughout the year. There were also significant numbers of market-size oysters at Lighthouse Point and Nickle Reef. Even though the Atchafalaya River was high during the last quarter of 2018 and beginning of 2019, low mortality numbers were observed. This pattern of low salinities and low mortality continued until water temperatures started to rise in May and June. Once temperatures rose, the eastern sampling stations (Bayou Blanc, High Spot) began showing mortality first with most sampling stations showing signs of increased mortality by July. Special oyster dredge samples were collected at High Spot, Nickle Reef, Big Charles and Lighthouse Point to monitor effects of the Mississippi River/Atchafalaya River flooding beginning in June. Special samples collected on July 1, 2019 showed High Spot had a total mortality of 100% while Nickle Reef had total mortality of 32%. Special samples collected at Nickle Reef, Lighthouse Point and Big Charles on July 29, 2019 had total mortalities of 50%, 62%, and 59%, respectively. Bottom salinity levels measured during July 2019 square-meter sampling varied from 0.2 ppt at Rabbit Island, Middle Reef, and Nickle Reef to 1.4 ppt at Vermilion Bay. Bottom dissolved oxygen was in the normal range at all stations and ranged from 5.1 to 7.6 milligrams per liter (mg/L). Most of the stations sampled during the 2019 square-meter sampling event contained no live oysters. Only Big Charles, Indian Point, and Lighthouse Point contained significant numbers of live oysters. The oyster stock found in CSA 6 is highly vulnerable to low salinity/high turbidity conditions often seen as a result of extended freshwater conditions associated with high Atchafalaya River discharge. Independent of local rainfall, biologists have noted a historical negative correlation between increased Atchafalaya River flow and reduced salinity levels in the bay system (*Figure 6.3*).

Tropical and Climatic Events

Atchafalaya River levels were elevated beginning in September 2018 when the average gauge height at the Butte La Rose station was 7.3 feet for the month. The river stages remained well above the 10-year mean river stage through July 2019 (*Figure 6.3*). the Floods of 2019 were the longest extended period of fresh hydrological conditions recorded within the Vermilion-Teche system in recent history as described in the Statewide Introduction section of this document.

Hurricane Barry made landfall at Intracoastal City, LA on July 13, 2019 as a category one hurricane with the highest winds located east of the center of the storm. Damage assessment conducted by CSA6 personnel on July 17 found the majority of the damage to commercial fisheries infrastructure to be located at Cypremort Point, LA and Louisa, LA. Field biologists noted dead nutria and muskrats floating within Vermilion Bay as well as large patches of floating marsh grass and hyacinth. Oyster dredge sampling and 16 foot trawls sampling conducted on July 16 noted no mud or grass within dredges, but grass observed in most of the trawls. The physical data collected at the sampling stations indicated that there were no dissolved oxygen issues at that time. The salinity had risen slightly at most sampling stations as well.

2018/2019 Oyster Season

The Commission opened the Vermilion/East and West Cote Blanche/Atchafalaya Bay public oyster seed grounds for both seeding and market-size oysters at one-half hour before sunrise on Oct. 29, 2018. The one-day bedding season closed at sunset, Oct. 29, 2018 with no oyster vessels observed bedding. The public oyster seed grounds remained open to sacking market-size oysters only, with a daily take and possession limit of 25 sacks of oysters per vessel. The Commission closed the season at one-half hour after sunset on April 30, 2019. There was only one boat observed harvesting on the seed grounds of CSA6 during the 2018/2019 season. The LDH Shellfish Harvest Areas that were "OPEN" consisted of partial area 26, area 27, and most of area 28. Area 25 was not open to harvest.

CSA 7

Introduction

CSA 7 is located in Southwest Louisiana, from the Louisiana/Texas state line to Freshwater Bayou in Vermilion Parish. It is comprised of Calcasieu and Mermentau River basins and the eastern portion of the Sabine River Basin. Calcasieu Lake is located at the southern end of the Calcasieu River Basin in Calcasieu and Cameron parishes; the lake consists of approximately 58,260 acres of water bottom with oyster reefs located throughout, especially in the southern end (*Figures 7.1 and 7.2*). There are no oyster harvesting areas in the Mermentau River Basin. Sabine Lake, located at the southern end of the Sabine River Basin in Cameron Parish, consists of approximately 55,057 acres of water bottom. Approximately 34,067 acres are located in the Louisiana portion of the lake; the remainder is in the Texas portion. Oyster reefs are mainly found in the very southern portion of the lake in Louisiana (*Figure 7.3*).

For assessment purposes, Calcasieu Lake has always been divided into two areas - East Side and West Cove (with the Calcasieu Ship Channel being the dividing line). The Louisiana Department of Health (LDH) classified the areas as conditionally managed giving LDH the authority to close the areas to oyster harvest based on health-related concerns due to poor water quality. It has been established health related closures of oyster harvest in Calcasieu Lake (East Side) when the river stage reaches 13.5 feet, and the West Cove would close when the river stage reaches 9 feet. Once the river falls below these levels for 48 hours, the LDH reopens the areas for harvest. Additionally, The East Side of Calcasieu Lake and West Cove are classified as Growing Area 29 (GA29) and Growing Area 30 (GA30) (*Figure 7.1*), respectively. LDH seasonal closure lines also limit the amount of acreage available to oyster harvest on the East Side due to water quality standards (prohibited area in the

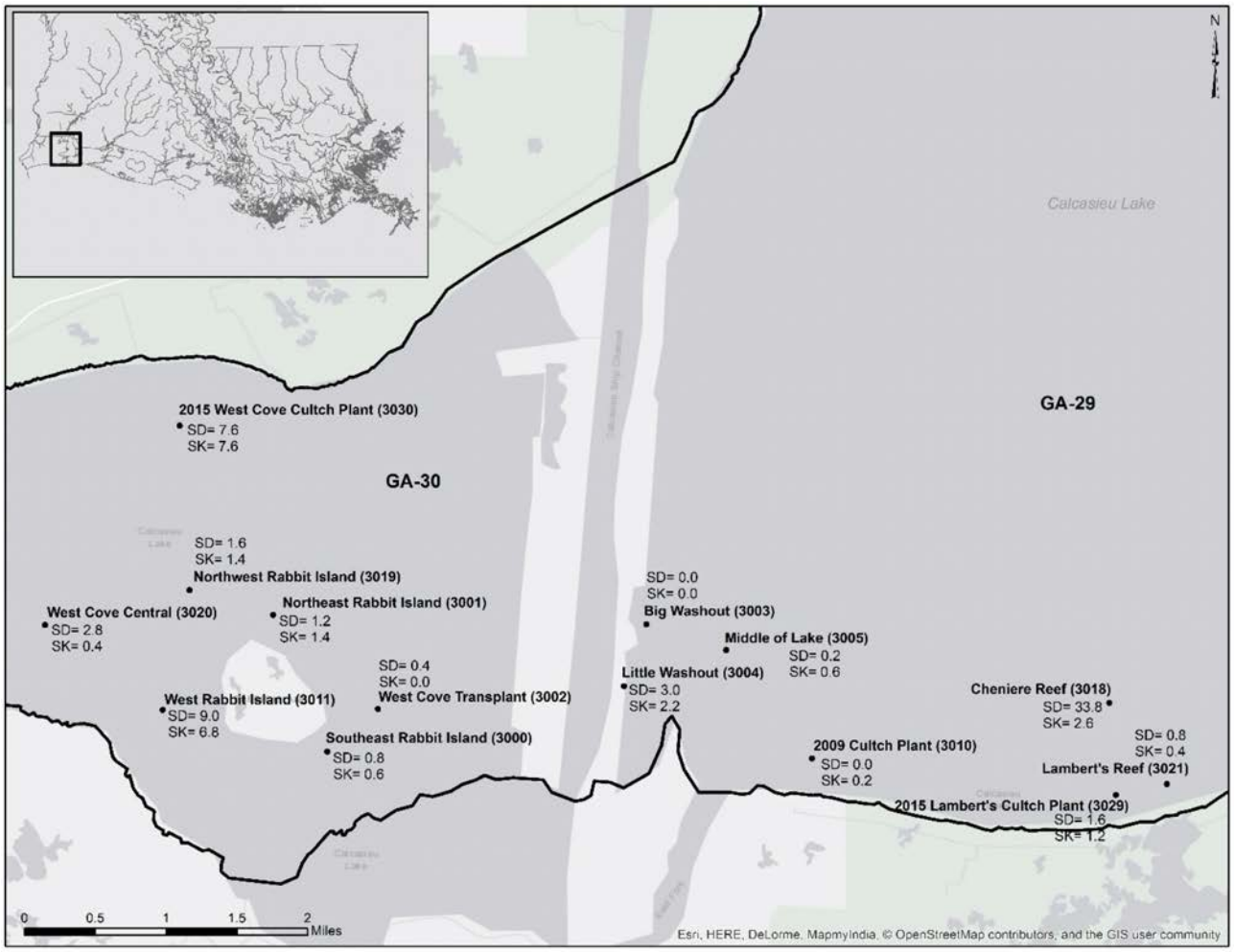

FIGURE 7.1. 2019 Coastal Study Area 7 oyster stock assessment sampling stations in Calcasieu Lake with average seed (SD) and sack (SK) oyster densities for each sampling station.

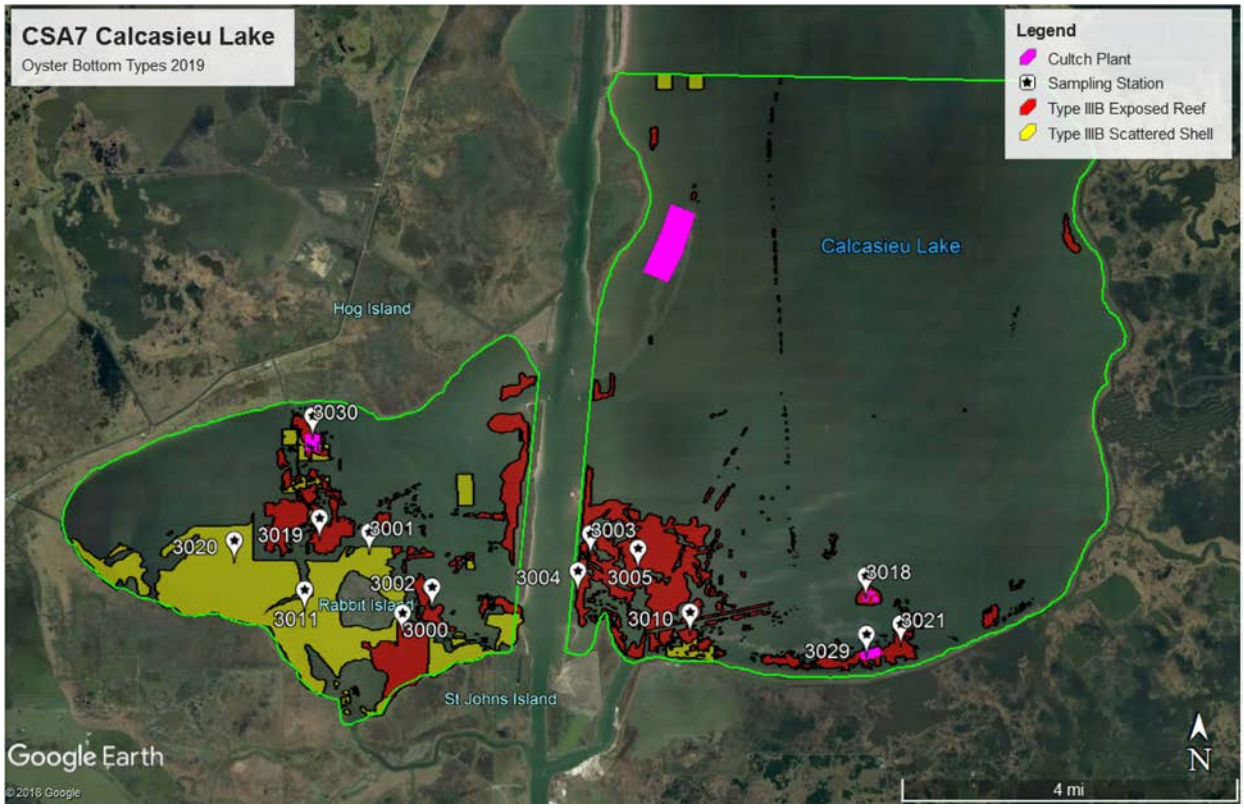

FIGURE 7.2. Estimated high quality oyster habitat (updated in 2019) coverage as delineated by side-scan sonar water bottom studies Calcasieu Lake.

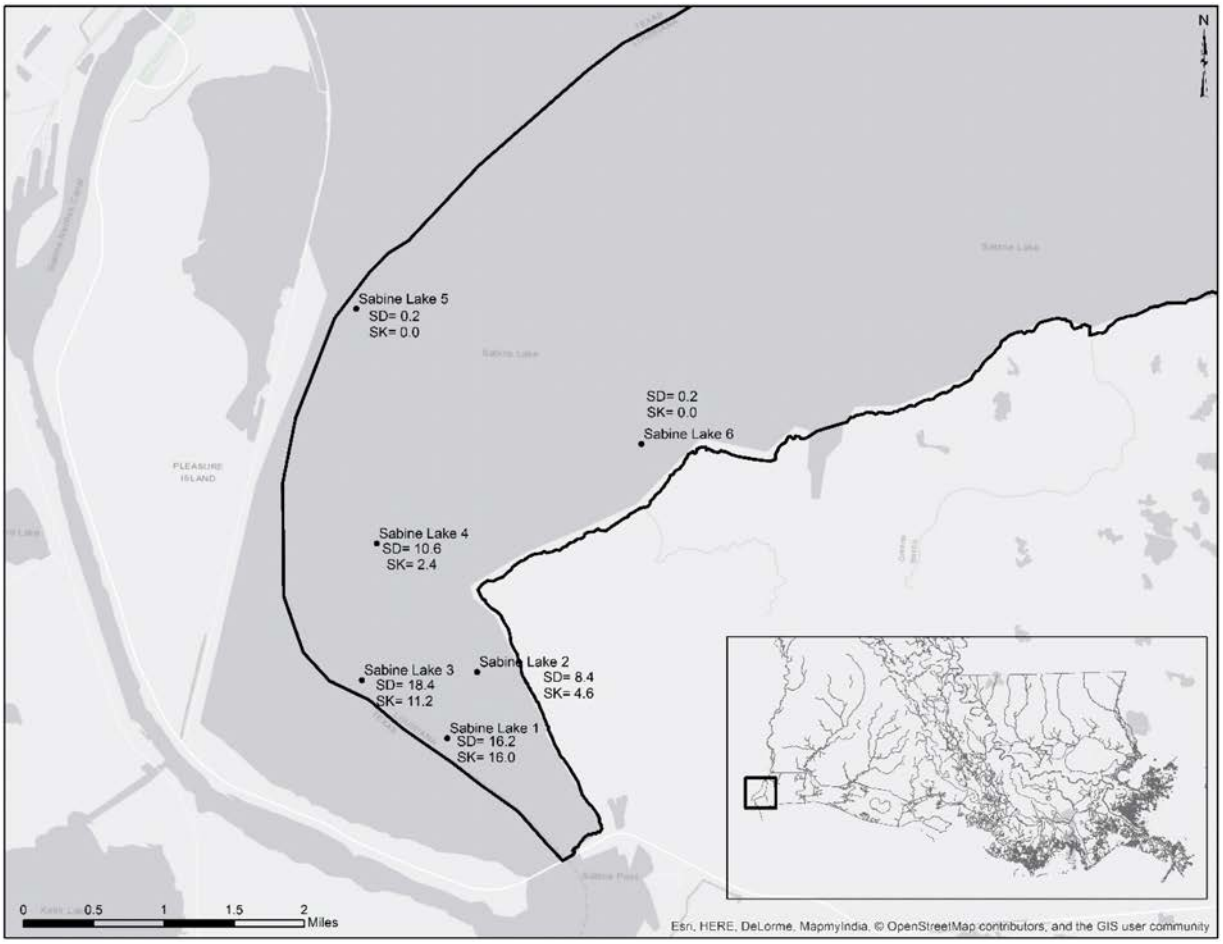

FIGURE 7.3. 2019 Coastal Study Area 7 oyster stock assessment sampling stations in Sabine Lake including average seed (SD) and sack (SK) oyster densities.

northern part of the lake). Oysters can only be harvested in the southern portion of the area (GA29) where water quality meets minimum standards.

Since 2011, LDWF oyster stock assessments in Calcasieu and Sabine Lakes have used acreage estimates determined by side-scan sonar water bottom assessments conducted in 2008 and 2011. LDWF identified all suitable oyster habitat (Bottom Type IIIB) within the LDH Public Oyster Growing Areas in Calcasieu Lake and classified this habitat into one of two bottom types: reef or scattered shell. The results of the side-scan studies estimated that GA-29 has a total of 1,962.3 acres of suitable oyster habitat, including 1,435.8 acres of reef and 526.5 acres of scattered shell bottom, and that GA-30 has a total of 3,387.8 acres of suitable oyster habitat, including 1,119.6 acres of reef and 2,268.2 acres of scattered shell bottom (*Figure 7.2*). After extensive surveying and sampling done between 2018 and 2019 of the scattered shell bottom type in GA29 it was determined that no suitable bottom-type material and no live oysters were present. Therefore, the 526.5 acres of scattered shell was deleted from oyster habitat calculations. 2019 stock assessment availability calculations (East Side) are based using 1,435.8 acres of reef habitat. The acreage estimates generated from the side-scan sonar studies only include those areas of Calcasieu Lake that lie within the LDH allowed harvest areas.

The Louisiana portion of Sabine Lake (GA31) has approximately 34,067 water bottom acres; 1479.5 acres of oyster habitat which includes 1,041.0 acres of Reef and 438.5 acres of Scattered Shell bottom type (*Figure 7.4*). Oyster seasons in Sabine Lake have not occurred since the early 1960s based on anecdotal information; neither Texas nor Louisiana can document concrete harvest data from Sabine Lake. LDWF has monitored oyster populations in Sabine using established monitoring stations and conducting annual oyster stock assessments (*Figure 7.3*), but in the 2018 regular legislative session, Act 159 was passed placing a permanent moratorium on the harvest of oysters in Sabine Lake. LDWF currently conducts population stock assessments every other year. During the 2019 oyster stock assessment, data was acquired in Sabine Lake, however oyster density and availability are not included in statewide estimates.

Method

LDWF biologists collected field samples for the 2019 oyster stock assessment on July 9, 2019 from a total of 14 stations within Calcasieu Lake and six stations within Lake Sabine according to the methodology described in the Statewide Overview of this report. One additional sampling station in Calcasieu (150-acre cultch plant was built near Long Point in 2017) was sampled by collecting 1/4 square-meter samples at randomly selected points within the area to characterize the oyster productivity on these areas. A total of five random grid samples were collected within the cultch plant boundaries.

There are no private oyster leases and no bedding (seeding) operations in Calcasieu and Sabine Lakes, therefore all harvest is direct market, and biologists report the data collected in sacks of market-size oysters rather than in bbls, the standard unit of measure used for oysters in other parts of coastal Louisiana (one barrel/bbls of oysters equals two sacks of oysters).

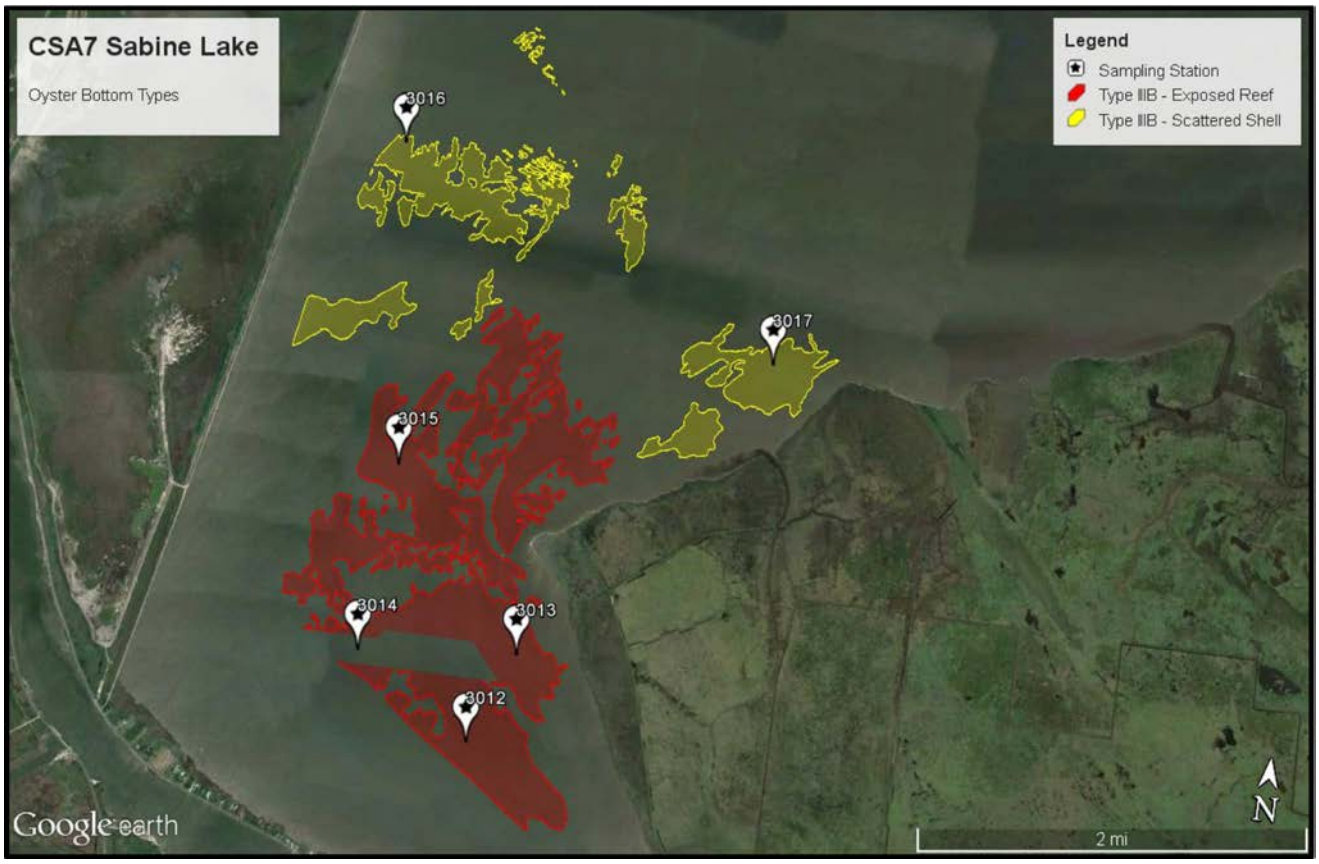

FIGURE 7.4. Estimated high quality oyster habitat (Bottom type IIIB) coverage as delineated by side-scan sonar water bottom studies in Sabine Lake.

Results and Discussion

Calcasieu Lake

Seed and Market-Size Stock

The 2019 stock assessment estimated that the current oyster stock in Calcasieu Lake was approximately 190,068 sacks of market-size oysters and 156,237 sacks of seed oysters (*Table 7.1*). As in previous years, the majority of Calcasieu Lake's market-size oysters were located in West Cove (GA-30).

There was a 26.9% increase in market-size oysters in the East Side (GA29) from 2018 to 2019 (*Table 7.2*). Market-size oyster numbers have increased from the 2018 oyster stock assessment; however, oyster populations remain 81.5% below the long-term average for this area. The majority of stock was found at cultch plants locations and natural reefs near Lambert's Bayou. It was also noted an increase of market-size oysters in some of the historic reef areas near the "Washouts areas" on the East Side.

There was continued increase in numbers of market-size oysters in West Cove from 2018 to 2019. The estimated populations increased 15.7% from 2018. This marked the third year in a row that market-size oysters increased in West Cove, and the population of oysters in this area was approaching long-term average (*Table 7.2*).

Spat Production

LDWF biologists continue to be concerned about the overall decline of seed oysters and a lack of significant recruitment in the traditional reef areas in Calcasieu Lake. According to the 2019 oyster stock assessment, the amount of available seed oysters in the East Side increased 82.6% compared to the 2018 estimate (*Figure 7.2*). There was also an upward trend in seed oysters in West Cove increased 186.6% from 2018 (*Table 7.2*). However, even with the yearly increases in both in East Side and West Cove, both areas remain 41.1% below the long-term average (2008-2018).

Hydrological Data

Average water temperatures recorded during dredge samples for Calcasieu Lake in May and June were 25.9 and 29.1oC respectively. These temperatures are slightly above the long-term average for these months (*Figure 7.5*). The average water temperature during the 2019 oyster assessment was 30.8oC, slightly higher than the long-term average temperature of 29.9oC.

Average salinities recorder during dredge samples for Calcasieu Lake in May and June 2019 were 11.6 and 6.5 ppt, respectively. May's average salinity levels were slightly lower than the May long-term average of 17.2 ppt (*Figure 7.5*). June's average salinity levels

TABLE 7.1. 2019 estimated oyster availability between East Side and West Side in Calcasieu Lake.

Public Oyster Area	Sacks of Spat Oysters	Sacks of Seed Oysters	Sacks of Market Oysters
East Side (GA-29)	1,759	32,227	23,334
West Cove (GA-30)	4,657	124,010	166,735
Total Harvest Area	***6,416***	***156,237***	***190,068***
Seed/Market Total (in sacks)			***346,305***

TABLE 7.2. Oyster stock assessments, in sacks, and percentage change of public oyster areas of East Side and West Cove in Calcasieu Lake.

Year	Market Oysters (≥ 3")		Seed Oysters (< 3")	
	East Side	West Cove	East Side	West Cove
2008	752,062	142,200	449,720	212,483
2009[1]	612,687	711,614	191,436	422,521
2010[1]	23,540	689,376	8,545	605,984
2011[2]	27,008	594,744	52,832	308,927
2012	0	236,440	0	85,171
2013	0	169,038	0	59,511
2014	0	188,616	24,210	213,951
2015	16,862	54,509	47,763	36,075
2016	27,024	45,576	34,398	57,131
2017	11,236	92,884	13,776	31,322
2018	18,390	144,101	17,647	43,270
2019	23,334	166,735	32,227	124,010
AVERAGE*	***126,012***	***269,653***	***72,713***	***183,363***
% Change from average	*-81.5*	*-38.2*	*-55.7*	*-32.4*
% Change from 2018	*26.9*	*15.7*	*82.6*	*186.6*

1 - Assessed using updated reef acreage from ENCOS (3,907.1) in 2008.
2 - Assessed using updated reef acreage from ENCOS (2008) and Bio-West (2011).
** Averages include 2019 data*

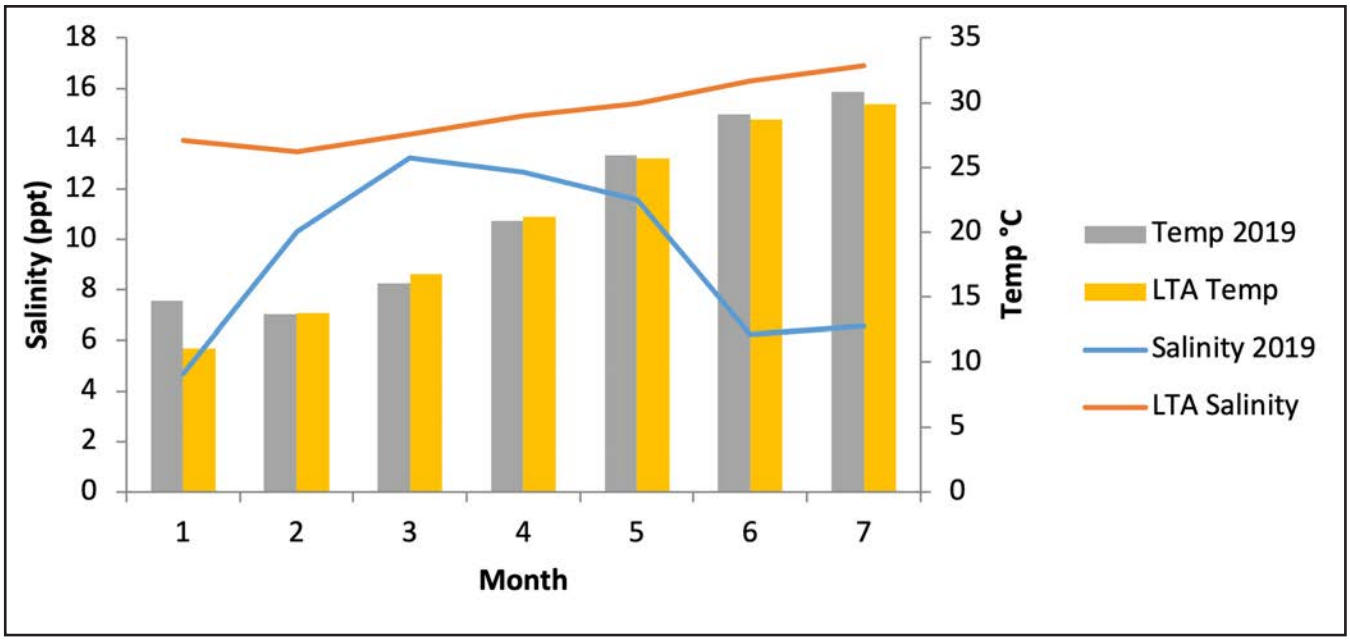

FIGURE 7.5. Salinity and temperature levels recorded during dredge and square-meter samples of the Calcasieu Lake public oyster areas in 2019.

were slightly lower than the June long-term average. Higher than normal rainfall during the spring and early summer caused salinity levels in the lake to remain lower than normal for an extended period of time.

Sabine Lake

Seed and Market-Size Stock

Due to the legislation that was passed in 2017 to prohibit harvesting of oysters in Sabine Lake, it was decided that a complete population assessment would only be conducted on a biennial basis. Based on data collected during 2019 oyster stock assessment, it is estimated that Sabine Lake (GA 31) contains approximately 200,107 sacks of market-size oysters (*Table 7.3*). These totals are not included in statewide numbers.

Market-size oysters in Sabine Lake decreased 52.6% from the 2017 oyster stock assessment (*Figure 7.6*). This marks the lowest number of market-size oysters recorded in Sabine Lake since assessments began in 2010 (*Figure 7.6*). Of particular concern are the oyster stocks further north in Sabine Lake which have virtually vanished. No market-size oysters were collected from the two most northern stations for the third year in a row.

Spat Production

LDWF biologists continue to be concerned about the decline and lack of oyster recruitment in Sabine Lake. Data collected in 2019 reveal there are approximately 157,795 sacks of seed-size oysters in Sabine Lake (*Table 7.3*), representing a moderate decrease compared to the 2017 assessment. The population of seed-size oysters decreased 33.9% and is currently 50.6% below the long-term average.

Persistent and frequent low salinity conditions from higher than normal rainfall amounts during the spring and summer months continue to negatively impact oyster stocks in Sabine Lake. Since 2015, the lake has experienced less than optimal habitat conditions for oyster survival. Oyster populations are expected to rebound in the lake once weather conditions return to normal.

Hydrological Data

Average water temperatures recorded during trawl sample monitoring for Sabine Lake in May and June were 24.1oC and 28.2oC, respectively. These temperatures are about equal to the long-term average (*Figure 7.7*). The average water temperature during the 2019 oyster assessment was 30.1oC which is nearly equivalent to the long term average of 30.0oC.

Average salinities recorded during dredge samples for Sabine Lake in May and June 2019 were 0.1 and 0.2ppt, respectively (*Figure 7.7*). May's salinity was slightly higher than the long-term average, while June's salinities were lower than the long-term average. The average salinity recorded during the 2019 oyster assessment was 1.5ppt, which was extreme lower than the long-term average of 11.7 ppt.

TABLE 7.3. 2019 estimated oyster availability in Sabine Lake (GA-31).

Public Oyster Area	Bottom Type IIIB	Seed Oysters per m^2	Market Oysters per m^2	Reef Acreage	Square Meters	Sacks of Seed Oysters	Sacks of Market Oysters
Sabine Lake	Reef	13.40	8.55	1,041.0	4,212,781.3	156,809	200,107
	Exposed Shell	0.2	0	438.5	1,774,548.1	986	-
					Total	***157,795***	***200,107***

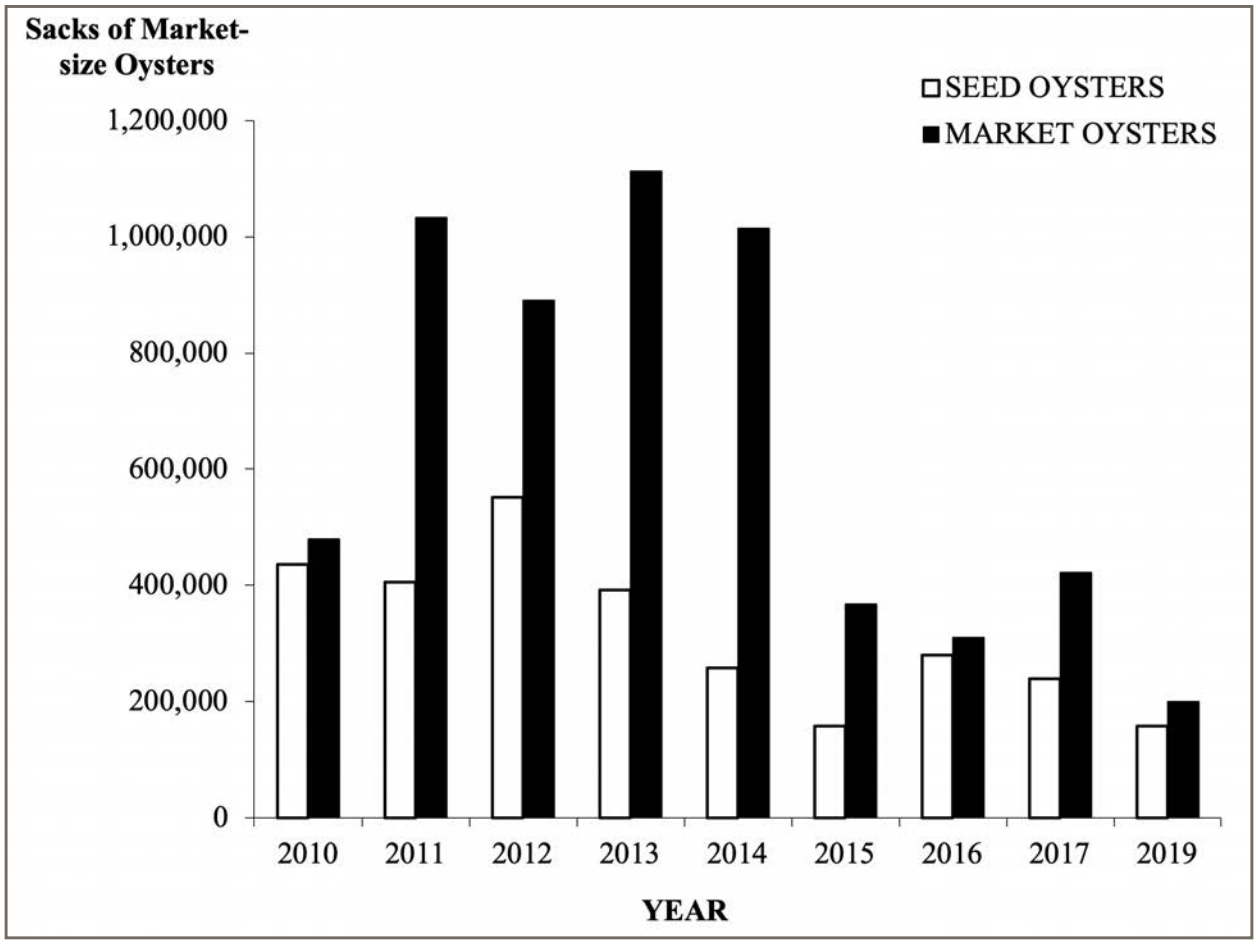

FIGURE 7.6. Historical oyster stock assessments from public areas of Sabine Lake (GA-31).

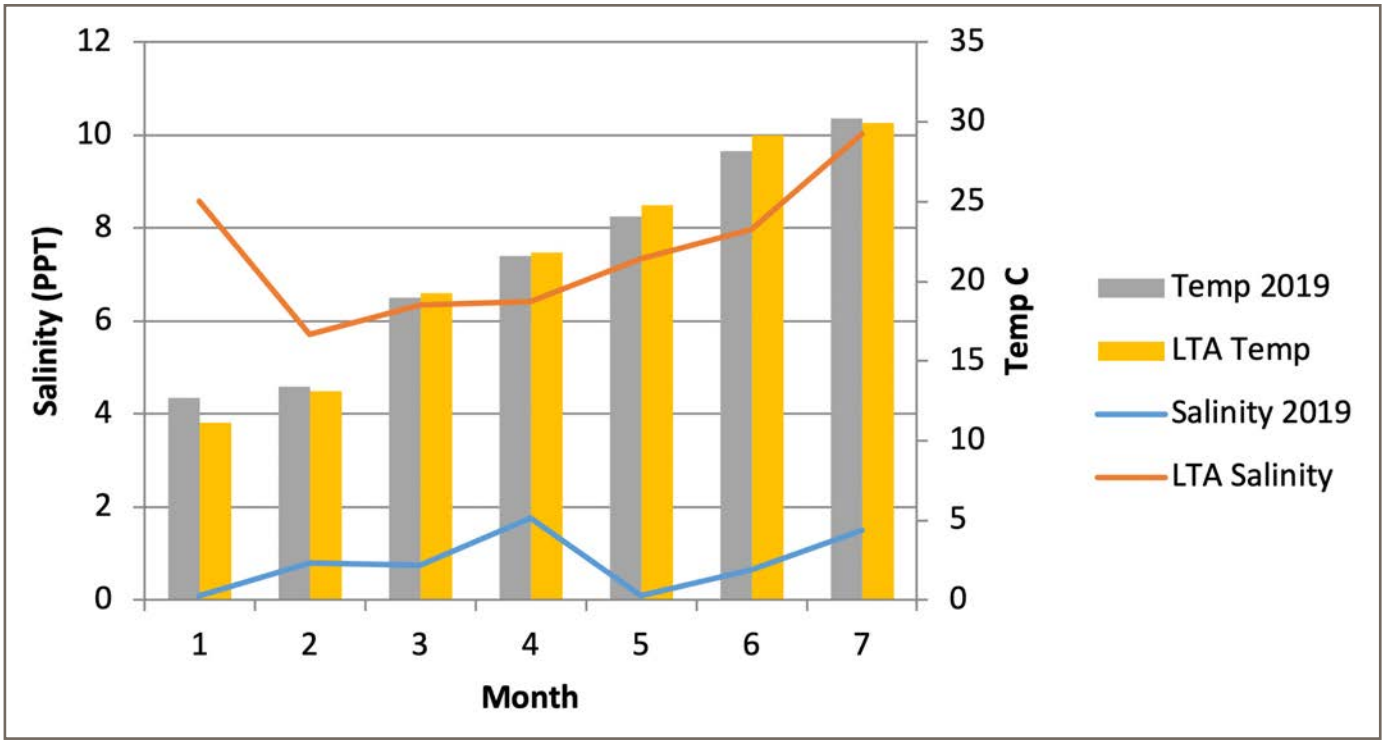

FIGURE 7.7. Salinity and temperature levels recorded during dredge and square-meter samples of the Sabine Lake public oyster areas in 2019 (GA31).

Tropical and Climatic Events

The 2019 flood event is discussed in the Introduction section of the Statewide Overview. However, no other significant tropical or climatic activity affected CSA 7 for the period covered by this report.

2018/2019 Oyster Season

The Commission opened East Side and West Cove beginning Oct. 29, 2018, with a daily sack limit of 10 sacks/per day (*Table 7.2, Table 7.4*), and closed on April 30, 2019. Based on LDWF trip ticket data, approximately 9,185 sacks of market-size oysters were landed from East Side and West Cove combined during the 2018/2019 season (*Figure 7.8*), representing a 9.5% increase over 2017/2018 season. Daily harvest effort was down from the previous harvest season. Based on LDWF trip ticket data, approximately 8 boats per day were actively harvesting oysters in Calcasieu Lake during the open days of the 2018-2019 season.

The number of closures to oyster harvesting in Calcasieu Lake due to LDH health concerns was slightly above normal for a typical oyster season with 48% of the total oyster season open to harvest in West Cove, while East Side was opened 80% of the time during the oyster season based on LDH health closures/openings (*Table 7.4*).

Comparing LDWF trip ticket data with results from 2018 stock assessment, approximately 6.0% of the standing crop of market-size oysters in Calcasieu Lake was harvested last season (*Figure 7.8*).

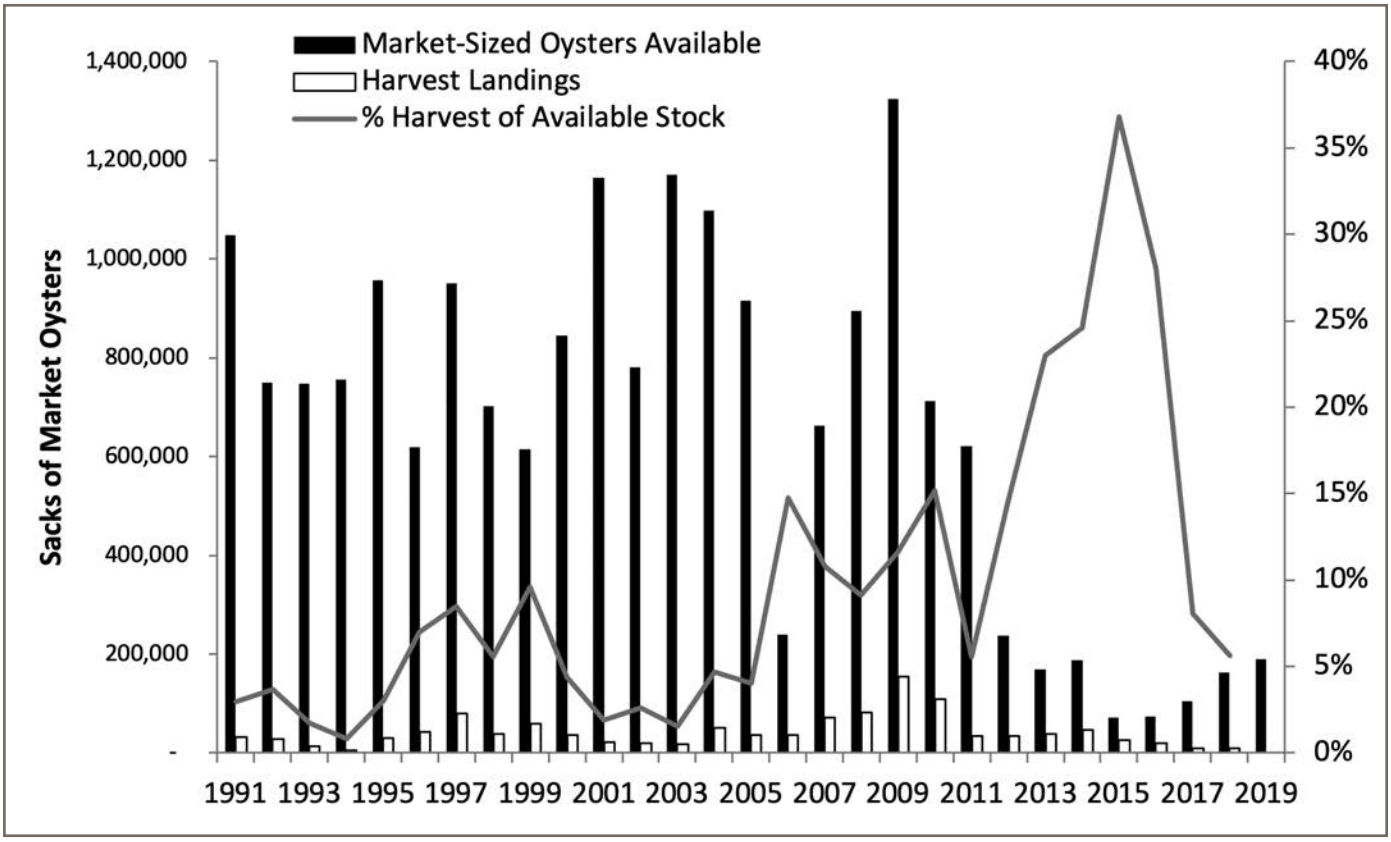

FIGURE 7.8. Historical stock assessments and landings (in sacks) of oysters from public oyster areas of Calcasieu Lake.

TABLE 7.4. Public oyster season and number of days open to harvest as a percentage for East Side (GA-29) and West Cove (GA-30) in Calcasieu Lake.

Season		Season Dates	Total Days	CALCASIEU LAKE			
				Eastside		West Cove	
				Days	% Open	Days	% Open
2005-06[1]	GA29	Oct.15 - April 30	198	187	94		
	GA30	Oct. 8 - April 30	205			165	80
2006-07	GA29	Nov. 1 - April 30	181	118	65		
	GA30	Oct. 16 - April 30	197			70	36
2007-08	GA29	Nov. 1 - April 30	182	165	91		
	GA30	Oct. 15 - April 30	199			131	66
2008-09	GA29	Oct. 15 - April 30	198	183	92		
	GA30					125	63
2009-10	GA29	Oct. 15 - April 30	198	157	79		
	GA30					80	40
2010-11[2]	GA29	Nov. 15 - March 25[4]	131	131	100		
	GA30[3]	Oct. 15 - April 30	198			186	94
2011-12[5]	GA29[6]	Closed	-	0	-		
	GA30	Nov.1 - April 30	182			92	51
2012-13	GA29	Closed	Closed	0	-		
	GA30	Nov. 1 - April 30	181			82	45
2013-14	GA29	Closed	Closed	0	-		
	GA30[7]	Nov. 1 - April 30	181			158	87
2014-15	GA29	Closed	Closed	0	-		
	GA30	Oct. 26 - April 30	187			111	59
2015-16	GA29	Closed	Closed	0	-		
	GA30	Nov. 1 - April 30	182			108	59
2016-17	GA29	Nov.1 - Feb. 13	105	86	82		
	GA30	Nov. 1 - Jan. 24	85			54	64
2017-18	GA29	Closed	Closed	0	-		
	GA30	Nov. 1 - May 15	196			130	66
2018-19	GA29	Oct. 29 - April 30	184	145	79		
	GA30					88	48

1. Starting with the 2005-06 season, the lake was divided into two conditional managed areas (CMA), were managed separately and may have different length seasons.
2. Starting with the 2010-11 season, the conditional managed areas were changed to Growing Areas (GA).
3. From 10/15 through 11/14, the daily sack limit in GA30 was 20. Daily limit reverted to 10 sacks for the remainder of the year.
4. GA29 closed due to heavy pressure on the resource; see LDWF new release from 3/22/11.
5. Oyster harvesting on Calcasieu Lake for the 2011-12 season was by special permit only; see LDWF news releases from 7/7/11 and 9/15/11.
6. GA29 was closed; see LDWF news release from 9/1/2011.
7. LDH closure threshold changed from 7.0 to 9.0 ft. at Kinder gauge.

APPENDIX I

Levels of the parasite *Perkinsus marinus* in sack and seed oysters: Louisiana Public Seed grounds, September 2019

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Since first described in 1950, dermo, the disease caused by the protistan parasite *Perkinsus marinus*, has continued to cause extensive mortalities of eastern oysters (*Crassostrea virginica*) in Gulf of Mexico and Atlantic estuaries when salinities are higher than 12 (about 1/3 full strength seawater) and temperatures exceed 25ºC (Burreson & Ragone Calvo 1996, Soniat 1996). Yearly dermo-related mortality rates can exceed 50% for market-size (>75 mm) oysters (Burreson & Ragone Calvo 1996, Powell et al 1996). The name of the disease "dermo" is derived from the original name of the parasite *Dermocystidium marinum* (Mackin et al. 1950) and is still widely used today.

Transmission of dermo is direct when parasites are released in the water from infected or dying oysters, and filtered by feeding uninfected oysters (Chu 1996). Infection rates and intensity are hence greatest in older larger oysters which filter more water. Infections cause reductions in oyster growth rate and meat yield as the parasites multiplies and feeds on oyster-derived nutrients (Paynter 1996, La Peyre 1996). Oysters generally succumb from this chronic wasting disease when infection intensity is beyond the rank of 3 on the Mackin scale (Dungan and Bushek 2015) equivalent to a number of parasites exceeding about 500,000 per gram of wet tissue.

In oyster tissues, the microscopic parasites are about 3-10 µm in diameter but when incubated in fluid thioglycollate medium (FTM), they enlarge many folds, develop a thick wall, and stain blue-black with Lugol's iodine solution (Ray 1952, Perkins 1996). These unique characteristics are the bases for the development of the Ray's fluid thioglycollate assay for the diagnosis of dermo (Ray 1966). Briefly, a small piece of oyster tissue (~5 mm^2 piece) is incubated in Ray's FTM (RFTM) fortified with antibiotics for one week. After incubation, tissues are minced, stained with a few drops of Lugol's iodine, scanned microscopically under low magnification at 40x and examined more thoroughly at 100x magnification. Perkinsus marinus infection intensity is scored using a 0-to-5 scale developed by Mackin (1962), where 0 is no infection, and gradually increases in infection level from light (1), light to moderate (2), moderate (3), moderate to heavy (4), and heavy (5) based on the abundance of parasites in the entire sample. The data of infection is presented at the sample level as percent of infection (PI) and weighted prevalence (WP):

PI = (number of oysters infected / number of oysters tested) x100

WP = Sum of Mackin's scale values / number of oysters tested

Mackin (1962) suggested that oyster mortality probably occur in the moderate to heavy infections and dermo levels will be a concern in populations with a WP of ≥ 2.0 because more than half of the oysters in the population have advanced (moderate to heavy) infection levels.

Louisiana public oyster grounds are managed by Louisiana Department of Wildlife and Fisheries (LDWF) that for logistical purposes currently divides the coast in five Coastal Study Areas (CSA 1, 3, 5, 6 and 7). All five areas were sampled in Sept. 9-11 of 2019 for a total of 15 sites across coastal Louisiana. Samples were taken from Cabbage Reef, West Karako and Drum Bay in Mississippi Sound (CSA1 North); Machias in Breton Sound (CSA 1 South); Upper Hackberry Bay in Barataria Bay (CSA 3); Lake Chien in Terrebone Bay (CSA 5 East); Grand Pass, Outlaw Cove, Bucksin Bayou, and Rat Bayou in Caillou Lake (CSA 5 West); Lighthouse Point in Vermilion Bay (CSA 6); Sabine Lake stations 2 and 3 in Sabine Lake (CSA 7 Sabine), and Chenier Reef and W. Rabbit Island in Lake Calcasieu (CSA 7 Calcasieu) (*Table 1*).

LDWF collected approximately 30 oysters for most of the sites (*Table 1*). Samples were brought to the Animal and Food Science Laboratory building at Louisiana State University Agricultural Center, Baton Rouge, for dermo diagnosis. Shell heights were measured using a digital caliper, and oysters classified within two categories, market-size (>75 mm) or seed oysters (25-74 mm). Oysters were then shucked and a ~5 mm^2 piece of mantle tissue, next to the labial palps, was incubated in RFTM for 7-8 days. The protocol described in "Ray's Fluid Thioglycollate Method - a standard practical guide for oyster sentinel participants" (*https://data.oyster sentinel.cs.uno.edu/RFTM_SOP.pdf*) was strictly followed to be consistent with past diagnoses. Results are summarized in *Table 1*. Overall, WP was very low at all sites, ranging between 0-0.5, with all the oysters showing no or light infections. Except for West Karako, Drum Bay, Machias, and Outlaw Cove stations, the remaining stations were sampled previously and comparisons were made between results from previous years and 2019. WP in market-size oysters was similar in 2019 to previous years for all the stations compared: Upper Hackberry Bay (2019:~0.2; 2013-

TABLE 1. Percent Infection (PI) and weighted prevalence (WP) of seed and market-size (sack) oysters from Louisiana Public Seed Grounds: September 2019. Date is collection date, T is temperature, S is salinity, PI is percent infection, WP is weighted prevalence, NS is number of seed oysters processed, NM is number of market size oysters processed.

Station	Date	T (°C)	S (ppt)	Seed PI	Seed WP	NS	Market PI	Market WP	NM
Cabbage Reef	9/10/2019	30.9	21.7	0	0	4	No data	No data	0
West Karako	9/10/2019	30.8	17.1	7	0	14	14	0.1	14
Drum Bay	9/10/2019	31.1	16.1	0	0	12	73	0.5	15
Machias	9/10/2019	30.4	12.4	7	0	14	0	0	16
Hackberry Bay (Upper)	9/11/2019	30.5	10	18	0.1	17	36	0.2	22
Lake Chien	9/9/2019	30.6	11.9	0	0	1	11	0.1	9
Outlaw Cove	9/9/2019	30	10.8	0	0	9	0	0	20
Grand Pass	9/9/2019	30.2	10	17	0.1	12	6	0.1	18
Buckskin Bayou	9/9/2019	30.4	9.5	8	0	13	9	0	22
Rat Bayou	9/9/2019	29.7	13.9	0	0	8	12	0.1	17
Lighthouse Point	9/9/2019	30.2	16.7	13	0	8	12	0	17
Chenier Reef	9/10/2019	30.9	16.2	25	0.1	12	28	0.2	18
W Rabbit Island	9/10/2019	30.6	12	0	0	15	33	0.2	15
Sabine - Lake 2	9/10/2019	30.9	22.9	0	0	10	5	0	20
Sabine - Lake 3	9/9/2019	30.5	20.6	14	0	14	6	0	16

2017: ~0-0.3), Lake Chien (2019:~0.1; 2007-2017: ~0-0.4), Grand Pass (2019:~0.1; 2009-2017: ~0-0.1), Bucksin Bayou (2019:~0; 2009-2017: ~0-0.1); Ray Bayou (2019:~0.1; 2009-2017: ~0-0.5), Lighthouse Point (2019:~0; 2015-2017:~0), Sabine Lake 2 (2019:~0; 2012-2017:~0-0.2), Sabine Lake 3 (2019:~0; 2013-2017:~0-0.5); Chenier Reef (2019:~0.2; 2016-2017:~0-0.4), and W. Rabbit Island (2019:~0.2; 2015~0.4).

Complete records of disease levels from this year and previous years are available from Oyster Sentinel (*www.oystersentinel.org*).

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