Oyster Restoration in the Gulf of Mexico

Proposals from The Nature Conservancy

2018

Oyster Restoration in the Gulf of Mexico

Proposals from The Nature Conservancy

2018

Robert Bendick
Director, Gulf of Mexico Program

Bryan DeAngelis
Program Coordinator and Marine Scientist, North America Region

Seth Blitch
Director of Coastal and Marine Conservation, Louisiana Chapter

The Nature Conservancy

Gulf of Mexico

Introduction and Purpose

The Nature Conservancy (TNC) has long been engaged in oyster restoration, as oysters and oyster reefs bring multiple benefits to coastal ecosystems and to the people and communities in coastal areas. Oysters constitute an important food source and provide significant direct and indirect sources of income to Gulf of Mexico coastal communities. According to the *Strategic Framework for Oyster Restoration Activities* drafted by the Region-wide Trustee Implementation Group for the Deepwater Horizon oil spill (June 2017), oyster reefs not only supply oysters for market but also (1) serve as habitat for a diversity of marine organisms, from small invertebrates to large, recreationally and commercially important species; (2) provide structural integrity that reduces shoreline erosion, and (3) improve water quality and help recycle nutrients by filtering large quantities of water. The vast numbers of oysters historically present in the Gulf played a key role in the health of the overall ecosystem. The dramatic decline of oysters, estimated at 50–85% from historic levels throughout the Gulf (Beck et al., 2010), has damaged the stability and productivity of the Gulf's estuaries and harmed coastal economies. Despite remedial efforts to stem the loss, the decline now seems to be accelerating, and oyster harvests are being further curtailed across the region.

The final *Programmatic Damage Assessment and Restoration Plan* for the Deepwater Horizon oil spill estimates that between 4 and 8.3 billion adult sub-tidal oysters died as a result of the spill. According to this document, the loss of such a substantial number of adults means that subsequent spawning years may have resulted in fewer larvae, representing a substantial loss for the already-stressed oyster resources in the Gulf of Mexico.

This paper builds on the *Strategic Framework for Oyster Restoration Activities*, cited above, and presents outcomes from an internal TNC workshop in December 2017 and the strategy on comprehensive, integrated oyster planning that resulted from that workshop. We offer recommendations from TNC on the restoration and management of oysters in the Gulf. We do not expect these recommendations to be adopted all at once, nor do we expect that TNC will be the implementer of most of these proposals. They are intended to stimulate discussion and a variety of actions by the many stakeholders involved in oyster restoration, harvest, research and management. We understand that they are consistent with or complementary to other oyster restoration initiatives being implemented in the Gulf.

Background

The loss of oyster resources associated with the Deepwater Horizon (DWH) spill only compounds existing challenges to maintaining long-term, viable oyster populations in the Gulf. Changes in freshwater flows to the Gulf's estuaries (from both droughts and floods), sedimentation from increasingly frequent storms, inconsistent replacement of cultch and heavy fishing pressure are principal factors that are hindering the recovery of oysters, and there are other conditions affecting oyster stocks and oyster management in the Gulf States.

The following is a brief review of the conditions of oyster resources in each state. These examples are not meant to disparage the oyster fishery or point to a lack of management or failure of restoration projects, but to illustrate the challenge of maintaining and growing the Gulf's oyster resources for all stakeholders and interests.

While additional effort is needed to restore and manage oyster resources around the Gulf of Mexico, the good news is that in many estuarine locations, water quality and larval supply are adequate for restoration, recovery and resilience. The Gulf of Mexico, in spite of recent and legacy problems with oyster stocks, continues to produce more oysters than anywhere else in the country; as a result, there is political and public support for efforts to restore oysters and sustain the culture of coastal communities.

TEXAS

In Texas, municipal and agricultural withdrawals have led to diminished freshwater inputs from rivers and to increases in salinity in estuarine and coastal areas that have traditionally supported oyster populations. Bays like Galveston, Matagorda and San Antonio see diminished freshwater inflow. The result has been a decrease in oyster populations and some migration of oysters up these systems to areas with more suitable salinity regimes. At some fishing grounds, oyster fishermen have requested lower daily sack limits from the managing agency, Texas Parks and Wildlife, because of fears that these areas will be fished out and to spread out the harvest season to secure more stable pricing. In other areas, intense harvesting pressure is further reducing remaining stocks. The early closure of Copano Bay to harvesting in the spring of 2018 is a result of these pressures. Alternating droughts and floods have also taken their toll on oyster populations.

However, oyster restoration is succeeding in some areas of the Texas coastline. In

© ERIKA NORTEMANN / THE NATURE CONSERVANCY

Matagorda Bay, TNC, in partnership with Texas Parks and Wildlife, the Texas General Land Office, the U.S. Fish and Wildlife Service, the National Fish and Wildlife Foundation and the U.S. Army Corps of Engineers, re-constructed a portion of the historic Half Moon Reef using limestone rock and recycled concrete as a substrate. This 54-acre site rapidly repopulated with oysters which have grown quickly to perform many of the functions of a natural reef, including providing habitat for a wide variety of other marine life. The development and performance of the reef has been carefully documented, including its extensive use for sportfishing and the economic benefits of that use. To monitor its growth and development, Texas Parks and Wildlife designated Half Moon Reef as an oyster sanctuary. Oyster harvesting is prohibited at this site until at least 2019

In addition to oyster reef restoration, TNC is working with others to protect freshwater river flows that are critical to the health of bays by purchasing water rights. The initial project, located in Matagorda Bay, will ensure that 80% of the total flows in the Tres Palacios River, a major source of freshwater in Matagorda Bay, are maintained. The project proposes to purchase private surface water rights, amend those rights to include instream flows as a beneficial use, and conserve them in perpetuity for the benefit of 31 species affected by the DWH oil spill. Such strategies might be replicated in other places.

LOUISIANA

In Louisiana, where most of the oil spill's damage to oysters occurred, the strong demand for oysters has put pressure on remaining oyster resources. In recent years, nearly 97% of the commercial harvest of oysters has come from private leases. However, leased areas are less than one-fourth of the coverage of public seed grounds. These public seed grounds often have cultch materials planted on them by the Louisiana Department of Wildlife and Fisheries (LDWF), and private lease holders legally collect that cultch and place it on their own leases. Most of the cultch material used in the state is either limestone or crushed concrete. Oyster shells themselves are in short supply, as they are shipped out of state with the half-shell market, become part of other supply chains (e.g., chicken feed supplement), or are discarded in landfills, although some efforts are being made to recycle shells.

In 2004, oyster reefs in Calcasieu Lake began to be harvested by dredging instead of the traditional tonging, which had been practiced for years. Not long thereafter, landings began to decline in the lake. Some areas that were harvested have been slow to recover, likely due in part to an increase in salinity caused by a reduction in reef height, the deepening of a nearby ship channel and possibly changes in freshwater inflows. As recently as the fall of 2016, LDWF recommended closure of the lake to allow oysters to recover, but LDWF commissioners did not authorize the closure, stating that those dependent on oyster harvesting in the lake would suffer economically. Passage of new legislation in 2017 reestablished the harvest of oysters in Calcasieu Lake as a tonging-only enterprise.


© BRIDGET BESAW / THE NATURE CONSERVANCY

Reductions in harvest elsewhere in the state have focused attention on the large natural reef in Sabine

Lake, which has not been harvested since 1966. Roughly two-thirds of that reef lies in Louisiana, with the remainder in Texas. It is likely the largest natural reef in the state, and possibly the Gulf, containing an estimated one million sacks of harvestable oysters. The water quality issues that closed the reef in 1966 have been remedied, and there is understandable interest in opening it to harvest. However, rigorous modeling initiated by the Louisiana Coastal Protection and Restoration Authority indicated that a degradation in reef height would increase salinity both over the reef and in the adjacent salt marsh. Permanent increases in salinity often increase oyster mortality from predation and disease, and can cause plant communities to decline, which is a pathway to erosion and land loss. In addition, Texas permanently closed its part of the Sabine Reef to harvest, citing its value as a fish habitat and to the sport fishery in Texas. In light of these factors, the Louisiana Legislature has passed a bill declaring the Sabine Reef a marine protected area. This is an important step in recognizing the multiple benefits of oyster reefs.

Finally, some oyster lease holders have concerns about the state's plan to reconnect the Mississippi River to coastal wetlands to reintroduce the supply of sediment and freshwater necessary to keep marshes healthy and slow Louisiana's rapid coastal land loss. Reconnection of the river will likely result in the waters of some leases becoming too fresh for oyster growth and survival and/or in some leases becoming covered in sediment. Options are being explored to offset these potential losses.

MISSISSIPPI

Roughly 13 years ago, Mississippi was harvesting about 500,000 sacks of oysters annually, but recent harvests have been closer to 10,000 sacks. This dramatic decline prompted Governor Bryant to assemble an oyster council, which produced a report on the restoration and resiliency of oysters in the Mississippi River. One of the defining and laudable goals of this report is to strive for an annual harvest of one million sacks of oysters by 2025. As was the case in Louisiana, recently there was some recovery of oyster resources, and the managing state agency, Mississippi Department of Marine Fisheries (DMR), recommended allowing stocks to continue to recover. This recommendation was overturned by DMR commissioners in response to the current economic needs of the oyster fishery. There was a recent effort by the DMR to establish an area for off-bottom aquaculture near Pass Christian to help boost production and take pressure off wild stocks. Off-bottom techniques involve growing oysters on a string or in a cage that is suspended over the bay bottom so that the oysters are not accessible to predators. This effort was halted by adjacent residents, who expressed concerns that such an activity would present an eyesore. However, DMR is working actively to establish off-bottom oyster culture as a significant component of increasing oyster production and reducing pressure on wild stocks as they rebuild.

ALABAMA

A decade ago, Alabama had oyster landings of just under one million pounds annually, but recent harvests have declined exponentially to less than 100,000 pounds annually. The earliest record of oyster landings was in 1880, and landings peaked at over two million pounds during the 1950s. Landings have fluctuated from year to year but have generally declined from the 1950s to the present. Currently, Alabama reefs are in recovery from physical damage and the effects of silting caused by Hurricanes Ivan (2004) and Katrina (2005), as well as intermittent drought conditions since 2005 that created ideal conditions for the proliferation of the oyster drill, a natural predator of oysters. The current level and length of decline of Alabama oyster resources is unprecedented since the recorded history of the fishery and has provoked an equally unprecedented response by state fisheries managers.

The Alabama Department of Conservation and Natural Resources, Marine Resources Division, has recently executed extensive reef restoration projects, including cultch planting and oyster relaying. Along with these projects, recent changes in legislation regarding oyster management have given this agency the ability to effectively and accurately monitor oyster harvest through the establishment of Oyster Management Stations.

In addition to commercial reefs, Alabama is beginning to produce a steady number of oysters through off-bottom aquaculture, commanding prices for the boutique oysters of $0.50–$3.00 per oyster.

Oyster reef restoration has occurred primarily in intertidal areas along shorelines that experience enhanced erosion. Several methodologies for intertidal reef construction have been employed and are

being monitored to determine what works best where and what benefits each approach offers. In addition to nearshore reef breakwater restoration projects, Alabama is working to have living shorelines become a more standard practice, especially along the major tributaries, since ~80% of the shoreline in coastal Alabama is privately owned. These living shorelines target marsh restoration more than oysters; however, oysters may settle and grow on the structural components.

FLORIDA

Historically, 90% of Florida's commercial oyster production has come from the natural oyster reefs in Apalachicola Bay. Oysters in this bay rely on variable freshwater flows from the Apalachicola River. Alternating periods of flood and drought allow for rapid oyster growth. The Apalachicola River is created by the convergence of the Flint and Chattahoochee Rivers, collectively called the ACF. The "ACF Basin" is nearly 19,800 square miles, and 88% of it is in Georgia. Municipal use of water by Atlanta, agricultural withdrawals in southwest Georgia and water resource management by the U.S. Army Corps of Engineers have, for decades, influenced water supply to Apalachicola Bay and the productivity of oysters. A severe drought in the ACF Basin in 2011–2012 precipitated a collapse of oyster resources in the bay. Oysters in this bay had adapted to extended periods of drought and flood, but for many reasons (chiefly, the loss of substrate and parent material, and cessation of a shelling program), they did not rebound well once the drought subsided.

The Suwannee River estuary has been similarly affected by reductions in freshwater flows, and the linear reefs at the mouth of the river and along the shorelines have declined in extent and condition. An oyster aquaculture industry has begun in the Cedar Key area, where hard clams have been grown for many years. Oyster harvesting occurs in other Florida estuaries, such as the Pensacola Bay system, although not at the scale of Apalachicola. Oyster aquaculture is also a growing industry, but it is limited by the number of designated aquaculture lease zones and other factors, including costs to start up and maintain the leases

There is substantial interest in oyster restoration throughout Florida, and various entities are developing and implementing projects in Florida's Gulf estuaries to restore oyster habitat, both for ecological and economic benefits. In October 2016, the State's Florida Department of Agriculture and Consumer Services completed a project in East Bay with DWH funding, restoring cultch material to several reef areas that are open for harvesting. Additional oyster restoration includes projects conducted by the Florida Department of Environmental Protection and Florida Fish and Wildlife Conservation Commission in the panhandle, and non-governmental entities, such as University of Florida in the Cedar Key area and Sanibel-Captiva Conservation Foundation in Charlotte Harbor.

Goal for Oyster Restoration

After discussion with many stakeholders, TNC proposes that the overall goal for oyster restoration in the Gulf should be the following:

> To restore oyster populations in all five Gulf states to enable a robust, viable oyster fishery to exist with the simultaneous recovery of oysters as a functional, self-sustaining habitat. We believe these goals are causally linked and that having both healthy oyster habitat and a prosperous oyster fishery is not an "either/or" scenario. Various forms of oyster aquaculture can and should supplement the production of wild oysters for the seafood market.

This overall goal encompasses the sub-goals set out in the Strategic Framework for Oyster Restoration Activities produced by the Region-wide Trustee Implementation Group for the Deepwater Horizon oil spill:

- Restore oyster abundance and spawning stock to support a regional oyster larvae pool sufficient for healthy recruitment levels to subtidal and nearshore oyster reefs.

- Restore resilience to oyster populations that are supported by productive larval source reefs and sufficient substrate in larval sink areas to sustain reefs over time.
- Restore a diversity of oyster reef habitats that provide ecological functions for estuarine-dependent fish species, vegetated shoreline and marsh habitats, and nearshore benthic communities.

To be clear, these goals should be achieved in addition to maintaining a viable and sustainable harvest of oysters for sale and consumption.

Within this context, TNC believes that it is possible to set oyster restoration goals for specific bays and estuaries based on the desired levels of oyster production and ecosystem services for those locations. This means calculating the actual quantity of oysters needed to make a difference in a bay/estuary over time and designing restoration and management strategies to achieve that goal.

Strategies to Achieve These Goals

What follows is a set of specific options/strategies that can aid in the recovery of oyster resources across the Gulf. We understand that there is overlap with the strategies set out in the *Strategic Framework for Oyster Restoration Activities*, but we arrived at our proposals independently. These are not meant to be viewed as "either/or" choices, but rather considered in an integrated manner to meet the specific needs of a particular geography and the goals of the various stakeholders in those geographies. Each of the Gulf states manages its oyster resources independently; thus, each state should select the combination of strategies that works best for its physical, social, economic and environmental needs. TNC believes that the states and all stakeholders will benefit from the collaboration of sharing ideas and experiences, research and the results of restoration projects within each state and across the Gulf region. Restored oyster reefs across the Gulf will both compensate for the losses of oysters from the Deepwater Horizon spill and contribute to the overall recovery of the Gulf ecosystem from years of decline.

A long-term objective is to manage the Gulf's oyster resources using a coordinated approach that delivers the ecosystem functions and services needed to sustain healthy reef habitats and economically sustainable oyster fisheries.

COMPREHENSIVE OYSTER PLANNING

The Deepwater Horizon Spill settlement included about $160,000,000 in Natural Resource Damage Assessment (NRDA) funding for oyster restoration. It is unlikely that there will ever again be so much money available for the express purpose of restoring oysters in the Gulf of Mexico. Planning for the expenditure of these funds is, obviously, critical to the success of oyster restoration. *The Strategic Framework for Oyster Restoration Activities* prepared by the Region-wide Trustee Implementation Group is a sound document that proposes strategies and actions consistent with TNC's perspective on oyster restoration. It should be considered a foundation for further oyster restoration planning.

Planning for the expenditure of NRDA oyster restoration funds, however, should be closely coordinated with planning for other elements of Gulf restoration. Toward this end, TNC endorses the decision of the RESTORE Council, the Gulfwide restoration organization established by the RESTORE Act following the Deepwater Horizon oil spill, to use a watershed approach to Gulf restoration planning. We agree that it is effective to identify priority watersheds, to assess the major problems in those watersheds or the threats to ecological health that they face, and to apply resources from the various DWH and other funding sources to address those threats in a coordinated way.

Oyster management planning is a multi-stakeholder activity that would create spatial plans *at appropriate and meaningful scales for implementation* and overlay several layers of available information, when and where the information is available. These integrated spatial plans can then inform discussions and trade-off analyses around how much area is available for restoration, where it is located, how much habitat is available for harvest, how the resources can be managed to maximize both harvest and ecological services and how restoration can be used to enhance oyster fisheries.

The appropriate scale to implement these plans will change depending on the location, but will have the following aspects in common: 1) it will be meaningful to the community and resonate with how the community views and uses its ecosystem; 2) it will be discrete enough to establish meaningful, but still realistic, goals and objectives; and 3) it will use a geographic scale that best represents oyster standing stock biomass to facilitate improved oyster harvest management.

Pilot locations for this type of planning should be chosen because they best meet the data and informational needs required to build a case-study example, while having the best potential for meaningful uptake by resource managers and industry. Possible other considerations include existing or planned ecosystem service science or fisheries projects and the presence or absence of existing state, regional or estuary oyster goals.

The categories below represent the types of information and data that can be utilized to create an oyster plan. It is highly unlikely that all this information will be available for every location. Plans can be modified on the basis of available data for the geographic region.

Information and data needs

- Data on existing oyster demographics (location, abundance, size frequency, density, mortality rates, etc.)
- Data pertinent to defining a 'stock,' as managed by the local resource agency (genetics, larval transport/hydrodynamics, etc.)
- Scientific evidence to predict ecosystem service values per areas of oyster habitat (e.g., water filtration, fish production, shoreline stabilized, denitrification rates)
- Habitat Suitability Index for the bay in question – how much area is available for more oysters (harvest, non-harvest and sanctuary areas)

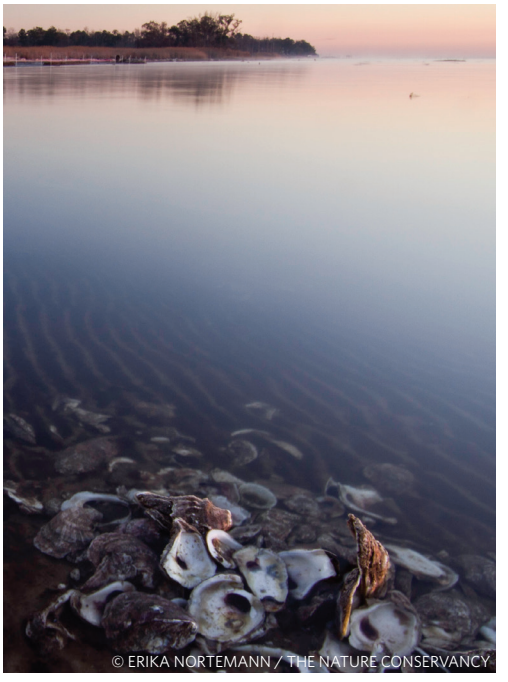
- Mapped management areas (e.g., changes to amount of areas that are open to fishing or restoration due to water quality closures, establishment of sanctuaries)
- Hydrodynamic models that exist for the area
- Harvest/extraction information (mapped harvest areas, harvest rate, effort and locations)

- Management considerations and potential for plan adoption
  - Is the community particularly supportive of restoration and recovery of oyster resources?
  - Are there existing relationships with resource managers?
  - Are there existing relationships with industry and community leaders?
  - Is there any indication that managers and/or industry could potentially have an appetite for this work, and thus would serve as strong partners and voices of support?
  - Are there sufficient staff resources to help carry out this work, as well as help or initiate changes in state policy (biologists, communications, government relations)?
  - What are the trends/shifts in the current management paradigm that managers need to be aware of?
    - For example, what strategies are currently being employed or were abandoned in the past (and why)?
    - Are public grounds/commons seeing changes in production and why?
    - Have there been changes in the ratio of public grounds to leased areas, changes in ability to implement aquaculture, or designation and/or maintenance of "sanctuary" or no-take areas?

These planning techniques for the restoration and management of oysters can be applied at the watershed, state and Gulfwide levels. TNC believes that planning at each of these levels is useful.

WATERSHED PLANNING

There are communities of interest around oysters in multiple bays and watersheds around the Gulf. We believe that the stakeholders in these areas (the oyster industry, relevant state agencies, universities, nonprofit organizations and local municipalities) can and should join together to develop plans to reverse the decline of oysters in their bay or estuary. TNC has been working closely with many leading Gulf scientists to develop the science to set oyster restoration and management goals on the basis of desired levels of ecosystem and oyster production results. This means establishing restoration goals for harvest and ecosystem services and adopting restoration and management actions to achieve those goals. In a number of Gulf watersheds, such as Mobile Bay, programs belonging to the National Estuary Program have already done much of this planning. In this context, oyster restoration priorities should be identified to work in concert with other restoration investments.


© ERIKA NORTEMANN / THE NATURE CONSERVANCY

STATE-LEVEL PLANNING

The Gulf states, which are, of course legally responsible for the management of their oysters, have recognized the continuing decline of wild oyster reefs and are taking steps to address this problem. Mississippi, for example, not only has developed a plan for restoration and resiliency but is looking for ways to improve the health of the Mississippi Sound by generating opportunities for off-bottom aquaculture. This will both reduce harvest pressure on wild stocks and allow commercial production to increase through oyster farming. Alabama continues to have one of the most developed off-bottom aquaculture industries, but Florida is beginning to view it as an option as well, and Louisiana will soon offer additional lease areas. Spat-on-shell techniques (growing oyster larvae and attaching them to cultch material) are also increasingly used to stimulate cultch plants in harvested areas, and are being explored as a means to accelerate the restoration of reef construction projects. In Louisiana, TNC is working with local, state and federal partners to create an integrated plan for oyster resources that is specific to Calcasieu Lake. The initial draft of this plan is nearly complete, and all parties have agreed to a "charter for collaboration."

Such plans constitute important steps toward a comprehensive approach to oyster restoration, and TNC urges all Gulf states to adopt management strategies that advance the multiple goals set out earlier in this paper.

GULFWIDE PLANNING

In early 2015, a group of stakeholders representing resource managers, oyster industry and conservation/restoration interests met to discuss the creation of a platform that would allow the stakeholders to work toward their common interest in recovering oyster resources in the Gulf of Mexico. The provisional name for this effort is the Gulf of Mexico Shellfish Initiative (GoMexSI). Since that time, the Gulf States Marine Fisheries Commission funded the Mississippi–Alabama Sea Grant Consortium to gauge interest in this type of regional approach among all five Gulf states. That was done over the summer of 2017, and TNC was a partner in the effort and co-facilitated each of the meetings. Participants at these meetings represented the fishing industry, state and federal resource managers, restaurants and restoration and conservation interests. There was broad and strong support for creating a body like GoMexSI, and for all stakeholders to collaborate toward a more integrated approach to maintaining and recovering oyster resources. A full report on those meetings will be available in the summer of 2018 and an excellent summary has been published.

A draft GoMexSI charter was created using the state of Washington's successful shellfish initiative as a model. The current goals of this charter are to ensure clean and plentiful water to protect and enhance shellfish beds, sustain commercial shellfish harvests and restore oyster stocks, create a public/private partnership for shellfish aquaculture and use an ecosystem services approach to manage shellfish restoration. An inclusive, transparent, functioning body like GoMexSI is a means to not only foster regional dialogue and understanding among these interests, but also to formulate actionable ideas that can have a positive bearing on management and policy decisions around oysters. The formation of, participation in and staffing of GoMexSI is an avenue toward reconciling the simultaneous recovery of oysters as a habitat alongside their recovery as a fishery/commodity.

CONSTRUCTED REEFS

Artificially constructed reefs are designed to act as substrates upon which larval oysters can attach, grow and mature into a fully functioning reef. Nearshore reefs have a vertical structure that abates wave energy and protects adjacent shorelines from erosion. This is particularly important in Louisiana, as the state

is losing 16 square miles of coastal wetlands annually. The ultimate goal of these projects is to create the conditions in which self-maintaining oyster reefs can, to the greatest extent possible, provide the suite of ecosystem services produced by oyster reefs as a habitat. These services, which increase the resilience of coastal communities, include protecting adjacent shorelines; providing forage and refuge habitat for commercially, recreationally and ecologically important species of fish, shrimp, crabs and other reef-associated estuarine species; improving/maintaining water quality via the filtration that takes place when oysters feed; acting to slow currents between reef projects and shorelines to allow sediment to drop out of suspension and diminish; limiting or minimizing erosion; and providing larval oysters to adjacent commercial and public harvest areas to stock these areas.

Some constructed reefs are completely subtidal and are not situated immediately adjacent to shorelines. Still, these projects have many of the same benefits described above and can serve as a physical barrier to salinity where native reef habitat has been lost (Calcasieu and Sabine are good examples). TNC has been directly involved in oyster reef construction projects and we cite them as examples here, but other organizations and agencies certainly have the capacity to build reefs and have done so.

© JEROD FOSTER / THE NATURE CONSERVANCY

TNC's oyster projects in Alabama have offered a very visible opportunity to engage community volunteers in placing reef structures in the water, such as at Helen Wood Park at Dog River. Involving the community can confer a sense of stewardship to the coastal communities that stand to benefit from the restoration of oyster habitat. TNC is involved in advancing oyster habitat restoration activities in Charlotte Harbor, Florida, including development of an estuary-wide oyster habitat restoration and management plan. The Conservancy received funding from the National Fish and Wildlife Foundation Gulf Environmental Benefit Fund to design a major reef restoration project in East Bay in the Pensacola Bay system, and that design and the associated permitting are nearing completion.

Goals related to enhancing economic benefits from oyster reef restoration include improving the productivity of the commercial oyster fishery, lowering the costs of and protecting built infrastructure along adjacent shorelines, and demonstrating a restoration alternative that largely maintains itself over time, thereby reducing the costs of coastal restoration.

The long-term success of constructed reefs depends on whether they are located in areas suitable for the natural growth and reproduction of oysters, on the engineering design of the reefs, and on the management of the harvest of oysters from such reefs. In some cases, these reconstructed reefs should have no or very limited harvests if they are to fulfill the role of spawning reserves proposed in the Strategic Framework for Oyster Restoration Activities. This role might be enhanced by constructing adjacent harvestable reefs that

are designed to allow controlled sustainable harvests.

Long-term, scientific monitoring is critical to determining the relative success of constructed reef projects. Monitoring should examine the biological success (or lack of it) of the reef, the ecosystem service impacts, and the social and economic impacts of reef construction. For example, monitoring of reefs so far has shown that, generally, reef structures slow the rates of erosion along adjacent shorelines. In addition, sediment settles and builds behind these reefs, and many reef-associated species are found around the reef structures not long after they are deployed. A recent study by The Nature Conservancy and Texas Sea Grant illustrated the economic boon to communities as a result of recreational fishing provided by the successful creation and protection of a large, subtidal reef in Matagorda Bay.

AQUACULTURE

Aquaculture can be an important component of a comprehensive oyster restoration strategy. Aquaculture of oysters can provide some of the services derived from natural/reconstructed oyster reefs and, importantly, can take fishing pressure off other oyster resources by providing jobs and income for people who were involved in the oyster fishery.

Seafood industry and coastal resource managers have sponsored meetings in the Gulf region to consider the creation of large aquaculture facilities (collectively called a "megahatchery") under a Gulf Oyster Hatchery Initiative. Techniques for growing oyster larvae and attaching them to cultch material are well developed. Oyster industry representatives believe that spat-on-shell techniques will help carry commercial harvesting through periods of naturally low production, help to increase overall production levels and serve as a supplementary source of income for people in the industry.

In addition to spat-on-shell, there are also a number of off-bottom culture techniques for growing oysters on string or in suspended cages. Off-bottom techniques can grow oysters in areas with higher salinity regimes than where they normally thrive. These forms of oyster aquaculture are growing rapidly at several locations in the Gulf.

In the context of Gulf restoration, some elements of aquaculture are promising. For instance, increasing commercial oyster production via aquaculture could be one means of taking harvest pressure off some wild stocks to enable those reefs to recover. In locations where oyster aquaculture is feasible, the oyster aquaculture industry, regulatory agencies and other affected stakeholders could consider adopting a standardized lease siting approach that equally considers and integrates environmental, economic and social needs. The approach should identify optimal aquaculture locations that avoid environmental and social impacts while also maximizing ecosystem benefits and economic profitability. Aquaculture projects could be sited in areas with active oyster restoration activities so that the larvae produced would augment restoration (of course, technical issues involving the kinds of oysters that are grown may limit this benefit). An integrated, collaborative approach to siting aquaculture and restoration activities around the Gulf could help meet commercial production needs regionally and ameliorate temporary, local declines in oyster populations that occur during extended periods of drought or flood, or due to anthropogenic events like oil spills.

THE USE OF PRIVATE CAPITAL

Private capital can create opportunities to invest in conservation projects that have clear environmental benefits and that will also generate a return to investors. Attracting "impact capital" to oyster restoration in the Gulf can expand both the scope and scale of system-wide oyster recovery and leverage government funds. Discussions have centered on investors buying existing oyster leases and resourcing the planting of large areas with cultch material. Sales of oysters harvested from these reefs would, over time, create a return

on investment. The leaseholder could set the harvest conditions (season, gear type, sack limit, etc.) with the goal of maximizing ecosystem services and dockside value of the product. Leases acquired through this investment model would be managed for long-term success of oysters as a habitat, and timing and methods of harvest would be employed with that goal in mind. In areas where leases are not common, a variation on this investment model could create subtidal "nursery" sites where modular, constructed reef units would be placed until they were completely covered in mature oysters via natural recruitment. Then these units could be transferred to adjacent shorelines where they would immediately function as a mature reef/living shoreline. Investors' initial costs in establishing the nursery sites would be covered by the purchase of the mature units by public and private interests, and the return on investment would rely not on harvest, but on the valuation and possible sale of ecosystem services, such as carbon and nutrient sequestration. This application of impact capital for oyster restoration and production is promising but remains in a conceptual stage.

FRESHWATER INFLOWS

The best restoration and recovery efforts can be undone by profound changes in freshwater supply to the estuaries where oysters exist. Both too much and too little freshwater can disrupt or destroy oyster populations. There are many examples of the importance of connectivity between watersheds and of the impacts of watershed change on the coast. Projects that seek to restore and maintain the dynamic flow regimes that maintain coastal habitats and processes should be viewed as integral to the restoration and recovery of oyster resources in the Gulf of Mexico. Because oysters are critically tied to freshwater flow regimes, actions that affect river flows *upstream* should consider downstream uses of the water, including restoration. Without this linkage, oyster restoration projects may be jeopardized due to decisions made far upstream. Examples where regional cooperation on freshwater flows would benefit oysters include the ACF Basin (too little freshwater flowing into Apalachicola Bay) and parts of Mississippi Sound (too much freshwater entering the Sound).

SHELL RECYCLING

The cessation of a state-led shell recycling program in Apalachicola Bay and other watersheds may be partly responsible for the decline in oysters in those systems. Oyster shells are an important resource for rebuilding natural reefs and for some forms of oyster aquaculture, yet shells from restaurants and other users continue to be discarded and landfilled. There are successful shell recycling projects in some communities around the Gulf. Usually, these projects require a continuing source of funding to keep them going. Shell recycling is a proven tool for rebuilding oyster stocks and should be adopted more comprehensively across the Gulf.


© CARLTON WARD JR. / THE NATURE CONSERVANCY

OYSTER STOCK MANAGEMENT

A significant challenge to oyster restoration in the Gulf (and elsewhere in the country) is how to manage oyster stocks in ways that accomplish restoration at a large scale but also take into account the need to maintain harvest levels so that oystermen can make a living. Outside Louisiana (where most harvesting comes from leased bay bottoms), oyster stocks have diminished as a result of multiple causes, and

harvesting pressure has increased on the remaining reefs. This has caused wild stocks to further decline so that at many locations they are no longer self-sustaining.

Rebuilding stocks will, thus, necessitate strict harvest limitations, which are a hardship for harvesters. Each of the Gulf states must find its own solutions to this problem, but several options are possible:

- Establish a network of oyster reef spawning reserves, including constructed reefs where harvesting is prohibited or very limited. Spawning reserves might be paired with harvestable constructed reefs that are carefully managed to ensure a sustainable stock of oysters.
- Evaluate different types of harvesting gear to ensure that the equipment does not damage reefs such that they require frequent cultch placement, reduce their height and thus make them susceptible to prolonged higher salinities, or increase their likelihood of becoming buried by sediment.
- Develop more comprehensive monitoring of reefs, with an eye to promoting long-term viability through a rotational harvesting schedule.
- Permit additional bottom and water column leasing to enhance production.
- Use funding for restoration to pay oyster harvesters for restoration work as an alternative to harvesting as stocks rebuild. Involve harvesters in shelling and relaying efforts and other activities that maintain and grow oyster resources. Essentially, develop a broader portfolio of income-generating opportunities for watermen (and women) that allow them to retain their sense of place, support working waterfronts, and expand the stewardship of the resource.
- Create dedicated shelling programs in each state (for each harvested estuary) to eliminate substrate deficits and reduce the need to mine rock in other states for cultch material.

In each case, management measures must be developed cooperatively with industry interests to ensure fairness and practicality.

MONITORING AND ADAPTIVE MANAGEMENT

Oyster restoration is not an exact science. It takes place in a dynamic environment where rainfall patterns and events, storms, oyster diseases and harvesting pressures can have a profound impact on success. Given this, oyster restoration must be accompanied by well-designed monitoring to record successes and failures and to try to determine the timing and causes of problems in order, where possible, to adapt practices and designs to address those problems. Restoration budgets should include funds for monitoring, and oyster restoration practitioners and scientists around the Gulf should share data to develop best restoration practices.

Specific Projects That Could Use Deepwater Horizon Funds

The following projects, when considered collectively, seek to recover oyster habitats and their constituent ecosystem services and improve the conditions and productivity of oyster fisheries and fishermen impacted by the spill. Those goals are not completely captured in any individual project, but they are designed to complement both habitat and fishery outcomes. Also, beyond the environmental, ecological and economic goals of these projects, recovery of oyster resources can help maintain a sense of place and well-being in coastal communities, which is another facet of recovery. While TNC is involved in some of the projects listed here, our primary purpose is to recommend practical and strategic oyster restoration projects regardless of the sponsor.

TEXAS

- Expand the Galveston Bay oyster reef restoration project. TNC, in cooperation with the Texas Parks and Wildlife Department, and Galveston Bay Foundation, proposed to build a 40-acre oyster reef in Galveston Bay. The project is funded through the National Fish and Wildlife Foundation's (NFWF) Gulf Environmental Benefit Fund. Construction is expected to occur in 2019. The project will include a 15-acre three-dimensional habitat reef, as well as several smaller satellite reefs to assess how the larger reef contributes to the distribution of larval oysters in the area. This project could readily be expanded.

- Expand Copano Bay oyster reef restoration by constructing a 42-acre oyster reef in Copano Bay. This project is being funded by the Texas NRDA Trustees using mitigation funds from the ASARCO Settlement, and construction is expected to begin in fall 2018. As in the case of Galveston Bay, this project could be further expanded.
- Expand the Half Moon Reef oyster restoration project in Matagorda Bay. Long-term monitoring continues on the 54-acre Half Moon Reef project, which was completed in 2014. Oyster colonization and growth has been outstanding, and many benthic and aquatic species are using the reef. Half Moon Reef has received a great deal of press coverage concerning the recreational and economic benefits it has generated. An additional reef can be constructed at this same location. This reef expansion project will likely increase the success of the existing structure and would continue to offset damages from the DWH spill.
- Restore freshwater inflows in the Guadalupe and San Antonio River basins. Ensuring healthy freshwater inflows to Gulf bays and estuaries may be accomplished through market and regulatory means. With other conservation partners, the Texas Chapter of TNC is undertaking an assessment for a water-market approach for freshwater flows. This can lead to a proof-of-concept water transaction that will benefit a Texas bay and set the stage for future transactions. This should also include a pilot project to purchase and protect 40,000 acre-feet of water for environmental flows in Texas' Colorado, Rio Grande, Upper Brazos and Lower Guadalupe basins. With partners, the Texas Chapter of TNC is also exploring the development and use of new water technologies, such as aquifer storage and recovery and desalination, to protect needed flows to bays and estuaries, which in many cases support oyster populations.
- Restore the Oliver Point reef. This reef is located at the terminus of Oliver Point, at the confluence of Tres Palacios and West Matagorda bays, and extends toward the Palacios Channel. The reef was a popular recreational fishing destination and supported a healthy population of oysters and a diverse finfish assemblage. Prior to 2003, the crown of Oliver Point reef was exposed at low tide and shoaled in many places during high tide, with water depths ≤ 1 foot at the apex of the reef structure. Following Hurricane Claudette in 2003, Texas Parks and Wildlife Coastal Fisheries staff observed substantially increased water depth (~ 3–4 feet) over the entire fetch of the oyster reef. This project would restore the height and size of the reef to pre-hurricane conditions, with the goals of recovering oyster resources and the recreational fishing that was associated with the reef.

LOUISIANA

- Build large constructed, intertidal reef projects in St. Bernard Parish. This work would be consistent with Louisiana's Master Plan. The coast here suffers from extreme land loss, which fringing reefs will abate.
- Establish large, subtidal reefs in the closed (northern) portion of Calcasieu Lake. Based on the example from Matagorda Bay, these reefs can generate local income by providing recreational fishing. A reasonable percentage of these reefs could also serve as a source of oysters to be relayed to public seed grounds to supplement the harvest there. Relaying would provide a job to those in the industry during the off season or when the harvest is closed for other reasons.
- In Calcasieu Lake, establish an intertidal reef around much of Rabbit Island to protect it. Rabbit Island is a largely vegetated, roughly 220-acre island in the southwest corner of Calcasieu Lake that has served as an important Brown Pelican nesting area for years. The island has a very low profile and is being lost to wave energy and increasing sea level. The long-term viability of the island could be bolstered by

introducing new sediment to areas that are being lost, and protecting its perimeter by encouraging the growth of oysters, which are already found in the area. The island is also a nesting site for Royal Terns and is heavily used by Great Egrets, Snowy Egrets and other terns and waders.

- Continue programs that recover oyster shells instead of losing them to landfills, cure them and return them to public seed grounds. In Louisiana, most of the material used to cultch these grounds is limestone and concrete. The state has worked to establish a shell budget, but does not possess the shells to realize it. This effort would continue work being done to collect shells from high-volume restaurants, cure them at LDWF facilities, and make them available as material for restoration projects, as was recently done in St. Bernard Parish on a joint Coalition to Restore Coastal Louisiana/TNC project.
- Protect freshwater flows in important oyster areas. Two of the state's larger public seed grounds are in Sabine Lake and Calcasieu Lake, both of which are heavily influenced by the amount of freshwater entering each system. Much of the freshwater supply in Sabine Lake is determined by releases from the U.S. Army Corps of Engineers–managed Toledo Bend Reservoir, and industrial and municipal use in the Calcasieu watershed affect that lake. As mentioned, the Sabine reef is special in the Gulf, and understanding how changes in freshwater quantity and quality could impact the long-term health of the reef and adjacent coastline can translate into strengthened coastal resilience. Similarly, the potential for oyster restoration and recovery at Calcasieu Lake is strong, but predicted changes in increased freshwater use could diminish those efforts. In both cases, NRDA funds could be employed to develop effective water science and decision-support tools that address the linkage between river flow and the health of oyster resources, so that these uses are considered when reviewing any future proposals to transfer water out of the Sabine and Calcasieu river systems. In addition to monitoring and modelling, community engagement would be a component of this effort on the front end and throughout the process.

MISSISSIPPI

- Expand subtidal reefs in Mississippi bays. Subtidal oyster reef cultch projects have been successful in building three-dimensional reefs that support local sport fish and produce brood stock supporting commercial shellfish areas in the Bay of St. Louis. Since oysters from closed waters cannot be consumed, this offers an opportunity to measure and test the effectiveness of various resource management techniques that can be applied to commercial harvest reefs. We recommend expansion of existing non-harvest reefs for this purpose in areas with suitable substrate.
- Expand subtidal oyster reefs in Back Bay of Biloxi and Biloxi Bay to restore historic ecosystem services. Restoration activities should be limited to a "best estimate" of the historic oyster footprint utilizing documented sources. Ecosystem functions that should be targeted for reestablishment include, but are not limited to, water filtration capacity, creation of wildlife and sportfish habitat, and bloodstock production.
- Utilize and expand intertidal oyster reefs in conjunction with the beneficial use of dredged material Successful examples have been implemented on Deer Island and can be used in places such as Round Island. These techniques can help increase the habitat value of these projects and create foraging areas for birds and fish.
- Create and establish stock and reproductive reserves or "banks" to ensure that enough wild brood stock is produced to support commercial harvest targets. Broodstock "banks" should be located in areas where water transport would disperse larval oysters to harvest areas.

ALABAMA

- Utilize and expand intertidal oyster reefs in conjunction with the Beneficial Use of Dredge Material Program. This has been done successfully at Little Bay, is underway at Marsh Island, and can be used in places such as Grand Bay. The use of dredged materials to make reefs can help increase habitat value and create foraging areas for birds and fish.
- Expand shell recycling. The recently initiated Oyster Shell Recycling and Restoration Program funded through NFWF Gulf Coast Conservation Grants Program to the Alabama Coastal Foundation should be expanded to include more areas.
- Complete evaluation of oyster restoration/living shoreline projects. TNC and partners are currently synthesizing monitoring data from multiple sites across the state to determine what approaches have worked best where and how they have affected ecosystem services. This synthesis will be used to help inform future restoration and also to identify critical monitoring parameters to ensure that project success can be tracked and compared over the long term. While information from Alabama projects will be beneficial, a larger synthesis should be completed that includes projects from across the Gulf.
- Evaluate larval settlement of oysters. The Marine Resources Division of the Alabama Department of Conservation and Natural Resources Department of Marine Resources, Dauphin Island Sea Lab, TNC and other partners are interested in reexamining larval oyster settlement due to recent declines. It is important to examine settlement at restoration sites, on commercial reefs and in non-harvest areas. This information will be coupled with DMR's ongoing Real Time Monitoring of Hydrological Data, funded by the NFWF Fisheries and Ecosystem Monitoring Program, which is monitoring changes in oxygen levels on oyster reefs as a result of sea-level rise.
- Assess ocean acidification impacts on oysters. The Alabama Department of Conservation and Natural Resources' Marine Resources Division, The Dauphin Island Sea Lab, TNC and other partners are

interested in monitoring ocean acidification and its effects on oyster growth. Changes in pH and alkalinity are of interest because they can affect oyster settlement, growth and survival. Studies have shown that under low-pH conditions, larval oysters use excessive amounts of energy to grow and maintain their shells, leaving them with essentially no resources for substrate selection and settlement (Waldbusser et al., 2011a).

- Evaluate the values produced by restored oyster reefs. Alabama Marine Resources Division, Dauphin Island Sea Lab, Auburn University, TNC and other partners are interested in studying ecosystem services and valuation of those services for protected/restored reefs vs. commercial reefs vs. aquaculture. All such services provide some benefits to the environment, the economy and communities. A study to establish these values will show the benefits for each oyster resource, as well as differentiating the additional or higher level of services derived from protected and/or restored reefs.

FLORIDA

- Fund the Pensacola East Bay oyster habitat restoration project. TNC is designing a restoration project for oyster reef habitat in East Bay, Santa Rosa County, which is part of the greater Pensacola Bay system, funded by the NFWF Gulf Environmental Benefit Fund. Commercially harvested oyster reefs adjacent to the TNC project were recently restored/clutched by the state of Florida, with Deepwater Horizon funding. These two restoration projects are designed to achieve different objectives—restoration for habitat improvement and restoration for fisheries—but are complementary to each other. Funding is needed for construction and post-restoration monitoring of the East Bay reef project once the design is completed and permitted.

- Construct multiple oyster restoration projects in Charlotte Harbor. A pilot project to test different oyster restoration methods has been deployed and is being monitored. The best method(s) will be used to construct a multi-site, large-scale reef restoration project (20+ acres) proposed for RESTORE funding and identified in the Southwest Florida Regional Ecosystem Restoration Plan that was adopted by the Tampa, Sarasota and Charlotte Harbor National Estuary Programs.
- Plan and construct oyster habitat restoration in other bays and estuaries proposed by multiple partners.
- Enable expansion of oyster aquaculture. Establish off-bottom aquaculture sites in areas that have diminished oyster populations, such as St. Andrews Bay, Pensacola East Bay and Escambia Bay. These are also areas where constructed reefs would aid in shoreline protection and habitat restoration and could be coupled with aquaculture. Funds could be used to establish lease areas and provide eventual lease holders with the training and materials required to begin an off-bottom aquaculture operation.
- Reduce sedimentation along the Yellow River in northwest Florida and other rivers that have sedimentation issues affecting Gulf estuaries. Reducing sediment loads from rivers by repairing unpaved roads, crossings and ditches will help improve the quality of water entering the Pensacola East Bay system and other estuaries, which will enhance oyster habitat recovery. This project will also aid in Gulf sturgeon restoration.
- Complete oyster reef mapping. This work is underway in the Apalachicola Bay system, where TNC has mapped the intertidal reefs, while the state is mapping the subtidal reefs. TNC has also conducted preliminary mapping of subtidal reefs in Pensacola East Bay and will continue the mapping with Santa Rosa County RESTORE funding. Mapping of oyster reefs in the Charlotte Harbor estuary is planned

as part of the large-scale project mentioned above. Partners have completed reef mapping in Sarasota County and have initiated mapping in Estero Bay. In addition, the State is coordinating data on past and existing oyster reef mapping and monitoring activities throughout the state through the Oyster Integrated Mapping and Management Program funded by the state's wildlife legacy grant program. Funding is needed to complete mapping and condition analyses of intertidal and subtidal oyster habitat mapping in some estuaries. This will establish the necessary baseline dataset to inform future restoration and management of this habitat, which has been reduced by 85% or more throughout the Gulf of Mexico.

GULF OF MEXICO

Officially establish the Gulf of Mexico Shellfish Initiative, GoMexSI, that was described above. Staff will be needed to coordinate stakeholder groups throughout the Gulf, schedule regular meetings and travel to plan, attend and facilitate them. Funding would cover those costs as well as any material costs (printing, supplies, etc.) required to keep the Initiative functioning successfully. Staff and stakeholders would work across all interests to initiate more collaborative ways of recovering oysters as both a habitat and a fishery.

Conclusion

Oyster populations have been lost from 85% of their historic global range. While there have been dramatic losses in the Gulf of Mexico, the region still leads the nation in commercial production, and the water quality conditions required to recover oysters are present in most locations. Gulf states have an opportunity to craft thoughtful, integrated restoration and recovery plans that can align the traditional use and cultural ties of the region to oyster harvesting, and to recover and maintain oysters as a habitat that coastal communities value for the multiple ecosystem benefits it provides. Such integrated plans and projects would be unique and would put the Gulf of Mexico at the forefront of oyster resource recovery worldwide.

For further information, contact:

Bob Bendick, Director, The Nature Conservancy's Gulf of Mexico Program, rbendick@tnc.org

Seth Blitch, Director of Coastal and Marine Conservation in Louisiana, The Nature Conservancy, sblitch@tnc.org


The Nature
Conservancy


Gulf of Mexico
nature.org/gulf