

Louisiana Oyster Management and Rehabilitation Strategic Plan

Draft – December 2020



Introduction

Louisiana's vast coastal wetlands provide ample habitat where American oysters (*Crassostrea virginica*) thrive under a variety of environmental conditions. Louisiana's oyster stock is one of the largest in the nation, supporting one of the state's largest and most valuable fisheries, and provides important ecological services to the state. The Louisiana Department of Wildlife and Fisheries (LDWF) is charged with managing the state's oyster resource by monitoring, conserving, and enhancing the size and health of oyster populations on nearly 1.7 million acres of public oyster areas. Oysters 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.

The oyster industry has historically used Louisiana's public oyster areas as a source of seed oysters (less than three inches in length) to transplant to privately-managed oyster leases for grow-out to market size. In Louisiana, approximately 400,000 acres of state-owned water bottoms are leased by private entities. The public oyster areas may also yield a supply of market-size oysters (greater than or equal to three 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, however oyster production on the public oyster areas of Louisiana is at an all-time low and rehabilitation of this valuable economic and ecological resource is needed.

Through the Louisiana Seafood Future project of 2019 (www.laseafoodfuture.com), the commercial seafood industry, including the oyster community, identified options that could be viable in their attempts to adjust to a changing coast. Physical space to work in the coastal zone is also at a premium with multiple users oftentimes vying for the same water bottom. The Coastal Protection and Restoration Authority (CPRA) and the oil and gas industry are sometimes in direct spatial conflict with existing oyster leases. In areas where such leases are productive, the LDWF aims to support and protect, to the maximum extent practicable, the oyster leaseholder in the enjoyment of their rights to cultivate leased water bottoms. As such, LDWF is providing this path for recovery and maintenance of Louisiana's oyster resources, and for assistance with industry adaptation and development, while reducing conflicts in the coastal zone.

These initiatives require implementation and funding in order to promote and maintain a thriving oyster resource and industry in Louisiana, and to allow for the most efficient utilization of coastal areas. In order to increase the likelihood of success, this plan requires a minimum of five years for implementation. The estimated budgets set forth in this plan assume full funding to begin in 2021. Additionally, it is recognized that some initiatives will be more difficult than others to address,

based upon various factors (e.g. cost, timing, etc.) and some will require feasibility studies to determine suitability and/or effectiveness, along with cost/benefits.

The state previously began efforts to assist the oyster industry in adapting to changing coastal conditions by lifting the long-standing oyster lease moratorium and turning some public oyster grounds into leasable areas (Bay Eloi area in St. Bernard Parish). In addition, two cultch plants and four spawning reefs are to be completed in 2021 as part of the oyster restoration projects approved by the Louisiana Trustee Implementation Group (TIG) in *Final Restoration Plan/Environmental Assessment #5: Living Coastal and Marine Resources – Marine Mammals and Oysters* with monies from the *Deepwater Horizon* (DWH) oil spill settlement (LA TIG, 2020).

Mission Statement

The LDWF Office of Fisheries is charged with the protection, conservation and replenishment of Louisiana’s renewable, aquatic natural resources, including Louisiana oysters. This crucial task has never been as important as it is today, in the wake of both natural and man-made disasters Louisiana’s coast has endured in the past years.

Goals and Objectives

The following goals of this oyster strategic plan are to be met within five years of plan finalization through these objectives:

1. Increase oyster density on the public oyster areas of Louisiana
 - Achieve/Maintain an average density of 20 seed-sized oysters/square-meter on 70% of managed areas of public grounds as identified by most recent oyster stock assessment.
2. Expand oyster resource resilience through:
 - a. Habitat improvement projects
 - Enhance a minimum of 1,000 acres of existing reef habitat through addition of hard substrate (i.e. cultch material); with at least two different coastal basins receiving enhancement projects.
 - Achieve same objective from #1 above on enhanced reefs.
 - b. Development and protection of spawning reefs
 - Create or maintain at least 40 acres of non-harvest spawning reefs across multiple basins.
 - Maintain presences of spawning-sized oysters (≥ 40 mm length) on at least one reef per basin each year.
 - c. Research to develop a low-salinity tolerant oyster
 - Test deployment of selectively-bred oysters in natural environment.
3. Provide resilience to oyster industry by offering options to:
 - a. Rehabilitate existing leased grounds in areas where production is likely to occur
 - Secure cultch material to be provided to lease holders
 - Secure spat-on-shell material to be provided to leaseholders
 - b. Develop new leased grounds in areas where production is likely to occur
 - Agreements for 100 “new” leases.

- Secure and provide cultch and/or spat-on-shell material to be used to develop “new” leases for oyster production.
- c. Expand operations into Alternative Oyster Aquaculture (AOC), such as off-bottom cage culture
 - Identify at least 100 acres suitable for AOC (parks) by Year 2
 - 50% of areas to have required permits by Year 5
 4. Expand hydrologic monitoring of oyster areas by installing continuous data collection platforms (DCPs) along the coast to collect parameters such as salinity, temperature, dissolved oxygen (DO), and pH
 - At least two DCP’s in-place and operational, and two experimental collection platforms for appropriateness of location.

Overview

LDWF has developed this strategic plan that, when executed, will guide the Louisiana public oyster resource and oyster industry to a more productive and sustainable future. The total budget estimate is approximately \$132.3 million. It is recognized that this total cost is an estimate and is likely to increase as time passes.

LDWF manages oyster resources by closely monitoring the status of oyster populations on public oyster areas within five coastal basins, as well as setting oyster seasons, monitoring harvest levels, enforcing state laws and administrative rules, and enhancing habitat (e.g., cultch planting, reef building, etc.). 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 oyster stock assessment reports help fulfill these data needs as they provide estimates of the current stock size of the oyster resource within each coastal basin. The oyster industry has historically utilized the public oyster seed ground (POSG) areas as a source of seed oysters (< 3” length) to transplant to private oyster leases managed by approximately 930 leaseholders. The public areas also yield a supply of sack-sized oysters (≥3” length) and these oysters may be taken directly to market during the open season.

The 2019 oyster stock assessment indicated that Louisiana is experiencing the lowest stock size on the public oyster areas ever recorded. The observed decline 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, and most notably, the 2018-2019 Mississippi River flooding event. This historical and unprecedented flood event dramatically reduced salinities across the basins in the state, and increased oyster mortalities were documented in subsequent biological sampling. It is the longest duration flood since records became available in 1900. In addition, the Bonnet Carré Spillway was opened in back-to-back years, including twice during the 2019 flood event. Since the beginning of the 2019 flood event, LDWF collected extra weekly dredge samples in select POSG locations, in addition to regular monthly scheduled dredge samples, to closely monitor oyster mortality in the POSG areas, which was found to be as high as 100% in some areas influenced by this prolonged freshwater flow.

In recent years, LDWF has invested millions of dollars in planting cultch in order to increase oyster production; however, the public oyster areas are too vast to rely solely on this expensive restoration technique and a multi-faceted approach is necessary. Additionally, coastal and environmental changes have caused some public oyster areas to decrease in productivity and it may be necessary to develop additional areas in zones of higher potential oyster productivity. It is important to note that the oyster industry had also invested in extensive cultch planting and had maintained high levels of oyster production on leased grounds through techniques refined over generations. According to some leaseholders, the unprecedented flood event negatively impacted the vast investments the oyster industry has made on private leases, along with LDWF's investments in POSG areas.

LDWF recognizes that there are multiple activities occurring within our coastal zone, with the most notable to the oyster industry being coastal restoration and the production of oil and gas resources. Spatial conflicts between oyster leases and other activities are well-known and multiple efforts to reduce these conflicts have occurred. While recent legislation outlines a process whereby conflicts can be reduced, there are many thousand acres of existing oyster leases that will not be subject to the recent legislative and administrative changes as those leases pre-date the regulatory changes. A portion of this acreage likely lies in areas that are incapable of oyster production, and it is in the state's best interest to have oyster leases where oyster production is likely to occur, while reducing leased acreage where oyster production is not likely to occur so that other activities on and around those unproductive water bottoms can exist.

General Considerations

Knowledge of site conditions is essential for selecting the best oyster restoration strategy for a particular site. Specifically, three main factors must be considered: hydrology, availability of oyster larvae, and availability of suitable substrate. Oysters require specific hydrologic conditions, which primarily include appropriate salinities, temperatures, dissolved oxygen, and flow. While local hydrology may be manipulated in the coastal zone of Louisiana, natural factors such as rainfall, river discharge, and drought typically dominate conditions and determine where suitable oyster habitat is located.

Suitable hydrology for oyster reproduction and growth is essential. Once hydrologically suitable areas are determined, an appropriate technique(s) can be chosen. Typical oyster restoration can be grouped into two broad techniques: placement of substrate, or the placement of live oysters; or a combination of the two. Determining whether live, reproducing oysters are present is an essential step in the site/project selection process. Projects improving substrate by placing material in the water on which oyster larvae can settle are best located in areas where oyster larvae are abundant. Adding live oysters to an area is best where low levels of larvae and recruitment are observed; however, suitable substrate must be available before live oysters are deployed. Height of substrate over surrounding water-bottoms is an additional consideration for restoration to help reefs persist through protracted low D.O. and/or high salinity events, and burial from suspended sediments. The basic decision-making process is outlined in Figure 1 below, but is not inclusive of all considerations. LDWF was involved with the development of the *DWH Oil Spill Natural Resource Damage Assessment (NRDA): Strategic Framework for Oyster Restoration Activities*, which contains extensive discussion on oyster restoration

techniques and can be found at: [https://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Oyster Strategic Framework 06.23.17.pdf](https://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Oyster_Strategic_Framework_06.23.17.pdf) .

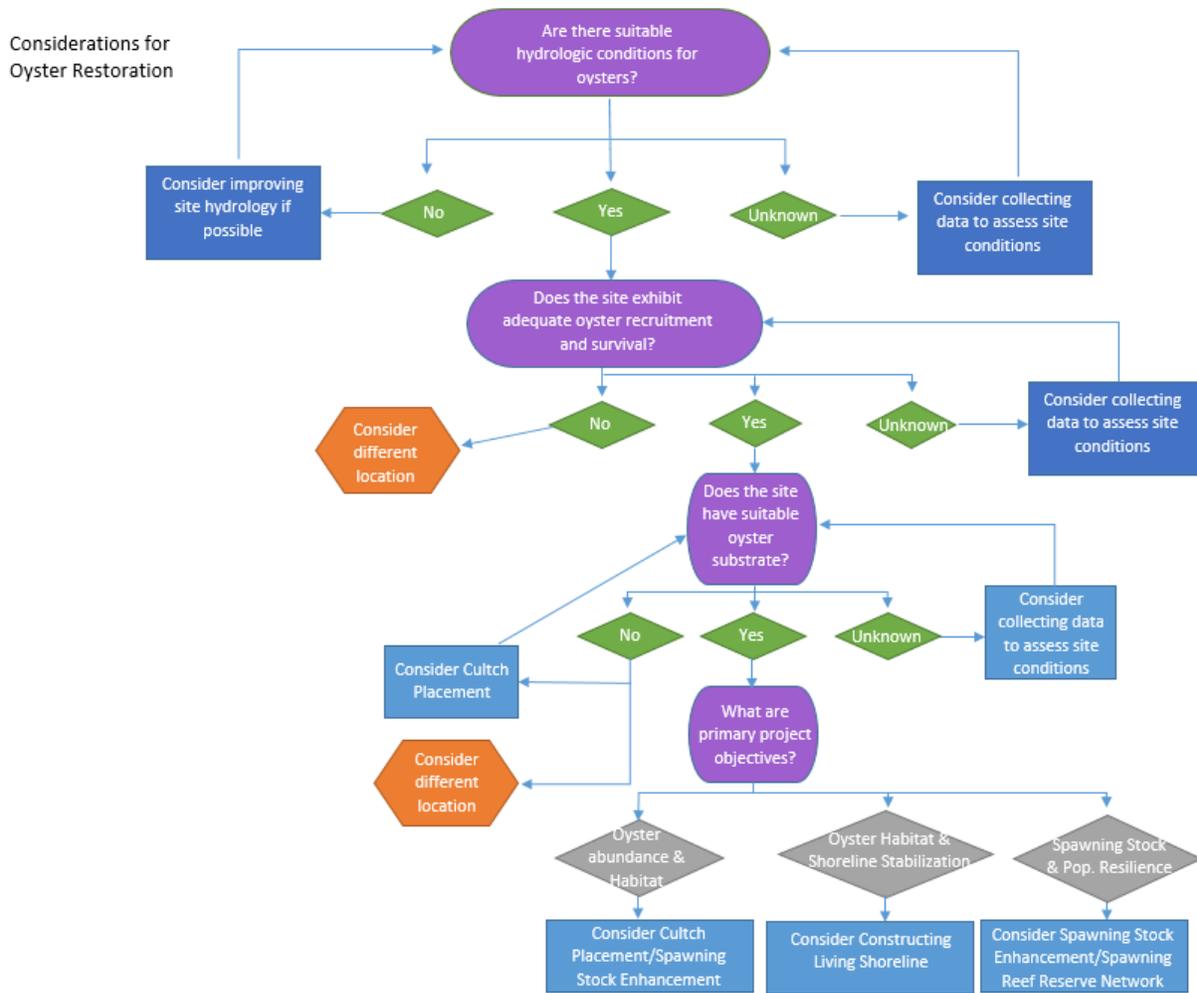


Figure 1. Flowchart of general considerations for oyster restoration

Initiatives

The following initiatives have been identified to assist in the rehabilitation process; increasing the productivity and viability of the public oyster areas in Louisiana, assisting the oyster industry with adjusting to a changing coast, allowing the industry to be sustainable into the future, and ways to identify, address and mitigate competing activities on coastal water bottoms. A general spatial representation of these initiatives can be seen in the map accompanying this document (Figure 2).

1. Traditional Cultch Planting and Water-Bottom Mapping (\$13.6 million)
2. Cultch Planting with Remote-Set Oysters (\$12.0 million)
3. Development of Spawning Stock Sanctuary Network (\$13.8 million)
4. Expansion of Alternative Oyster Aquaculture (\$10.0 million)
5. Private Oyster Lease Rehabilitation (POLR) Program (\$12.0 million)

6. Expansion of Hydrologic Monitoring (\$5.0 million)
7. Evaluation of Leases Incapable of Oyster Production (\$5.0 million)
8. Establishment of Cultivation and Production Requirements on Leases (\$5.0 million)
9. Establishment of New Public Oyster Areas (\$5.0 million)
10. Mississippi River Gulf Outlet Hydrologic Evaluation (MRGO) (\$1.6 million)
11. Evaluation of Restoration of the Bohemia Spillway Water Control Structure (\$24.3 million)
12. Research and Development (\$25.0 million)

Initiative 1 - Traditional Cultch Planting and Water-Bottom Mapping

Louisiana's public oyster areas have historically been used as a source of seed oysters for transplant to private oyster leases to be grown out to market size. The public oyster areas also yielded a supply of market-size oysters which may be taken directly to market. LDWF manages public oyster areas to balance the economic opportunity of the fishery with the biological sustainability of the resource. Natural and man-made processes remove exposed shell mass from reefs on an annual basis. As oyster larvae require clean, hard substrate on which to settle and grow, replacing the lost habitat is vitally important. LDWF continues to place appropriate cultch material on suitable water bottoms within areas with appropriate environmental conditions on the public oyster seed grounds. Recycled oyster shell has been shown to be the ideal substrate for seeding cultch, supporting the need for oyster shell recycling programs. Discarded oyster shells added back into the water strategically can serve the dual purpose of restoring coastal wetlands that can protect the coastline from storms and supporting Louisiana's oyster fisheries.

Efforts to map unknown water bottom types on the public grounds should be continued to help provide needed information on possible project locations. Water bottom assessments include a comprehensive habitat characterization and assessment (side-scan sonar survey with ground-truthing) of selected portions of the public oyster areas, and can cover the entire extent of known oyster habitat within different basins and identify acreage of oyster habitat (Table 1). The data from water bottom assessments can also provide an updated estimate of reef acreage used for stock assessment calculations since the original water bottom assessments for some areas were performed in the mid-1970s. Table 1 shows proposed locations for first five years of cultch planting and water bottom assessments.

Table 1. 5-year cultch planting plan and budget.

Year	General Project Area (Public Oyster Area)	Parish	Cultch Planting (\$)	Side-Scan Sonar (\$)
2021	Sister Lake	Terrebonne	2,400,000	
2021	Biloxi Marsh	St. Bernard	2,400,000	500,000
2022	Sister Lake	Terrebonne	1,200,000	
2022	Bay Eloi	St. Bernard		500,000
2022	Biloxi Marsh	St. Bernard	1,300,000	
2023	Lake Chien	Terrebonne	1,200,000	
2023	Vermilion Area	Vermilion/Iberia	1,200,000	500,000
2024	Biloxi Marsh	St. Bernard	1,200,000	
2025	Sister Lake	Terrebonne	1,200,000	
			12,100,000	1,500,000
			TOTAL	13,600,000

Initiative 2 - Cultch Planting of Remotely Set Oysters

Restore the public grounds by conducting spat-on-shell depositions (e.g. cultch planting), an oyster restoration technique discussed in the *DWH Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement* (Final PDARP/PEIS; DWH Trustees, 2016; Section 5.5.9). This initiative will utilize hatchery-raised remote-set oysters to augment natural reefs and existing broodstock sanctuaries lacking sufficient natural recruitment. It could also benefit from oyster recycling projects, since recycled shell has been shown to be an ideal substrate for seeding cultch. In many instances oyster spat settle and survive better on whole oyster shell than on crushed concrete or other materials. Potential short-term benefits of spat-on-shell deployments include directly increasing oyster abundance and improving the reproductive potential for oysters in each area. Potential long-term benefits include increasing oyster production and associated ecosystem services resulting from high oyster abundance, and improved oyster population connectivity, resilience, and stability. Both the short-term and long-term potential benefits are largely dependent on future hydrologic conditions of each area.

With the collaboration of Louisiana Sea Grant, LDWF will utilize larvae produced at the Michael C. Voisin Oyster Hatchery on Grand Isle and private hatcheries to increase the concentration of oysters within the public oyster areas of Louisiana. In addition to existing natural reefs, all cultch planting projects listed in Initiatives 1 or 3 would be considered for augmentation using remote-set oysters, along with living shorelines or other coastal protection type projects constructed where oysters may thrive. Success monitoring of the various remote settings achieved will be evaluated periodically to help inform future utilization of this technique as a stand-alone and in conjunction with relevant initiatives.

Initiative 3 - Development of Spawning Stock Sanctuary Network

Restoring oyster abundance and spawning stock to support a regional oyster larvae pool sufficient for healthy recruitment levels to subtidal and nearshore oyster reef is another oyster restoration goal discussed in the Final PDARP/PEIS (DWH Trustees, 2016; Section 5.5.9) document.

Managing oysters as crucial habitat is vital to maintaining abundant oysters in order to support a sustainable fishery and a wide range of marine species. Active maintenance of spawning populations for the purposes of providing adequate larvae to support oyster populations has historically not been required in Louisiana due to high oyster abundances found throughout the coast. As such, most restoration activities involved the placement of cultch with the assumption that cultch would be successfully colonized by oysters. However, in certain areas of the state, oyster spawning potential now appears to be limited. Creating and/or maintaining mature spawning populations protected from harvest may be necessary to ensure adequate numbers of large oysters are, and remain, available to increase reproductive potential. Unharvested spawning reefs can provide beneficial ecosystem services, as they can help replenish oysters in surrounding areas open to harvest through larvae dispersal. These spawning reefs can support both restoration efforts and directly contribute to the oyster fishery over time, and they would contribute to the productivity of the entire reef system.

Depending on area designated for its creation, a spawning stock reef could consist of a small mature oyster reef protected from harvest or contain hard substrate piled vertically to supply relief over hypoxic conditions and unavailable for harvest. Key considerations of a spawning stock reef network include locating individual reefs along different salinity gradients to improve population connectivity and production, but also to help maintain oyster production in some portion of an estuary during periods of anthropogenic/natural stress and help facilitate recovery from mortality events when suitable hydrologic conditions are restored. Reef locations for this proposal could be located from the upper-estuary to lower-estuary depending on logistics and needs within basins. Strategic siting of reefs for networking would be based on trends in salinity, observed population response from previous mortality events, proximity to living shoreline projects, and/or available larval transport models. Modeling simulation results from Munroe et al. (2014) have shown that siting protected areas for oyster restoration in lower salinity areas may interact with development of disease resistance (e.g. Dermo) in the metapopulation by altering genotype transfer from protected to unprotected “down-estuary” populations. Therefore, there is a potential value of lower-estuary sanctuary habitat and the role it may play when we have significant freshets and upper and mid-estuary populations are affected; these higher-salinity “down-estuary” populations would play a vital role in helping to reestablish “up-estuary” and “mid-estuary” populations (Melancon pers. comm.). Oysters left undisturbed on spawning reefs can grow to reproductive sizes, producing and contributing with larvae to the surrounding ecosystem, thus increasing recruitment potential. Spawning reefs benefit by maintaining oysters within multiple age classes, and when they attain a high density of larger adults can have a higher recruitment potential.

This initiative could be assisted by coastal restoration projects for shoreline protection (e.g. living shorelines, oyster recycling programs) that are placed in productive oyster areas, benefiting both natural reefs and private oyster leases. One recently completed project in Louisiana was Queen Bess Island which was restored to benefit the brown pelican population, but at the same time will provide settlement areas for oysters on the rock substrate used to protect the island’s rim. Possible oyster projects that could be considered for this initiative may include the purchase and relocation of oysters from permanently “closed” private lease areas based on Louisiana Department of Health (LDH) closure areas, in order to establish spawning stock sanctuaries or possibly relaying these oysters to strategic locations across the public oyster areas and placing them in some of these sanctuary networks.

All spawning stock sanctuary reefs would be considered for augmentation using remotely-set oysters cited in Initiative 2 (Table 2).

Table 2. Proposed spawning broodstock reefs and budget.

Year	General Project Area (Public Oyster Area)	Parish	Spawning Reef with Remote Setting (\$)
2021	Sister Lake	Terrebonne	1,380,000
2021	MS Sound	St. Bernard	1,380,000
2022	Sister Lake	Terrebonne	1,380,000
2022	Bay Eloi	St. Bernard	1,380,000
2022	Biloxi Marsh	St. Bernard	1,380,000
2023	Lake Felicity	Terrebonne	1,380,000
2023	Vermilion Area	Vermilion/Iberia	1,380,000
2024	Calcasieu Lake	Cameron	1,380,000
2024	Sister Lake	Terrebonne	1,380,000
2025	MS Sound	St. Bernard	1,380,000
		TOTAL	13,800,000

Initiative 4 - Expansion of Alternative Oyster Aquaculture (AOC)

Historically, Louisiana estuaries have had an adequate supply of oyster larvae to replenish reefs that were impacted by natural and anthropogenic events. However, this is not the case any longer due to natural and man-made modifications to the estuaries. In order to adjust to changing coastal conditions, techniques besides traditional on-bottom farming need to be initiated and/or expanded to assist the oyster industry in remaining sustainable into the future. One such technique is the use of alternative oyster culture for providing marketable oysters. This technique allows for the cultivation of oysters while taking into account the possibility of natural and anthropogenic changes to an estuary. In Louisiana, the technique most often associated as alternative culture is that of “off-bottom” culture.

Encouraging alternative oyster culture techniques, such as off-bottom cage culture, could help reduce industry reliance on the public oyster areas of Louisiana and provide the oyster industry with options to successfully raise marketable oysters. Off-bottom culture of oysters can be done within floating or suspended containers that provide protection from predation and siltation as well as afford the operator ability to move to different growing areas in response to episodic events or longer-term changes in salinity. AOC farms located in strategic places which raise diploid oysters could contribute larvae to the surrounding oyster public grounds and oyster leases increasing recruitment and benefiting the system. The State of Louisiana recognizes AOC as an initiative that can help diversify the oyster industry and add a level of sustainability as the industry adjusts to a changing coast. The state will consider a program whereby existing and/or new industry members can be educated on this technique and be provided with resources to assist in diversifying into this new type of oyster production.

Seed production grants – Grant funding could be made available to entities interested in spawning and rearing diploid or triploid seed oysters (*Crassostrea virginica*) for sale to Louisiana

alternative oyster culture (AOC) and traditional oyster industry participants. This would provide another source of seed for the oyster industry, including for cage culture, plus help reduce demand for wild seed from the public grounds.

Hatchery diploid and triploid production- Current production issues at the oyster hatchery appear to be related to the condition and quality of the tetraploid broodstock, or possibly attributed to water quality issues. To increase diploid and triploid brood stock capacity, additional funding could be allocated to research and acquire a new strain of tetraploid brood stock, and conduct water quality studies within the hatchery to determine if additional treatment options should be considered

AOC startup grant - This grant program is designed for individuals interested in entering the growing AOC industry. AOC provides those fishermen who want an alternative to traditional oyster farming an opportunity to grow oysters in a variety of ways. AOC allows flexibility to avoid environmental challenges faced by traditional oyster farmers but the costs associated with startup can be a deterrent. Applicants could qualify for grant funding to assist with the purchase of eligible equipment. Eligible items for reimbursement would include lease fees, seed or larvae costs, grow-out equipment costs (longline systems, floating cages, etc.), and permitting fees. The percentage and amount would be determined based on expected startup expenses and number of eligible participants.

Education and Outreach - Establish a training program and information exchange for oyster industry members interested in transitioning/entering AOC activities. This program would introduce industry members to the tools, techniques, laws, and other pertinent information necessary to participate in the AOC sector.

Designated (Special) Management Use Areas - The State recognizes that siting and permitting may be a barrier to entry in alternative oyster culture. Therefore, areas on state-owned water bottoms could be designated specifically for use by oyster growers engaged in alternative oyster culture and permitted as such by the State, and administered by local parish authorities. While it would be the intent to establish multiple areas across the coast, future environmental conditions within the different basins will dictate availability and location. A working example of this concept is the aquaculture park currently administered near Grand Isle by the Grand Isle Port Commission.

Initiative 5 - Private Oyster Lease Rehabilitation (POLR) Program

This program was instituted after Hurricanes Katrina and Rita (2005) and was successful in assisting leaseholders to restore oyster productivity on their private leases. Private oyster leaseholders were compensated to perform one or more approved actions to help rehabilitate oyster resources on their private leases. Participants could be reimbursed for the purchase and placement of cultch material and/or spat-on-shell onto their leases. Encouraging the placement of spat-on-shell on top of the cultch material could help reduce industry reliance on a natural spat set and, at the same time, decrease the reliance on the public oyster seed areas of Louisiana, providing the oyster industry with options on how to successfully raise marketable oysters. The state will consider an outreach program whereby existing and/or new industry members can be educated on

this technique and be provided with resources to assist in transitioning into this new type of oyster production.

Initiative 6 – Expansion of Hydrologic Monitoring

This initiative will serve to install additional Data Collection Platforms (DCPs) at strategic locations across the coast to continuously collect critical water quality data in areas where oyster rehabilitation work is occurring, or is expected to occur. The need for such an expansion of monitoring is great. For example, within the over 300,000 acres of public oyster seed grounds in St. Bernard Parish, only one DCP currently exists. The map in Figure 2 depicts eight areas where continuous water monitoring would be beneficial to understanding, and managing, oyster populations. These additional DCPs would monitor water quality parameters such as salinity, temperature, dissolved oxygen, and pH, at a minimum. Costs of this initiative would include both construction and annual operation and maintenance. It is anticipated that the U.S. Geologic Survey (USGS) would be the contracted partner to perform this work so that the new DCPs would tie in seamlessly with the current USGS Streamflow Network, System Wide Assessment and Monitoring Program (SWAMP), and Coast Wide Reference Monitoring System (CRMS) sites.

Initiative 7: Evaluation of Leases Incapable of Oyster Production

In consultation with the oyster industry and CPRA, evaluate coastal zone conditions to determine areas and leases where oyster production is currently non-existent and are forecasted to remain incapable of producing oysters into the future. Confirmation of the lack of oyster productivity may be necessary in some areas, such as collecting biological and physical data (e.g., 5-year average salinity data), and/or water bottom surveys. Once areas incapable of oyster production are identified, the information will be presented and reviewed by the oyster industry for input and consideration. Existing oyster leases in areas determined incapable of producing oysters by LDWF may not be renewed upon expiration of the term. Should this determination change due to changing conditions, the former lessee could be offered the first right to re-establish the lease (likely would require new legislation). Although this initiative could provide short-term relief to competing uses of water bottoms, full completion of this initiative would take 15 years. The budget for this initiative would cover costs associated with collecting biological and physical data, and/or water bottom surveys assessments from private oyster leases.

Initiative 8: Establishment of Cultivation and Production Requirements on Leases

LDWF is supportive of oyster leases that are capable of producing oysters and will assist the oyster leaseholders in the enjoyment of their rights in areas where oyster productivity is possible. Cultivation and production were once required to be certified on leases in order to renew the lease, but such requirement was removed from state law in the early 2000s. This requirement could be re-established in law or administrative rule so that the state ensures that water bottoms leased for oyster production are actually being used for that intended purpose. Oyster production not captured on traditional LDWF trip-tickets, such as oyster seed production and cultch planting, would be captured by alternative reporting means. Modifications to the traditional trip-ticket forms may be needed to document direct harvest from specific leases, or leases in specific areas. Funding associated with this initiative would assist in the development of electronic reporting capabilities,

which should also be considered by LDWF to help accurately document harvest activity of market-size or seed-size oysters, and other cultivation activities.

Initiative 9: Establishment of New Public Oyster Areas

The coastal environment in Louisiana is dynamic and has undergone a variety of environmental changes over the past few decades. Some productive public oyster areas have gone fallow, and expected environmental changes due to coastal restoration activities may necessitate the development of new public oyster areas. Funding will be needed to survey the water bottoms, and mark these new public seed ground areas, as well as to plant cultch for development of new reefs. The placement of spat-on-shell on top of the cultch material in the new designated oyster grounds could help establish the new reefs, decreasing the reliance on a natural spat set. In addition, strategic establishment of spawning stock sanctuary initiative such as broodstock reefs and/or living shorelines could assist the new grounds by providing a larval source for future oyster generations.

Initiative 10 - Mississippi River Gulf Outlet (MRGO) Hydrologic Evaluations

In 2009, the MRGO was closed with a rock dam at the Bayou La Loutre ridge to prevent it from serving as a conduit for storm surge into St. Bernard and Orleans Parishes. Further, Congress authorized a feasibility study and environmental assessment to address damage resulting from increased salinities in the surrounding ecosystem over decades caused by the MRGO. Since then, a return to reduced salinities in Lakes Borgne and Pontchartrain have been observed, accompanied by documented instances of a reduction in oyster productivity on leases and public oyster seed grounds in Lake Borgne.

Alteration of the existing rock dam to allow tidal movement of water may have the potential to improve hydrology and water quality in the area, benefiting nearby oyster and other fishery resources. During flood events and when the Bonnet Carré Spillway is open, this could also help disperse freshwater through the MRGO into the Breton and Chandeleur Sounds. This project will focus on evaluation, by engineering and hydrologic experts, of the feasibility of altering the structure (i.e. if the structure could physically withstand the removal of a portion of the rocks, or if all of the rocks would need to be removed and the structure rebuilt). Hydrologic questions also exist as to how much flow would be required to improve salinity conditions in Lake Borgne to levels that would promote oyster production.

Even with a favorable evaluation, the process of restoration might be difficult to implement due to the following challenges:

- a. *Congressional Involvement:* As the rock dam was a congressionally-authorized project when constructed, it would require congressional action to de-authorize the project.
- b. *Public Support:* While many recreational and commercial fishermen appear to be supportive of a reopening of the rock dam, it is unclear if the larger population in the St. Bernard and Orleans parishes would consider such as a flooding threat. The rock dam was constructed after Hurricane Katrina as it was felt that floodwaters traveling northwest up the MRGO contributed heavily to the flooding in both St. Bernard and Orleans Parishes.

Additionally, environmental-based Non-Governmental Organizations (NGOs) have expressed concern about altering this structure.

Initiative 11 – Evaluation of the Restoration Bohemia Spillway Water Control Structure

Mardi Gras Pass (MGP) formed on the east bank of the Mississippi River in 2011 and is located at the Bohemia salinity control structure near Pointe-a-la-Hache, LA, in Plaquemines Parish. This structure is part of a larger Bohemia Spillway that connects the Mississippi River to the back-levee canal. The MGP breach in the Mississippi River levee at the Bohemia salinity control structure has facilitated hydrologic change in the Breton Sound area in combination with other freshwater influences. Through Plaquemines Parish government, an engineering evaluation was completed in December 2018 to determine options for control of MGP. Based on that engineering evaluation, it would cost \$24.3 million to rebuild a control structure at MGP, although it is possible the cost will climb with each passing year.

Historically, the Breton Sound area accounted for a significant portion of the statewide harvest of both sack and seed oysters. During the years 2000 - 2009, this area produced approximately 47% of the statewide commercial oyster landings. Oyster populations have declined in the area and landings have substantially decreased. The increased input of fresh water has contributed to lowered salinities near the structure, as well as increasing the amount of nutrients in the water, possibly leading to more hypoxic events, increased sedimentation on reefs and bio-fouling of reef material. Reestablishing water control of this site would allow the ability to manage hydrology to benefit oyster resources within the area of influence of Mardi Gras Pass.

This initiative will focus on evaluating current and future hydrological conditions and flow needed to benefit oyster production and management in the area, while also considering the benefits and impacts of flow through other diversion structures in the area. Further, the management of the freshwater flowing from this spillway should also be evaluated to determine if there are potential engineering options to move freshwater away from oyster reefs yet still provide coastal restoration benefits.

After evaluations however, the restoration of the structure might encounter the following challenges:

- a. *Cost*: an updated engineering cost-estimate would likely be needed.
- b. *Other user group conflicts*: While many recreational and commercial fishermen appear to be supportive of closing or controlling the structure to decrease the amount of freshwater entering the receiving basin, it is unclear if the larger state and local population would support such a closure. Additionally, environmental-based Non-Governmental Organizations (NGOs) have expressed concern about closing or controlling the structure.

Initiative 12 – Research and Development (R & D)

It is recognized that innovative solutions are needed to help the Louisiana oyster industry thrive into the future. If increased fresh water inputs into the estuary are to be expected, developing a line of eastern oyster broodstock capable of survival, growth, and reproduction in lower-salinity environments would be of great help. Research results have shown that genetic analysis of extreme low salinity survival of the eastern oysters suggest that this trait is heritable and could be selectable

in a breeding program (McCarthy et al. 2020). The R&D initiative would attempt to develop an oyster population capable of increased survival during low-salinity “freshet” events, selected through a breeding program done by researchers and research institutions in Louisiana. McCarthy et al. (2020) discusses that offspring testing should be conducted on a site-specific basis, justifying the need to develop a lineage of oysters capable of surviving in low-salinity waters, specifically for Louisiana.

In addition to research towards a low-salinity tolerant oyster, other research projects should be funded that could assist in future development, sustainability, and connectivity of both the oyster industry and the oyster resource. One example could be the development of a guidance document that could help best direct the location of some of the initiatives described above. Such as developing a science-based, data-driven, decision-making platform to inform LDWF’s efforts at rehabilitating Louisiana oyster resources, considering future conditions (landscape, hydrology, episodic/sporadic events, etc.) and utilizing a multi-faceted approach (source/sink reefs, alternative oyster culture, living shorelines, spat-on-shell seeding, larval models, etc.) to enhance resilience of recovering oyster populations, while avoiding areas not suitable for current and future oyster production; allowing for efficient utilization of funding as it becomes available by identifying suitable areas for various restoration technique(s) most likely to succeed at expanding oyster habitat and providing for their long-term sustainability.

This guidance document would be built upon existing data from sources such as CPRA and USGS. These data sources provide clues that could help correctly site rehabilitation efforts such that the likelihood of success is increased as much as possible.

Potential Funding Sources and Timeline (Tables 3, 4 and 5 below)

1. *LDWF Funding*: Limited funds exist within LDWF which are not already committed to current operations. It is possible that some Oyster Seed Ground Development Account monies could be used to construct cultch plants, but such would be no more than \$1 million annually. Artificial Reef Fund monies could be used to build no-harvest, spawning stock sanctuaries which would serve oyster restoration and recreational fin-fishing at the same time, but such is very limited. It is anticipated that approximately \$1.5 million per year (\$6 million over 5 years) will be available.
2. *DWH Oil Spill Restoration*: Approximately \$26 million currently remains in the \$40 million NRDA oyster restoration fund. A plan utilizing this remaining \$26 million was recently approved and will provide some funding for cultch planting, spawning stock sanctuaries and spat-on-shell initiatives via long-term operational funds for the Michael C. Voisin Oyster Hatchery on Grand Isle.
3. *Federal Fisheries Disaster Assistance*: The funding level is currently set at \$10 million from the \$58.3 million allocated to Louisiana. These funds should be available to LDWF by late spring of 2021.
4. *CPRA Funding*: Environmental changes are occurring, both of natural causes and from man-made actions, that has impacted the productivity of oysters in traditional areas on our coast. CPRA has committed a substantial source of funds (\$17 million) from their existing monies to assist LDWF in meeting the initiatives outlined in this oyster strategic plan. Additionally, CPRA has further committed their assistance in securing future funds from

available sources such as DWH Region-wide and Wetlands, Nearshore, and Coastal Habitat funding pots. Existing CPRA monies include:

- a. \$2 million from the National Fish and Wildlife Federation (NFWF) Mid-Breton Diversion pre-monitoring monies for expansion of hydrologic monitoring (Initiative 6)
- b. \$15 million from CPRA adaptive management monies for as-needed initiatives of this strategic plan.

Additional CPRA-led funding sources that could provide for future oyster initiatives:

- c. The DWH Region-wide TIG will have approximately \$43 million available to allocate to oyster restoration projects across the Gulf. CPRA has committed to assisting LDWF with vigorously pursuing Louisiana-based oyster projects from these funding sources to assist with meeting initiatives of the oyster strategic plan.
- d. The DWH Louisiana TIG also manages an allocation for wetlands, coastal, and nearshore habitat restoration projects. CPRA will assist LDWF in obtaining up to \$30 million in the near-term from this funding source for projects that meet the initiatives of the oyster strategic plan. As allocations become available, CPRA is committed to working with LDWF to include oyster components as part of future restoration plan proposals. One such example is the Biloxi Marsh Living Shoreline Project that is designed to protect sensitive eroding marshlands, but will have additional benefits to oyster resources by providing a potential source of protected oyster broodstock.

Table 3. Funding commitments currently in place to implement initiatives of the Oyster Strategic Plan over the next five years

Funding Source	Funding Level
LDWF - Seed Ground Development Account*	\$3,000,000
LDWF - Artificial Reef Fund*	\$3,000,000
NOAA - 2019 Federal Fisheries Disaster*	\$10,000,000
DWH – Louisiana Trustee Implementation Group (TIG) Oyster Restoration*	\$26,000,000
CPRA/NFWF - Hydrologic Pre-Monitoring of Breton Sound Sediment Diversion	\$2,000,000
CPRA – Adaptive Management	\$15,000,000
Total	\$59,000,000

*funding is considered “in-hand”

Table 4. Potential future funding sources to assist with implementing the initiatives of the Oyster Strategic Plan over the next five years

Funding Source	Funding Level
DWH - Region-wide TIG Oyster Restoration and Monitoring and Adaptive Management	\$43,000,000
DWH – Louisiana TIG Wetlands, Coastal, and Nearshore Habitats	\$30,000,000
Total	\$73,000,000

Table 5. Preliminary timeline of occurrence of initiatives within the Oyster Strategic Plan¹.

<i>Initiative Number</i>	<i>Initiative Description</i>	<i>Year 1</i>	<i>Year 2</i>	<i>Year 3</i>	<i>Year 4</i>	<i>Year 5</i>
1	Traditional Cultch Planting and Water-bottom Mapping	X	X	X	X	X
2	Cultch Planting with Remotely-Set Oysters	X	X	X	X	X
3	Spawning Stock Sanctuary Network	X	X	X	X	X
4	Development of Alternative Oyster Aquaculture	X		X		X
5	Private Oyster Lease Rehabilitation (POLR) Program		X	X		
6	Expansion of Hydrologic Monitoring	X				
7	Evaluation of Leases Incapable of Oyster Production		X			
8	Cultivation and Production Requirements on Leases		X			
9	Establishment of New Public Oyster Areas		X	X		
10	MRGO Hydrologic Evaluation		X	X		
11	Bohemia Spillway Water Control Structure Evaluation		X	X	X	X
12	Research and Development	X	X	X	X	X

¹ Actual timeline will depend upon several factors, including availability of funds and when the plan is officially adopted. The Year 1 expects to begin July 1, 2021 and follow the state fiscal year.

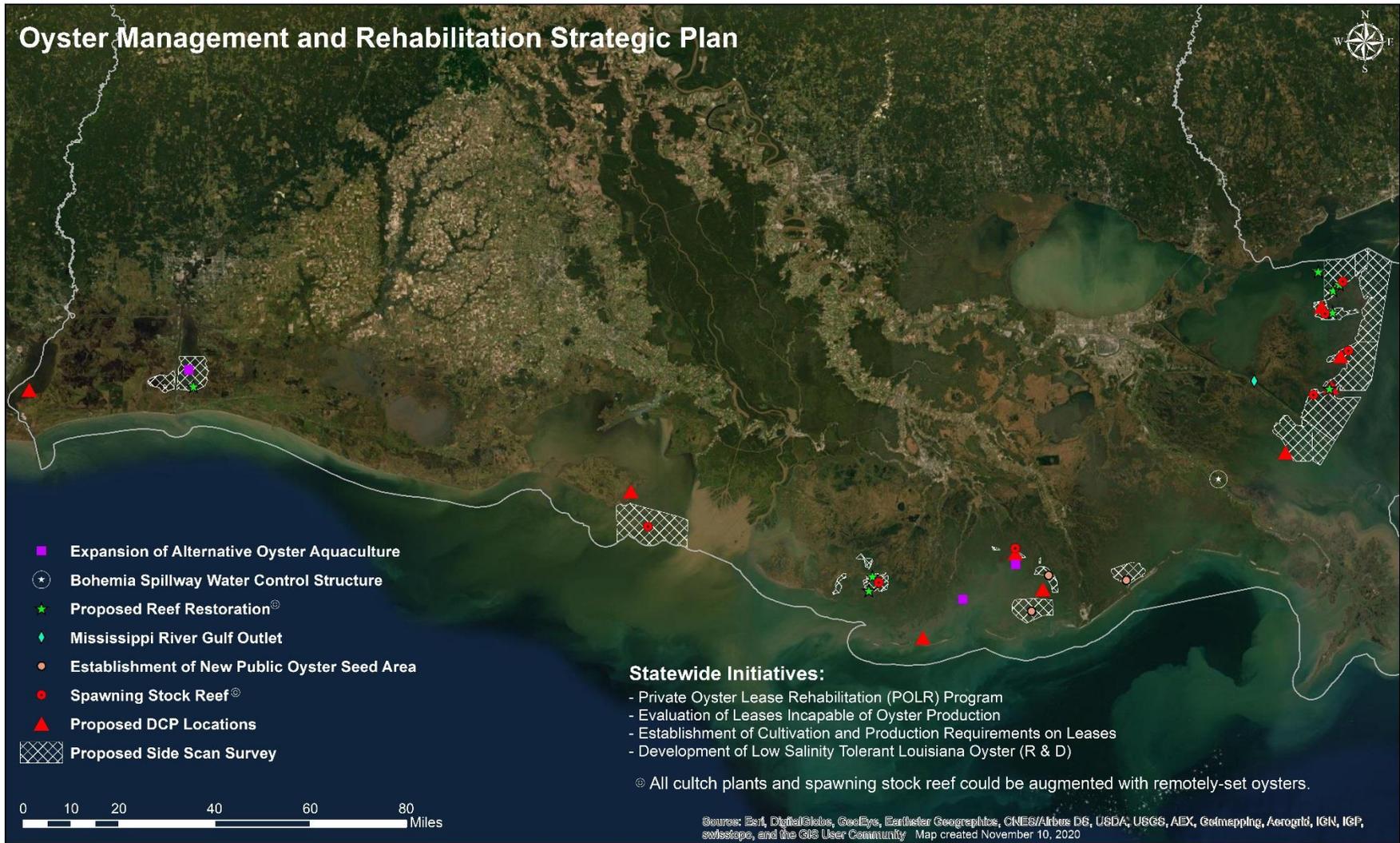


Figure 2. Map of strategic plan initiatives.

Literature Cited

Deepwater Horizon Natural Resource Damage Assessment Trustees (DWH Trustees). 2016. *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement*. Available at: <https://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan>.

_____. 2017. Strategic Framework for Oyster Restoration Activities. Available at: https://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Oyster_Strategic_Framework_06.23.17.pdf.

Louisiana Trustee Implementation Group (LA TIG). (2020). Louisiana Trustee Implementation Group Final Restoration Plan/Environmental Assessment #5: Living Coastal and Marine Resources (LCMR) - Marine Mammals and Oysters. Available at: <https://www.gulfspillrestoration.noaa.gov/sites/default/files/2020-03%20LA%20TIG%20Draft%20RP%205%20Mammals%20Oysters%20Full%20Plan%20218%20pg.pdf>

McCarthy, A.J., K. K. McFarlanda, J. Small, S.K. Allen Jr, L.V. Plough. 2020. Heritability of acute low salinity survival in the Eastern oyster (*Crassostrea virginica*). *Aquaculture* 529 (2020): 735649.

Munroe, D. M., J. M. Klinck, E. E. Hofmann, & E. N. Powell. (2014). A modeling study of metapopulation genetic connectivity in Delaware Bay oysters and the role of marine protected areas. *Aquatic Conservation*, 24, 645-666.