RESTORING GULF OYSTER REEFS

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Opportunities for Innovation

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None of the opinions or comments expressed in this study are endorsed by the companies mentioned or individuals interviewed. Errors of fact or interpretation remain exclusively with the authors. We welcome comments and suggestions.

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List of Abbreviations

BLS	Bureau of Labor and Statistics
COSEE	Centers for Oceans Sciences Education Excellence
CWPPRA	Coastal Wetlands Planning Protection and Restoration Act
DEP	Department of Environmental Protection
DMR	Mississippi Department of Marine Resources
DNR	Louisiana Department of Natural Resources
EPA	Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
NOAA	National Oceanic and Atmospheric Administration
NPCA	National Precast Concrete Association
NRDC	Natural Resources Defense Council
NSF	National Science Foundation
OBAR	Oyster Break Artificial Reef
OCPR	Office of Coastal Protection and Restoration
SBA	Small Business Association
TNC	The Nature Conservancy
TPWD	Texas Parks and Wildlife Department
USACE	United States Army Corps of Engineers

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[1] Click here to explore an online interactive map with the full list of firms identified in this report.

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I. Executive summary

The Gulf of Mexico's oyster reefs are a vital resource whose true economic value is often overlooked. In addition to providing a delicious source of food that helps define cultural cuisines, oyster reefs also benefit other industries vital to the U.S. economy. Yet several factors threaten Gulf oyster reefs, and put them at risk of being lost. Depending on the location, 50 to 89 percent of oyster reefs have disappeared in the Gulf of Mexico during the last 130 years (Beck et al., 2011). This rapid decline jeopardizes the wellbeing of several Gulf Coast industries, the infrastructure that supports them, and the residents who depend on them.

Gulf of Mexico oyster reefs – large clusters of oysters growing together – support businesses and communities on shore by providing the following four ecosystem services: First, oyster reefs increase oyster production, generating revenue for the commercial oyster industry and creating jobs in seafood processing. Second, they increase marine fisheries production, supporting more than 200,000 jobs in a $2.4 billion fishing industry (Gordon et al., 2011). Third, oysters filter excess nitrogen and other chemical pollutants from water, providing a service otherwise carried out by expensive wastewater treatment plants (Newell et al., 2005; Piehler & Smyth, 2011). Fourth, oyster reefs reduce wave energy, preventing erosion and fortifying wetlands that provide valuable flood protection against storm surge (Coen et al., 2007; Scyphers et al., 2011).

As a follow-up report to "Restoring the Gulf Coast: New Markets for Established Firms" (Lowe et al., 2011), this study examines how several approaches to restore oyster reefs fit into conventional coastal restoration strategies. Government agencies and various stakeholder groups in Gulf Coast states are developing coastal restoration plans that call for dozens of projects worth billions of dollars. Artificial oyster reefs could be used in many of these projects, and serve as a cost-effective means to incorporate an array of valuable ecosystem services.

If sufficient funds are made available to fully integrate oyster reef restoration into Gulf Coast states' restoration plans, what kinds of jobs will be created? What types of firms will be involved? Where will this job growth take place?

This study analyzes 132 firms linked to oyster reef restoration projects that are either completed or under way. The analysis examines all types of firms across six categories of the value chain: primary materials, secondary materials, planning and design, construction and deployment, transport services, and science and technology R&D.

Five Key Findings:

1. **Restoring oyster reefs provides job opportunities in the Gulf Coast and 17 other states.** Of the 445 relevant employee locations identified, 366, or 82 percent, are located in the five Gulf States of Texas, Louisiana, Alabama, Mississippi, and Florida. Additional smaller concentrations are in the Mid-Atlantic States of North Carolina, Maryland, and Virginia.

2. **Most firms are small businesses.** According to SBA guidelines on number of employees, 85 percent of the firms in our sample qualify as small businesses. Nearly half—61 of the 132—firms have fewer than 25 employees. While some larger firms take interest as projects grow in size, oyster reef restoration projects so far have been particularly important to small businesses, providing much-needed revenue in a fragile economy.

3. **Small innovative specialized firms are leading the way, but medium-size and larger firms from other industries are gaining interest and diversifying.** Until recently, the only firms involved in oyster reef restoration were newer smaller firms dedicated to innovating new ways to build reefs. However, as more coastal planners find these projects favorable and indicate they may fund more in the future, firms established in other industries—especially extractive industries, marine construction, and shipping— are gaining interest. These firms recognize oyster reef restoration as an opportunity to diversify and use existing resources to increase revenues.

4. **Oyster reef restoration creates opportunities for innovation.** Small businesses act as agents of change for the larger economy when they invent new methods to improve efficiency and effectiveness. This innovation is taking place across nearly every type of firm identified in this report, from small startups, to established construction firms, to non-profit environmental organizations.

5. **More funding for controlled research will demonstrate to coastal engineers the benefits of integrating oyster reef restoration into larger ecosystem-scale restoration efforts.** Despite anecdotal evidence from more than a decade of experience that suggests many new oyster reef restoration designs are effective, coastal management plans such as the Louisiana Master Plan include few oyster reef restoration projects. Planners say this is because coastal engineers have little empirical evidence for which designs function best and under which conditions. Coastal engineers are reluctant to use artificial oyster reef designs in coastal restoration projects until thoroughly understanding their performance. For engineers to fully understand how these designs work, agencies need to provide funding to carry out more tests. Some of the first demonstration projects are now underway, but more are needed so that engineers can confidently incorporate these structures into future coastal restoration projects.

Restoring an ecologically meaningful number of oyster reefs will require that we manage oysters for a broader array of ecosystem benefits, and less as solely a fisheries commodity. To do so will also require that significant funding be committed over decades. Incorporating innovative oyster reef designs into the Gulf Coast States' coastal restoration and land conservation planning efforts is one important step in creating a funding stream for restoration. This will not only improve the overall quality of these plans by highlighting the human benefits that accrue from reef restoration, but will also facilitate innovative growth and create jobs in small businesses.

II. Introduction

America's oyster reefs are a vital resource, the true value of which is often overlooked. In addition to providing a delicious source of food that helps define local cuisines and cultures, oyster reefs afford numerous ecological benefits that support industries essential to the U.S. economy. Oyster reefs support the nation's largest fishing industries, stabilize and protect the valuable coast, and filter water to provide clean, safe, beautiful areas for recreation and tourism (Grabowski & Peterson, 2007; Henderson & O'Neil, 2003). Unfortunately, 85 percent of the world's oyster reefs have been lost over the past 200 years (Beck et al., 2011). Today, most of the world's remaining wild capture of native oysters comes from just five eco-regions in North America. Of these, the Gulf of Mexico is by far the most productive region, yielding nearly as many oysters as the other regions combined (Beck et al., 2011). Still, several factors threaten Gulf oyster reefs, and put them at risk of being lost as well. Depending on the location, 50 to 89 percent of oyster reefs have disappeared in the Gulf of Mexico over the last 130 years (Beck et al., 2011). This rapid decline jeopardizes the wellbeing of several Gulf Coast industries, the infrastructure that supports them, and the residents who depend on them.

Oyster reefs are the temperate equivalent of coral reefs. Like coral, they are referred to as "ecosystem engineers" because they change their physical environment and build habitats for other organisms (Lenihan & Peterson, 1998). In the Gulf of Mexico, oyster reefs support businesses and communities on shore with the ecosystem services they provide (see Table 1).

Table 1. Economic and Environmental Benefits of Oyster Reefs

Type of Benefit	Significance of Economic and Environmental Benefits
Oyster Harvest	Oysters generate revenue for the commercial oyster industry and support thousands of jobs. Across the Gulf, oyster shuckers and seafood processors hold 30 to 50 percent of seafood industry-related jobs.
Marine Habitat	Oyster reefs are the "condominiums of the sea" providing nooks and crannies of habitat for dozens of marine resident species. One acre of oyster reef increases fisheries catch values by $4,200 annually. Oysters are at the foundation of a food chain that supports a $2.4 billion fishing industry and more than 200,000 jobs.
Water Filtering	Each individual oyster filters up to 1.5 gallons of water per hour, providing a service otherwise carried out by expensive wastewater treatment plants. This removes excess nitrogen that contributes to marine dead zones. Each acre of oyster reef provides $6,500 in denitrification services annually. Filtering suspended sediment allows sunlight to reach the underwater floor, and facilitates growth of marine grasses necessary to hold the wetlands in place. Clean clear water is important for recreation and tourism, an industry worth more than $20 billion in the Gulf Coast.
Shoreline Protection	Oyster reefs stabilize bottom sediments, reduce wave energy and prevent erosion. Thus, they fortify wetlands to serve as horizontal levees that provide $23 billion worth of storm protection annually to Gulf Coast businesses and communities. This protection extends to the valuable oil and gas pipeline infrastructure near shore, which ensures economic and energy security for the entire United States.

Source: (EPA, 2011; Gordon et al., 2011; Grabowski & Peterson, 2007; Grabowski et al., 2011; Henderson & O'Neil, 2003; Jacobsen & Beck, 2010; Lenihan & Peterson, 1998; MDNR, 2011; NRDC, 2011; Parker, 2006; Plunket & Peyre, 2005)

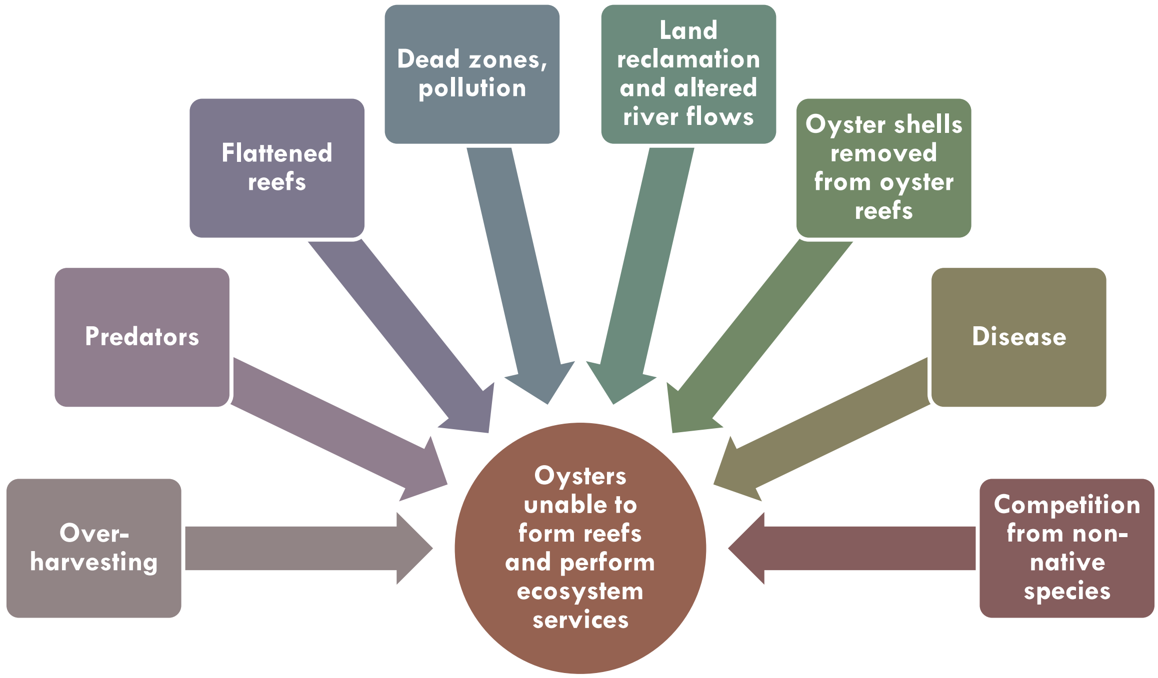
As an integral part of Mississippi River Delta ecosystem, oyster reefs provide an array of support within an ecosystem that itself provides billions of dollars in natural capital services every year (Gulf Restoration Network, 2010). At more than $23 billion per year, shoreline protection may be the most significant of these services, one in which oyster reefs play an important role (Gordon et al., 2011).

Unfortunately, fewer and fewer Gulf oyster reefs are available to provide these services. Though natural events such as hurricanes and native predators can damage oyster reefs, man-made activities pose a larger threat to these important ecosystems (see Figure 1). Historical overharvesting and destructive fishing practices have damaged much of the resource (Skoloff, 2011). For decades oyster shells were harvested for roadbed construction (Foret, 2011). Using a dredge to harvest oysters is especially harmful, as it levels the three-dimensional reef structures that prevent oysters from being smothered in sediment. Introducing non-native marine species, though less common in the Gulf than in the Chesapeake Bay, destroys oyster reefs by exposing them to new destructive diseases and parasites (Beck et al., 2011).

The offshore oil and gas industry is also responsible for considerable damage to oyster reefs (DNR, 2012). The 2010 BP Deepwater Horizon disaster got a lot of publicity because of the extent of oil damage. It is perhaps less widely known that pipelines and oil platforms have failed for decades, spilling millions of gallons of oil into oyster reef habitats (OCEANA, 2011; USDOT, 2011). Hurricane Katrina alone resulted in 44 individual oil spills from damaged pipelines and platforms (MSNBC, 2005).

Further damage comes from onshore. Urban coastal development loosens and disperses sediment into the Gulf, burying vulnerable reefs at an accelerated pace (Beck et al., 2011). Engineered shipping channels and dredged navigation waterways alter the natural hydrology, creating salinity levels unsustainable for oyster populations (Beck et al., 2011). Another threat is excess nitrogen. Fertilized agricultural land along the Mississippi River feeds nitrogen into the Gulf, creating oxygen-starving dead zones that kill oysters (Bruckner, 2011).

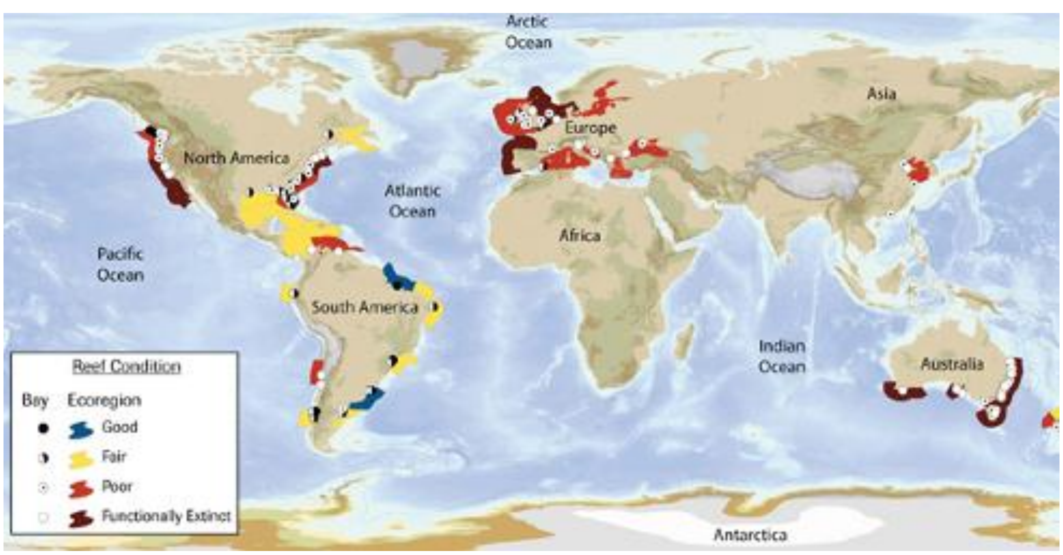
Figure 1. Natural and Human Threats to Oyster Reefs



Source: CGGC based on (Mann & Powell, 2007)

These human activities have led to enormous losses of oyster reefs worldwide, and many are damaged beyond repair (see Figure 2) (Beck et al., 2011). The Gulf of Mexico is a rare exception. Despite well over 50 percent loss, it harbors one of the few oyster ecosystems still in fair condition, making it one of the best candidates to repair and restore oyster reefs to historical levels (Beck et al., 2011).

Figure 2. Conditions of Global Oyster Reefs



Source: (Beck et al., 2011)

Taking advantage of this opportunity will require substantial financial investment. However, this investment will do more than just restore a precious resource; it will establish economic benefits across several industries and create jobs. Oyster reefs support several important industries. They are the foundation of commercial and recreational fishing industries (Grabowski et al., 2011). They promote sedimentation and provide erosion control that fortifies coastlines and protect billions of dollars of infrastructure (Henderson & O'Neil, 2003). Because this infrastructure includes a vast network of oil pipelines and nearly 47 percent of U.S. oil refining capacity, it can be said that oyster reefs help ensure the nation's energy security (NPRA, 2009). Finally, these investments will fuel small businesses and enhance local economies.

Oyster reef restoration in the Gulf of Mexico has yet to take place on a scale comparable to other larger programs like those in the Chesapeake Bay. Most projects are very small and have so far relied heavily on a network of small, innovative startup companies, nonprofits, grants and volunteers (Lorber, 2011). However, oyster reefs' array of benefits is gaining the attention of many government and industry leaders. As a result, many of these leaders would like to incorporate oyster reef restoration projects into coastal management plans like the Louisiana Master Plan, something that has not yet happened on a significant scale. The primary constraint, they say, is a lack of hard data for how artificial structures perform (Belhadjali, 2012; Graham, 2011).

Despite anecdotal evidence from more than a decade of experience that suggests many new oyster reef restoration designs are effective, there is little empirical evidence to back it up. Planners say without empirical evidence for which designs function best and under which conditions, engineers hesitate to use artificial oyster reef designs in coastal restoration projects (Belhadjali, 2012; Graham, 2011). For engineers to fully understand how these designs work, agencies need to provide funding to carry out more tests. Some of the first demonstration projects are now underway, but more are needed so that engineers can confidently incorporate these structures into future coastal restoration projects. Doing so has the potential to activate a full supply chain of regional and national materials providers, transportation and deployment services, engineering and construction contractors, and environmental resource firms.

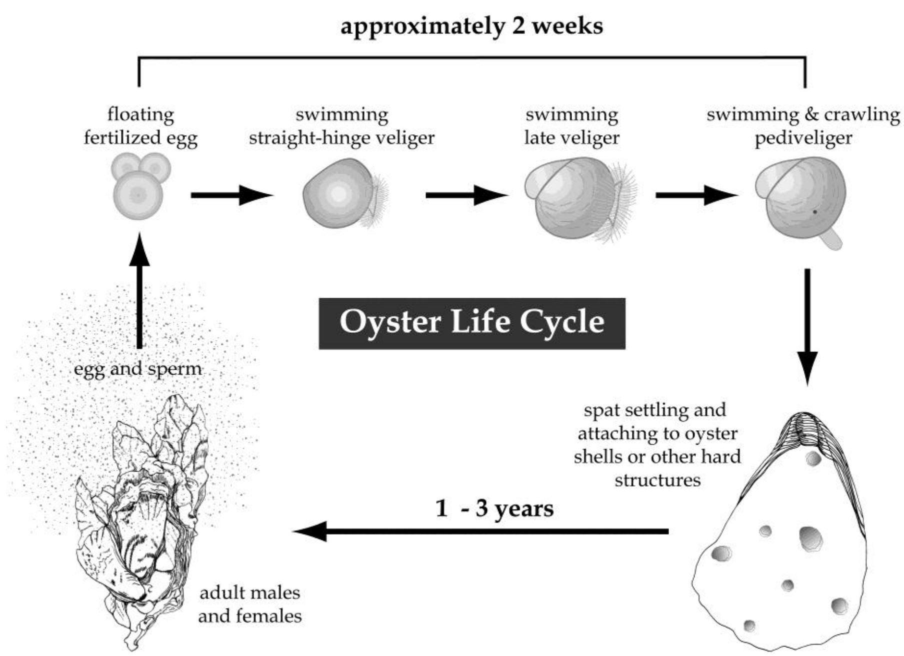
III. What is oyster reef restoration?

Most traditional oyster restoration efforts emphasize oyster production for the oyster industry. These "put-and-take" fishery enhancement projects involve the enhancement of shallow reefs that will be harvested after about three years (Brumbaugh, 2012). More recently, an increasing focus has been placed on restoration of a broader array of ecosystem services, and these projects in the Gulf are increasingly focusing on the establishment of sustainable, three-dimensional living shorelines that protect the coast and enhance the ecosystem (Coen et al., 2007). These latter projects and the industry surrounding their implementation are the focus of this report.

In the most basic sense, enhancing oyster populations entails providing a substrate that is suitable for juvenile oysters to attach to and grow. For more than a century, fisheries enhancement efforts throughout the United States have involved deployment of shell or other hard substrates on natural or leased beds. Such efforts have focused exclusively on just one particular benefit or ecosystem service – oyster production. Because ecological studies have documented that oyster reefs provide so many other ecological and economic benefits, there is increased interest in managing reefs as natural assets and not just as a commodity. Restoration projects, therefore, must increasingly be designed to match clear and specific management objectives. To achieve these objectives and to ensure an ongoing flow of benefits, it will be necessary to build sustainable substrates on which oysters can grow and continue to provide a diverse set of benefits over time.

Before moving on to the various methods used to build these substrates, it is useful to understand the basic oyster life cycle (see Figure 3). Adult male and female oysters release sperm and eggs into the water above them, where fertilization occurs. The fertilized eggs quickly hatch into larvae – also called veliger or, more frequently, spat. During this two week phase larvae float, feed on plankton, and rely on wind and currents to carry them until they find an attractive place to attach and grow. Oyster larvae choose this location based on physical cues (firmness and texture) and chemical cues (emitted from adult oyster shells) (Brumbaugh et al., 2006; Zivkovik, 2010). Because the oyster will not have another chance to move, it is critical to find a location that will ensure it can survive and grow to adulthood.

Figure 3. Oyster Life Cycle



Source: Karen R. Swanson, COSEE SE/NSF

Three project types

Central to oyster reef restoration is building a substrate that sends the cues that attract oyster larvae. It must also be high enough to keep oysters from sinking in sediment. A high-relief substrate that mimics a natural oyster reef is essential for maximizing growth and establishing shoreline protection, the principal objective in the Gulf of Mexico (DeQuattro, 2011; Graham, 2011; Schulte et al., 2009). These three-dimensional foundations may be built in one of two tidal zones—intertidal or sub tidal. Intertidal zones are the areas near shore between high tide and low tide, and are exposed during low tide. Sub tidal zones are always below the water surface. For the purposes of this report, projects may be grouped into three categories: 1) high-relief planted cultch, 2) contained cultch, and 3) precast concrete.

1) **High-relief planted cultch** reefs (hereafter cultch reefs) are, at their simplest, mounds of crushed material—called cultch—piled at least 0.3 meters tall to increase recruitment of juvenile oysters and keep oysters above the sediment (Lipcius, 2011). One commonly used cultch material is oyster shells, as they provide the texture and chemical cues that attract oyster larvae and increase recruitment. Where shell is in short supply, materials like crushed rock (limestone or granite) or concrete have proven to be comparable substitutes, and sometimes a veneer of shells is added to increase recruitment. Cultch reefs are most often created in sub tidal zones, though no deeper than 10 to 15 feet below surface (Lipcius, 2011). To build these reefs, firms transport large quantities of cultch material on barges to the project site, and then use excavators, cranes or high-pressure water hoses to push the cultch overboard (see Figure 4)

Figure 4. High-Relief Planted Cultch Deployment

Source: Barry Truitt at TNC

2) **Contained cultch** reefs provide a more structured foundation, and are built using various containers filled with cultch (see Figure 5). Commonly located in intertidal zones, the most basic contained reefs consist of mesh bags of oyster shells piled on top of one another. Occasionally The Nature Conservancy (TNC) in Alabama installs a veneer of oyster bags over a limestone cultch reef to achieve a more natural look near residential waterfronts (DeQuattro, 2011). For more structure, wire mesh cages called gabions are used in both intertidal and sub tidal zones. Made of a material similar to chain-link fencing, gabions are filled with shells and ballast, then stacked and wired together to construct sturdy, three-dimensional structures. Other techniques such as oyster mats create low-relief substrates with oyster shells tied to anchored geotextile grids (Birch, 2011). New patented designs combine gabions with other materials. The Hesco Delta Unit design by Hesco Bastion Environmental, Inc. (HBEI) consists of geotextile-lined gabions filled with soil for ballast and shell facing the exterior for cultch. As marine grasses take root and grow in the soil, the units reinforce the shoreline. ReefBlk (pronounced, "reef block") units are made of rebar welded into triangular prisms that have facets of geotextile mesh bags filled with oyster cultch. The units are assembled in intertidal zones to create an interlocking linear barrier parallel to the shore.

Figure 5. Contained Cultch Designs

Sources: (clockwise from top left) Erika Nortemann on TNC website, Dennis Barkemeyer, Beth Maynor Young on TNC Website, Reefblk

3) **Precast concrete** oyster reefs are built using a series of molded precast concrete structures that are designed to mimic the attributes of a natural three-dimensional oyster reef. In some cases the concrete mixture is fortified with an additive to increase oyster recruitment. In the Gulf of Mexico precast concrete structures are built mostly in intertidal zones. The two most common designs are Reef Balls and OysterBreak (see Figure 6). Reef Balls are hollow concrete mounds with several holes that provide attachment points for oyster recruitment. They come in several sizes, which allow versatility across a number of marine environments ranging from estuaries to open water. OysterBreak is a system of large stackable concrete rings. They are capable of being stacked to various heights. Like Reef Balls, OysterBreak is designed for both estuaries and deeper waters with higher wave energy (Turley, 2011).

Figure 6. Precast Concrete Designs

Source: (clockwise from top left) ReefBall, ReefBall, NPCA, NPCA

Regional characteristics

The strategies chosen to restore oyster reefs are determined by a number of factors that change according to each region. Each oyster-producing region has its own unique environment, economy and municipal framework, which plays a role in deciding which approach will achieve the optimal mix of ecosystem services that oyster reefs provide. Further, while the National Oceanic and Atmospheric Administration (NOAA) and TNC have led most of these efforts, other funding agencies may also influence the project type. For this reason, no two regions' oyster reef restoration techniques will look the same (see Figure 7). The following characteristics are meant to illustrate general trends in oyster reef restoration across regions, and do not reflect all project designs in a given area.

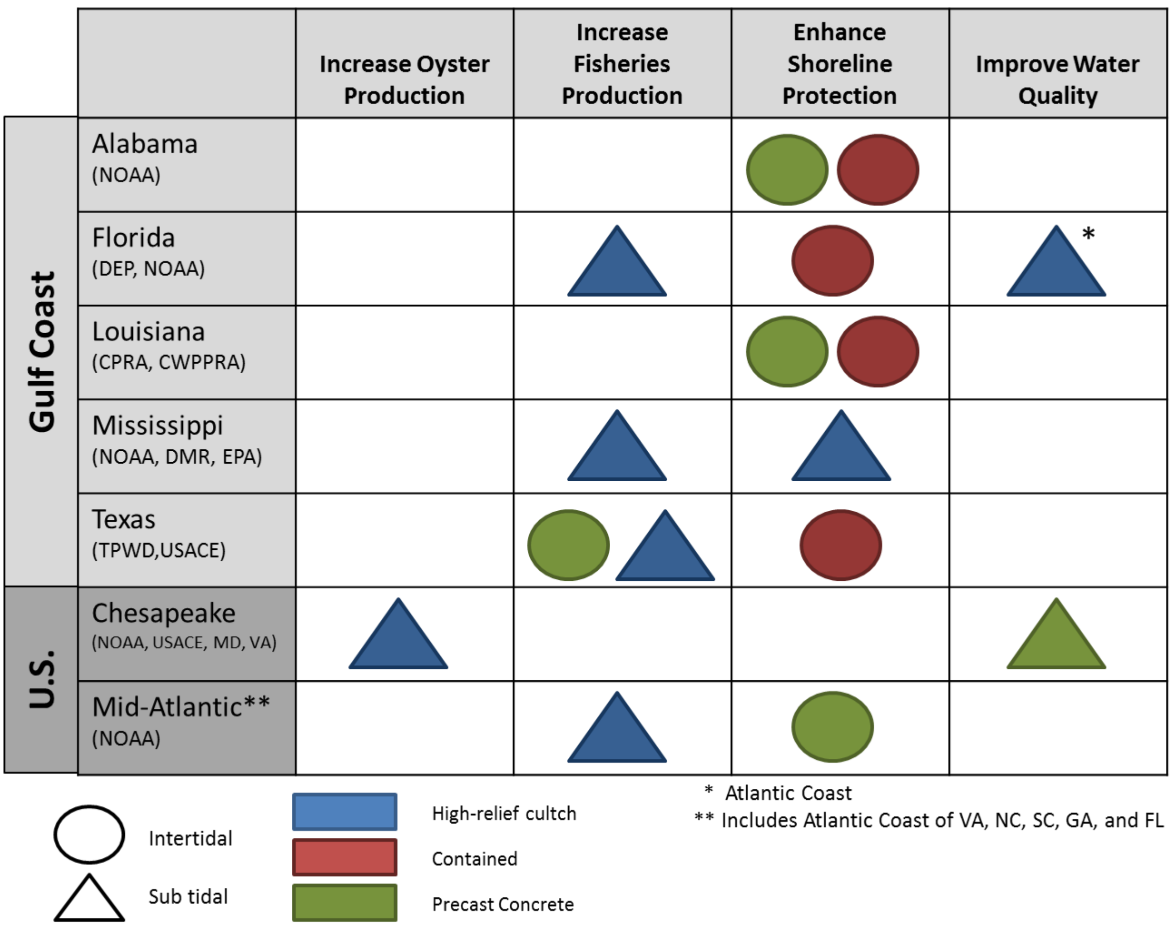
Broadly speaking, an overarching objective across the five Gulf Coast states is restoring reefs that provide diverse ecosystem functions and benefits to people. One of the most compelling benefits across the region is establishing shoreline protection (DeQuattro, 2011). Alabama and Louisiana have the most ambitious shoreline protection campaigns (Blitch, 2011; DeQuattro, 2011). In Alabama, a broad coalition of organizations has initiated the "100-1000 Restore Coastal Alabama" plan. This effort sets out to build 100 linear miles of oyster reefs and 1,000 acres of shoreline-stabilizing marshland and sea grasses (100-1000: Restore Coastal Alabama, 2011; DeQuattro, 2011). Alabama prohibits the use of shells in areas closed to oyster harvest, so many of these projects use precast concrete structures instead of cultch, which helps to clarify the purpose of the project for public stakeholders and mitigates the risk of illegal harvest (Brumbaugh, 2012). In areas where shells are permitted, sub tidal limestone cultch reefs are covered with an oyster shell veneer (DeQuattro, 2011).

Agencies in Louisiana are putting forth similar efforts to stabilize the fragile shoreline. The state averages 27 cold fronts a year, each one capable of increasing the height of shoreline-eroding waves up to six feet (Foret, 2011). In order to fortify against erosion from these waves, the Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) agency is experimenting with a variety of oyster reef restoration designs as part of their regular coastal restoration demonstration projects (CWPPRA, 2011a; Foret, 2011; Graham, 2011). These include a combination of precast concrete and contained cultch reef designs suitable for various wave environments. The soft undersea floor in Louisiana presents additional challenges to project engineering and design. In one project, engineers designed limestone-filled geotextile mattresses to put under the structures in order to keep the reefs from sinking (Turley, 2011).

Oyster reef restoration programs in Florida, Mississippi and Texas are smaller, with a less cohesive effort toward a singular objective. In Florida, restoration on the Gulf Coast is funded mostly through the Department of Environmental Protection (DEP) (Reardon, 2011). Most of these projects are sub tidal oyster cultch reefs designed to improve biodiversity, increase fishery production, and provide shoreline protection. NOAA has funded similar projects, though they are intended to improve water quality in estuaries (The Oyster Reef Restoration Project, 2009).

Mississippi has a large area north of the east/west CSX rail line that prohibits commercial harvest of shellfish, which makes it an ideal location to expand restoration efforts. TNC was recently awarded two grants to build 35 acres of new oyster reef in this zone (Mohrman, 2011). In such cases, the Mississippi Department of Marine Resources (DMR) often buys large quantities of cultch material for nourishing commercial oyster beds, and allows TNC to bid with them for oyster shell. Because this greatly reduces the price, it makes oyster shell cultch the natural choice for reef restoration design (Mohrman, 2011). In Texas the Parks and Wildlife Department (TPWD) has worked with the U.S. Fish and Wildlife Service (FWS) to install sub-tidal cultch reefs in order to boost marine fisheries production (TPWD, 2009). The U.S. Army Corps of Engineers (USACE) has funded other projects using precast concrete structures (Beggs, 2011).

Figure 7. Regional Objectives for Oyster Reef Restoration



Source: CGGC based on ARRA completion reports and industry interviews

Regional approaches to oyster reef restoration outside the Gulf Coast are equally diverse. Responding to severe habitat loss from historic overfishing and, more recently, exposure to disease, Chesapeake Bay states started restoration before most other regions. Several state and federal agencies along with regional conservation organizations have collaborated to install mostly sub tidal cultch reefs. The principal objectives are to restore the oyster population, as well as the environment by filtering nitrogen and other pollutants from the water (Schulte, 2011). The mid-Atlantic region includes the Carolinas, Georgia, and Florida's Atlantic coast. While oyster reef projects are as varied as the coasts along these states, they are generally either sub tidal cultch reefs to improve fisheries production, or intertidal precast concrete reefs designed for shoreline protection and fisheries. With some exceptions, most projects in this region have been community-based efforts highly reliant on volunteers for implementation (NOAA, 2011).

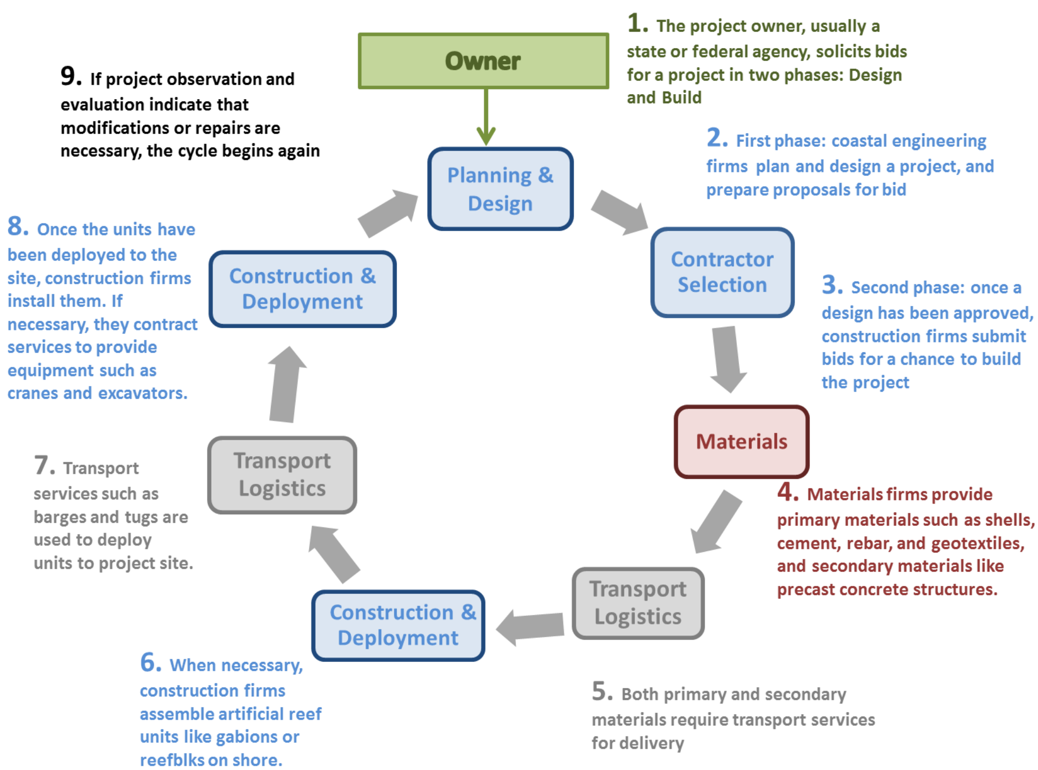
IV. U.S. value chain

Our depiction of the value chain for public projects to restore oyster reefs comprises a wide range of materials and service providers. This analysis will map out the major players and organize them into six categories. Before turning to the details of the value chain, however, it is useful to consider how an oyster reef restoration project cycle engages firms (see Figure 8).

Coastal project cycle

Each stage of the project cycle for oyster reef restoration projects engages firms to varying degrees. A generic depiction of the project cycle is shown in and described below.

Figure 8. How an Oyster Reef Restoration Project Cycle Engages Firms



Notes: Red boxes denote materials firms. Blue boxes denote service firms. Grey boxes denote transport firms.
Source: CGGC based on CWPPRA completion reports (CWPPRA, 2011b) and industry interviews

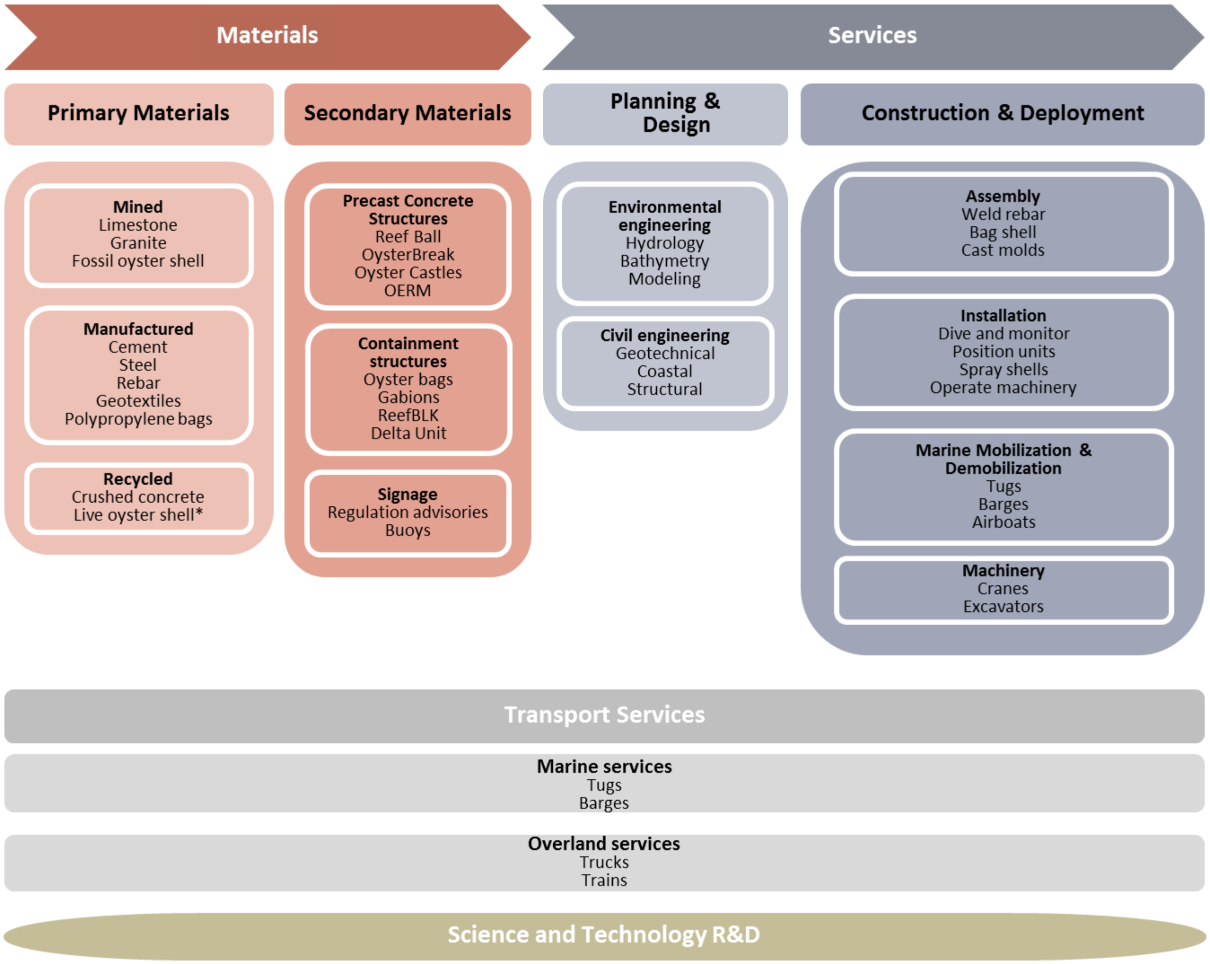
The cycle begins when the owner, usually a state or federal agency, solicits bids for a project in two phases: design and build. Upon learning of the first phase, engineering firms design cost-effective, high-quality projects appropriate for the environment. The owner then approves a design, and construction contractors bid for the opportunity to build the project. The type of project determines which firms provide the materials. Some primary materials like cultch go directly to the project, and others like cement go to secondary materials manufacturers. In both cases, primary and secondary material manufacturers must contract transport services to deliver their products to the appropriate destination (Dwoskin, 2012). When artificial reef units are assembled on shore near the project site, the construction firms are responsible for building them. Once all materials are assembled and on shore, construction firms contract transport and equipment firms to deploy them, along with labor, to the project site. Once everything is deployed, the construction firm uses equipment and labor to build the oyster reefs. If observation indicates modifications to the structure are necessary, the project cycle may begin again.

Six value chain categories

Figure 9 shows the value chain for oyster reef restoration projects. For this study, we have divided the value chain into two main sections: Materials (in red), and Services (in blue). The two columns under Materials & Equipment (primary materials and secondary materials[2]), serve as inputs to the Services in the two blue columns (planning & design and construction & deployment). At the bottom of the chart, spanning both main sections of the value chain is a fifth category in grey, Transport Services. This consists of all marine and overland logistics used to transport materials, equipment, and labor. The sixth value chain category is Science and Technology R&D (in beige). Each category is described below.

[2] For this report, the terms "primary" and "secondary" materials are not used in the traditional sense as defined in many other fields of study. Rather, they refer to the order in which the materials are used in the oyster reef restoration value chain.

Figure 9. U.S. Value Chain for Oyster Reef Restoration Projects



Source: CGGC based on industry interviews.
**While the oyster shell is not actually "live", this is the most commonly used term in the industry*

1. Primary Materials

The primary materials used in oyster reef restoration projects include mined, manufactured and recycled materials. The value chain box for each is described below.

Mined materials typically serve as direct inputs to a project, and include those materials most commonly used for cultch: limestone, granite, or fossil oyster shell. While granite has proven effective in the Chesapeake Bay, limestone is the most common stone used for cultch in the Gulf, and comes from a number of quarries in the southeast owned by firms such as Lafarge and Martin Marietta Materials (Ortego, 2011; Stulb, 2011). Though the rocks are crushed to various sizes, "57s" are the most desirable for oyster reefs. They are between ¾" and 1½" in size (Stulb, 2011). The price of these materials fluctuates more with the cost of fuel used to extract and transport them than it does with demand. Nearly all fossil oyster shell for the region comes from a mine in Carrabelle, FL run by Gulf Coast Aggregates. Sale of the million-year-old fossil shell makes up a substantial part of their business, though demand has fallen considerably since the BP Deepwater Horizon oil spill in April 2010. Since then, oyster lease owners have cut back on planting shell cultch because they don't know if the oysters will survive (Cook, 2011).

Manufactured materials include cement, steel, rebar, geotextile and polypropylene bags. Generally, these serve as inputs to make secondary materials. Cement is used to make precast concrete structures. Steel, rebar, and geotextiles are used to make various types of gabions. Polypropylene mesh bags are filled with oyster shell to make contained cultch structures.

Recycled Materials include crushed concrete and live oyster shells[3]. Each may serve as both direct inputs to build cultch reefs, as well as raw materials used to make secondary materials such as gabions. Crushed concrete is recycled by companies like Pontchartrain Materials which has machines capable of crushing 150-200 cubic yards of concrete a day. Though traditionally the concrete comes mostly from old roads and bridges, since Hurricane Katrina, much of it comes from the foundations of homes destroyed in the storm (Stulb, 2011).

Live oyster shells are simply the shells left over after shucking and eating the oyster, though they must be cleaned and sanitized properly before use. The most common source of live oyster shells is oyster processing plants located along the Gulf Coast, the largest of which are J&L Seafood in Bayou LaBatre, Alabama, Motivatit Seafood in Houma, LA, and AmeriPure Processing Company in Franklin, LA (Banks, 2011; Mohrman, 2011).

Despite these large facilities, we found there is an almost universal shortage of oyster shell available for oyster reef restoration projects. Demand from even the very modest scale of current oyster reef restoration efforts outstrips the available supply of live shell. As a result, project owners and contractors preparing bids for projects make one of three choices: use fossil shell, use another aggregate such as limestone or crushed concrete, or decide on one of the patented artificial substrate designs like ReefBlk, Reef Ball, or Oysterbreak. When faced with these decisions, firms and project owners must consider other constraints such as transport and availability. For example, when trucking fossil shell from Florida is too expensive, and crushing concrete for a 30,000 cubic yard job may not be possible, Pontchartrain Materials will automatically price limestone into their bids (Stulb, 2011).

2. Secondary Materials

Secondary materials used in oyster reef restoration projects are often proprietary products made from primary materials. They are designed to mimic a natural oyster reef (see examples in "What is Oyster Reef Restoration" on page 11). Based on the way they are made, we have grouped secondary materials into two categories: precast concrete structures and contained structures. These value chain boxes are described in detail below.

[3] While the oyster shell is not actually "live", this is the most commonly used term in the industry

Precast concrete structures are made by pouring a mixture of cement and sand into a specially designed mold. Molds used to make precast concrete structures are made of fiberglass or steel (see Figure 10). In many cases a special formula is added to the mixture that will attract oyster spat to the structure.

Figure 10. Precast Concrete Molds

Sources: Reefball, Wayfarer Environmental Technologies

The most commonly used precast concrete structures in the Gulf are OysterBreaks and Reefballs. OysterBreaks are large, open-ended cylinders designed by Wayfarer Environmental Technologies. To increase oyster recruitment, Wayfarer uses OysterKrete—a concrete with physical properties and additives designed for attracting oysters—which was developed by ORA Technologies (Ortego, 2011). Weighing approximately 2,000 pounds, OysterBreaks are some of the largest precast concrete structures used. Because of their hefty size, some project plans include a rock-filled geotextile mattress under the OysterBreak units to prevent them from sinking in a soft undersea floor (Turley, 2011). The units are arranged in lines parallel to shore, and may be stacked on top of one another in deeper waters. Reefballs are hollow domes with several grapefruit-size holes that provide habitat space for various marine life. They come in various sizes. Those used in the Gulf are around 400 pounds, and are suitable for creating living shorelines in low-energy wave environments (Turley, 2011).

Contained cultch structures are built to hold oyster shell to which oysters may attach and grow. Made of various primary materials, these include oyster bags, gabions and ReefBlks (see examples in "What is Oyster Reef Restoration" on page 11). In most cases, contained structures are assembled on shore near the project site. Oyster bags are pillow-sized mesh bags filled with oyster shells then stacked into mounds parallel to the shore. Gabions require steel and oyster shell, and can also be assembled on site. Modular Gabion Systems and Hesco Bastion Environmental use American-made steel for the gabions they manufacture (DeQuattro, 2011). Some gabion systems are designed specifically to reinforce shorelines.

With the cooperation of Modular Gabion Systems, Marine Solutions and Construction Solutions International developed a gabion system called Oyster Break Artificial Reef (OBAR) (Ragazzo, 2012). Hammond, Louisiana-based Hesco Bastion Environmental (formerly Hesco Bastion USA) designed its Hesco Delta Unit system for shorelines (see Figure 11) (Barkemeyer, 2011). The interior cage of each system is filled with soil and then planted with native grasses to reinforce the shoreline. The exterior cage is filled with oyster shell to recruit oysters and facilitate growth.

Figure 11. Hesco Delta Unit – A type of shoreline gabion system

Source: Hesco Bastion Environmental

Signage includes anything installed near a restored oyster reef to warn swimmers or boaters that the reef is there. Generally, these are signs and buoys. The U.S. Coast Guard establishes the regulatory framework for these materials, which outlines the size, color, and wording for the signage, as well as the number and frequency of signs per linear mile. While this only makes up about 2.5 percent of project costs, it is an essential project component (Dwoskin, 2012). Two of the firms that make signage for projects in the Gulf Coast are Houston, Texas-based Tideland Signal and Gilford, New Hampshire-based Watermark Navigation Systems (Dwoskin, 2012).

3. Planning and Design

Planning and design of oyster reef restoration projects requires environmental as well as civil engineering. During the planning stage, engineering firms make environmental assessments of the soil, waves, wind, tides, hydrology (water movement), and bathymetry (water depth) (USACE, 1989). Once these environmental assessments are completed, geotechnical engineers determine the most appropriate structure configuration (cultch, contained, or precast concrete). Engineers will factor in available resources and transport options when determining the ideal structure. After the engineering phase, the owner must obtain permits from the USACE, the difficulty of which varies region to region.

Planning and design take considerable time and resources. While many projects can be built in a matter of months, the planning, permitting and design phase can draw out the total project time to more than two years (Turley, 2011). The engineering costs of oyster restoration reef projects are comparable to other coastal restoration projects, averaging 10 percent of total project costs (Dwoskin, 2012). While engineering is a necessary component of the project cycle and enhances effectiveness and sustainability, it may be an ideal area to reduce project costs. Generally, low-wave-energy environments with hard sea floors can provide such opportunities (DeQuattro, 2011).

4. Construction and Deployment

Construction and deployment phases of oyster reef restoration projects frequently overlap. Construction includes assembly and installation, and these steps often require deployment services, including marine transport and heavy equipment. These are discussed in detail below.

> Assembly is required of all projects except cultch reefs. Most often, precast concrete structures are made in a facility away from the project site. Designers of the patented structures instruct employees at precast concrete facilities about using the molds and the proper mix ratios. For instance, Wayfarer Environmental Technologies has worked with Oldcastle Precast and AMPOL to build OysterBreak. The structures are mobile, but transport costs are significant enough that the manufacturing facility's proximity to the project site will often be a factor in reducing overall costs (Turley, 2011). In some cases Reef Ball structures may be assembled on site using a cement truck to fill the molds (see Figure 12).

Figure 12. Reef Ball Molds Being Filled on Site

Source: Chuck Epes/Chesapeake Bay Foundation/cbf.org

Construction workers assemble some types of contained structures on shore near the project site (Barkemeyer, 2011; Gagliano, 2011). Oyster bags are the simplest form of contained structures, and are most commonly used in smaller, community-based, volunteer-supported projects. While in the past it took dozens of volunteers to fill the bags by hand, Wayne Eldridge of J&W Marine Enterprises in Bayou La Batre, Alabama recently invented a mechanized conveyer belt that fills 2,000 bags a day with much less labor (Beggs, 2011; DeQuattro, 2011). Gabions such as the Hesco Delta Unit are pre-assembled in factories, but pinned together and filled at the project site (Barkemeyer, 2011). ReefBlk units, designed by Coastal Environments, Inc., are also assembled on shore near the project site. Coastal Environments, Inc. hires local workers to weld the rebar and fasten the geotextile bags inside the rebar structure (Gagliano, 2011).

Deployment takes place once the structures have been assembled and are on shore near the project site. This requires marine transport services that provide tugboats, barges, airboats, crew boats, and—for long term projects away from shore—quarter boats for employees to live in during construction (Foret, 2011; Ortego, 2011; Stulb, 2011). While almost all projects require shallow draft barges to access project sites, cultch reefs require large hopper barges to transport the material. Once near the project site, the material is transferred from the hopper barge to the shallow draft barges (Stulb, 2011). Delta Towing, Canal Barge Line, Pearl River Barge, and McDonough Marine are some commonly used firms that provide these services (Dwoskin, 2012; Stulb, 2011). In addition to these transport services, docks or other waterfront space must be rented. Depending on project location, this space may be residential or commercial (Foret, 2011).

Machinery and equipment is necessary for various aspects of project installation. High-powered water hoses spray cultch from barges. Cranes and excavators load and unload materials, and lift and place structures into position at the project site. While some construction firms own this equipment, others choose to rent it instead. Commonly used firms in the Gulf are Essex and Conmaco for cranes and Bottomline Equipment and Scott Machinery for excavators (Dwoskin, 2012).

Installation takes place once all the materials, reef structures, equipment, and labor have been deployed to the project site, and it involves the actual construction of the artificial oyster reef. A construction firm manages the reef installation, and in most cases an engineer ensures that the project is located and positioned correctly. Cultch reefs are built by placing the cultch in the appropriate locations and up to the specified height. The same applies for reefs built with oyster bags. Heavy structures like gabions, precast concrete and ReefBlks are installed using barge-mounted cranes that lower them into the water. Construction laborers and divers work in the water to install the structures.

Depending on the project, different firms manage the reef construction. Nonprofit organizations like TNC will manage small volunteer-driven projects using oyster bags or oyster mats (Birch, 2011). For other small projects using patented designed structures, firms like Coastal Environments, Inc. may serve as the sole source for smaller projects, managing all aspects of project installation (Gagliano, 2011). However, as the size of these projects increases, company roles change. Larger projects often require more labor and equipment than these small firms are able to provide. In these cases, a larger firm may assume the role of general contractor, and then subcontract out the smaller firms as needed. Generally, these projects cost around $1 million a mile, but TNC Alabama has been distributing competitive bids in an attempt to get the costs down. They have found that on larger scale projects, the costs come down considerably (DeQuattro, 2011). Representatives from TNC predict this may have a similar effect of attracting larger firms for project management that hire various subcontractors to carry out specific aspects of installation (DeQuattro, 2011). These firms include construction companies (Aquaterra or Bertucci), aggregate materials manufacturers (Pontchartrain Materials), or design-build firms (Weston Solutions).

5. Transport Services

The transport services category extends across all other segments of the value chain and includes marine services (tugboats and barges) and overland services (trucks and trains). Transport provides the logistics for delivering materials to service firms, as well as the mobilization and demobilization needed to deploy and install projects. Generally speaking, the materials supplier arranges for logistics and the contractor arranges for mobilization and demobilization (Dwoskin, 2012). Marine equipment used for logistics are tugboats and barges (see the Value Chain section on Deployment). Most overland transport of materials is by truck, though trains are capable of moving much of the fossil oyster shell from Florida (Cook, 2011). United Vision Logistics out of Lafayette, Louisiana has a large network of transport service locations in the Gulf Coast region.

6. Science and technology R&D

The science and technology category includes monitoring existing oyster reef projects, as well as developing and testing products. Equipment used to monitor and collect data ranges from low-tech tongs to planes for aerial photography (Blitch, 2012; Brumbaugh et al., 2006). Engineers use software for hydrodynamic, wave, and sediment transport modeling programs. In the United States, universities with dedicated coastal engineering programs develop much of this software (for more background on these programs and their role in coastal restoration, see (Lowe et al., 2011)). Louisiana State University (LSU) has a program that deploys and monitors these devices (Luettich, 2011). The university has also worked with ORA technologies to develop OysterKrete, a concrete with physical properties and additives to attract oysters (Ortego, 2011).

Monitoring restored oyster reefs provides important data that facilitates research and development. Oyster reef restoration projects may include several years of monitoring in the project budget, and some types of grants require a monitoring component. In such cases the project owners often bid for private technicians to do the work (DeQuattro, 2011). Academic institutions such as the Dauphin Island Sea Lab and LSU have also monitored Gulf Coast oyster reefs (Blitch, 2011; DeQuattro, 2011).

V. Firm-level data

This section analyzes the different types of firm that provide materials or services to restore oyster reefs. We used public documents for projects that have been completed in the Gulf of Mexico to compile the list of firms.[4] We then interviewed representatives from these firms who identified other companies they consider vendors, subcontractors, or competitors for oyster reef restoration projects. We excluded hundreds of firms that have the capacity and capabilities to work in oyster reef restoration but have not yet worked on or bid on projects. The result is a refined list that includes only those firms with verified links to oyster reef restoration projects.

The 132 firms identified in this study vary in many ways. In particular, there is a wide range for how much business each dedicates to oyster reef restoration. While oyster reef restoration makes up the largest share of business for some firms like ORA Technologies, for others like Aquaterra it is less than 5 percent (Dwoskin, 2012; Ortego, 2011). Most firms that have a high percentage of business from oyster reef projects are new businesses striving to be at the forefront of what they believe to be an emerging industry. Firms that have a small percentage of business from oyster reef projects tend to be established in other industries—especially extractive industries, marine construction, and shipping—but recognize oyster reef restoration as an opportunity to diversify and use existing resources to increase revenues. Firms in this study fall, to varying degrees, between these two extremes. Oyster reef restoration projects are particularly important to smaller firms seeking work in a sluggish economy.

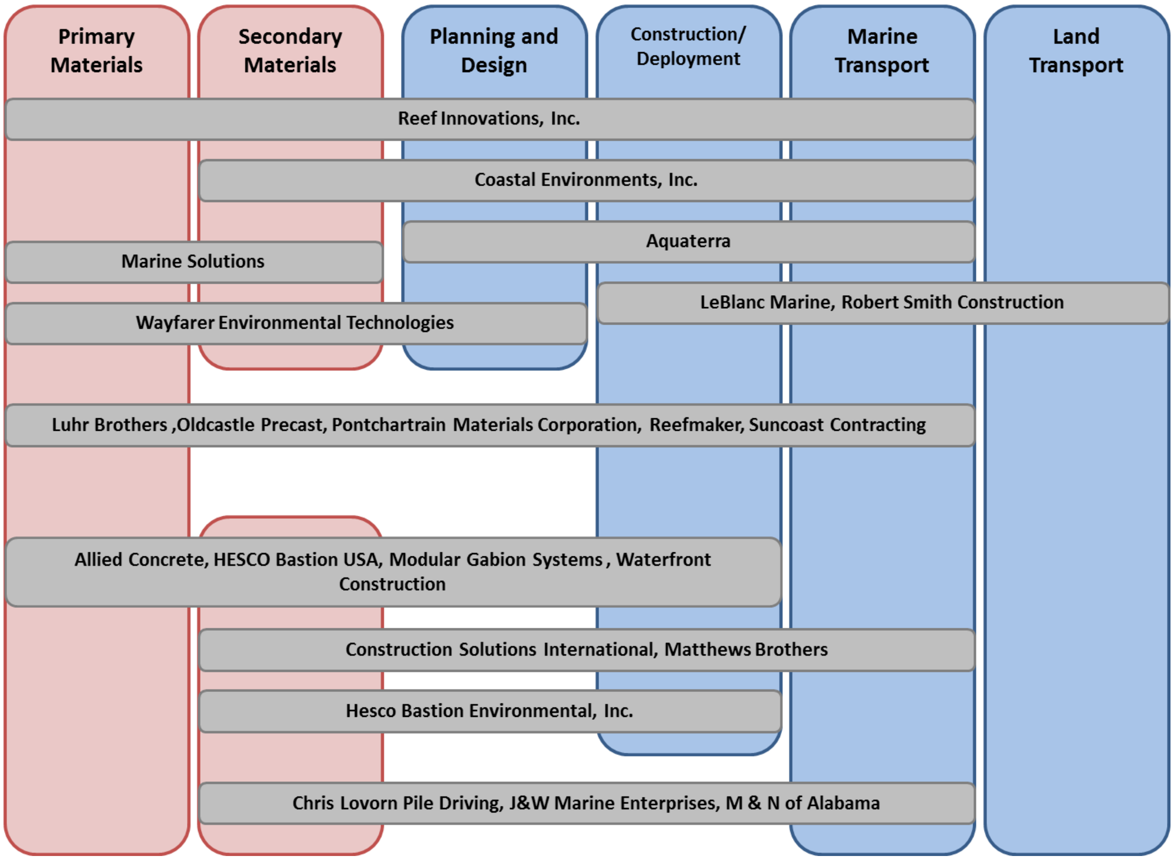
The list of all 132 firms and their characteristics is on page 41. Our analysis of these firms yielded useful observations in three areas: their capabilities across the value chain, their median size, and their role in innovation.

Capabilities of firms across the value chain

To organize firms into segments of the value chain, we identified whether each firm contributes to oyster reef restoration primarily through materials or services. Some firms are vertically integrated and capable of providing materials or services across several segments of the value chain (see Figure 13). Some examples of vertically integrated firms are primary materials providers (e.g., Pontchartrain Materials) that provide marine transport and construction services. Some marine transport firms (e.g., LeBlanc Marine) are well-positioned to provide construction and deployment services. Construction firms (e.g., Aquaterra) plan and design projects and provide marine transport for deployment. Interestingly, we found that some of the smallest firms (e.g., Reef Innovations, Coastal Environments, Inc., and Coastal Reef Builders) are the most vertically integrated, providing materials and services across four or five segments of the value chain.

[4] Project completion and bid lists from (Banks, 2011; DeQuattro, 2011; Foret, 2011; Stephenson, 2011)

Figure 13. Firms' Capabilities Across the Oyster Reef Restoration Value Chain



Source: CGGC, based on industry interviews, company websites, and project documentation (Banks, 2011; DeQuattro, 2011; Foret, 2011; Stephenson, 2011)

Median size of firms

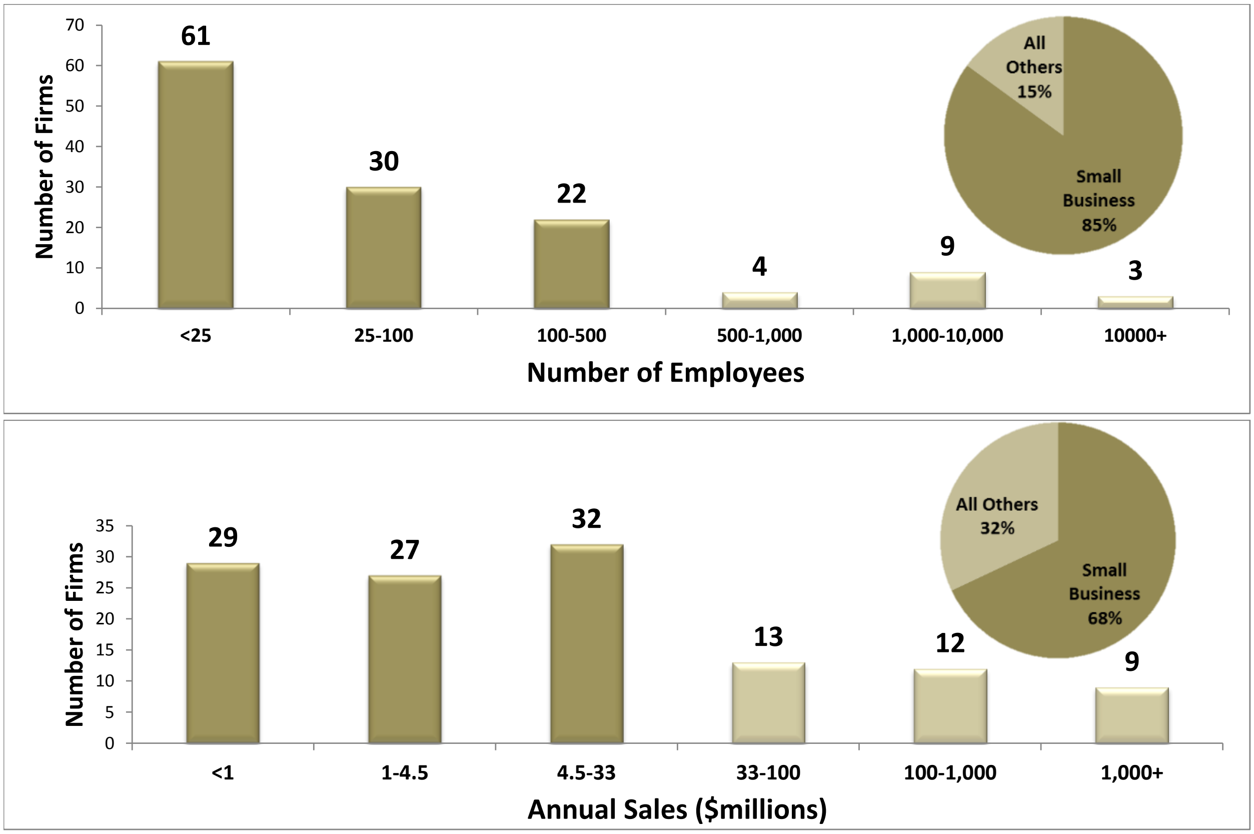
The study identified mostly small businesses (see Figure 14) to be part of the oyster reef restoration value chain. The U.S. Small Business Administration (SBA) provides varying definitions of small businesses according to the characteristics of a given industry.

For example, for a heavy civil construction firm to qualify as a small business, its annual income may not exceed $33 million. However, for an engineering services firm to qualify, its annual income may not exceed $4.5 million (SBA, 2011). More than 68 percent of firms in this study meet the income requirements to be considered small businesses.

In terms of number of employees, 85 percent of firms in this study qualify to be small businesses. Nearly half – 61 of the 132 firms– have fewer than 25 employees.

The large number of small firms in our sample indicates not only the small size of oyster reef restoration projects, but also the newness of the industry in general. Nevertheless, some larger firms are beginning to take interest as projects grow in size.

Figure 14. Distribution of Firms by Size Category, Oyster Reef Restoration Value Chain



Source: CGGC, based on industry interviews, company websites, Hoover's database, and OneSource database.

Table 2 shows the median figures for employees and annual sales across the six segments of the value chain. There are one or two very large firms in each segment of the value chain that distort the averages of several much smaller firms. Therefore, we chose to use the median figures, as they provide a more accurate description of the firms in each section.

Secondary materials providers are the smallest firms. Most businesses in this category are small firms like Coastal Environments, Inc. and Wayfarer Environmental Technologies that have developed proprietary materials and designs for artificial oyster reefs. Nine of these firms have fewer than 10 employees.

Construction firms and marine transport firms are slightly larger, with a median between 20 and 30 employees, and less than $5 million in annual sales. Many of these firms—such as Aquaterra Contracting and LeBlanc Marine—have excess capacity and are positioning themselves to take on more oyster reef restoration work. The largest firms are in the remaining three segments of the value chain—overland transport, primary materials providers, and planning and design firms. These generally include firms that are well established in other industries but can also provide materials or services for oyster reef restoration work. Such firms generally have 40 to 80 employees and annual sales in excess of $10 million.

Table 2. Median Size of Firms by Activity, Oyster Reef Restoration Value Chain

Type of Firm	Median Total Company Employees		Type of Firm	Median Total Company Sales
Secondary Materials	7		Secondary Materials	$ 2,000,000
Marine Transport	22		Construction & Deployment	$ 4,000,000
Construction & Deployment	28		Marine Transport	$ 4,000,000
Overland Transport	35		Overland Transport	$ 14,000,000
Primary Materials	60		Primary Materials	$ 15,000,000
Planning & Design	75		Planning & Design	$ 41,000,000

Source: CGGC, based on industry interviews, company websites, Hoover's database, and OneSource database.

Innovation

Field visits and industry interviews revealed several examples of innovation emerging in response to increased investment in oyster reef restoration (see Table 3).

Small firms are leading one front of innovation by developing artificial reef structures and materials to recruit oysters. Companies like Coastal Environments, Inc., Reef Ball, and Wayfarer Environmental Technologies have designed unique artificial reef products. Some of these innovations were conceptualized and developed in universities. For example, OysterKrete was developed at Louisiana State University (Ortego, 2011).

J&W Marine Enterprises developed an oyster shell bagging machine (Beggs, 2011), which has drastically reduced the labor required for contained cultch oyster reef construction.

TNC Alabama is an example of a non-profit organization innovating by changing its traditional role; that TNC office is positioning itself to become a "vendor of the state." This will allow them to hire licensed subcontractors and contractors and to bid competitively for Natural Resource Damage Assessment (NRDA) projects (DeQuattro, 2011). Other non-profits like the Coalition to Restore Coastal Louisiana (CRCL) are working with a network of restaurants to establish new oyster shell collection initiatives (Collis, 2012).

Finally, firms established in other industries—such as manufacturing and marine construction—are using their experience and resources to develop new substrate designs and make processes more efficient. After years of manufacturing flood prevention gabions for the USACE, Hesco Bastion Environmental, Inc. developed the Hesco Delta Unit, a gabion system engineered to recruit oysters and build living shorelines. For a project in Louisiana, Aquaterra Contracting developed a way to speed up the process of installing precast concrete structures. Previously, the units had been placed one at a time with a crane attachment. Aquaterra designed a new steel crane attachment that can place up to 8 units at a time, substantially reducing project time and costs. Because of this innovation, they are now well-positioned to win future bids. More importantly, innovations like this reduce cost of future projects, making oyster reef restoration more appealing to agencies and policy makers.

Table 3. Examples of Innovation in Oyster Reef Restoration across Various Organizations

Type of Organization	Examples of Innovation
Small Startups	• Firms like Coastal Environments, Inc., Reef Ball, and Wayfarer Environmental Technologies have developed proprietary substrate designs engineered to achieve an optimal mix of shoreline protection and oyster recruitment.
Universities	• LSU and ORA Technologies developed OysterKrete, a concrete with physical properties and additives designed for attracting oysters.
Volunteer	• Wayne Eldridge developed an oyster bagging conveyor belt that increased productivity to 2,000 bags per day, the equivalent labor of 20-40 volunteers.
Nonprofit	• TNC Alabama is set to become a vendor of the state, allowing them to hire licensed subcontractors and contractors, and to bid competitively for NRDA projects. • Several organizations like the Coalition to Restore Coastal Louisiana (CRCL) are developing new oyster shell collection initiatives.
Established Manufacturing Firms	• After years of manufacturing flood prevention gabions for the USACE, Hesco Bastion Environmental, Inc. recently developed the Hesco Delta Unit, a gabion system engineered to recruit oysters and build living shorelines.
Established Construction Firms	• Aquaterra Contracting developed a new crane attachment that deploys up to 8 OysterBreak units at a time, substantially reducing project time and costs.

Source: CGGC, based on (Barkemeyer, 2011; Beggs, 2011; Collis, 2012; DeQuattro, 2011; Dwoskin, 2012; Ortego, 2011)

VI. Oyster reef restoration and jobs

One of the objectives of this study is to analyze the scope and nature of the jobs supported by oyster reef restoration. By mapping out the value chain for artificial oyster reefs, this study shows the ripple effects of restoration projects on employment in an array of materials and services providers.

Despite some difficulties with hiring, artificial oyster reef contractors attest that projects so far have run on time and have not suffered a shortage of labor. However, given the generally small size of these firms, a sudden increase in funding could test their capacity—at least temporarily.

Rather than count current jobs or project future employment, we analyze oyster reef restoration's role in creating and sustaining jobs. Our analysis will 1) list the types of jobs directly involved in producing artificial oyster reefs, 2) map out the geographic distribution of employee locations, and 3) summarize potential growth for oyster reef restoration work.

Types of Jobs

A wide range of occupations is involved in oyster reef restoration, from corporate executives to dispatchers for trucking companies. Table 4 lists common jobs for materials firms, and Table 5 lists those for service firms. Here, we list the occupations most essential to oyster reef restoration, according to contractors who have managed parts of the process.

The Bureau of Labor Statistics (BLS) provides estimates of median hourly wages for job titles by industry. Here, we used the cost estimates for Nonresidential Building Construction, Cement and Concrete Product Manufacturing, Water Transportation, and Truck Transportation industries as proxies for oyster reef restoration costs.

For the selected occupations, median hourly wages range from $12.02 for laborers providing transport services to $51.73 for general operations managers providing secondary materials for artificial oyster reefs. The major job categories are engineering, management and business operations, science, construction, and transportation and transport of material.

Some job titles—for example, crane operators—appear more than once in the table below. This is because crane operators are needed at various stages in the project cycle, and their wages are different depending on the area or industry they work in. For instance, a crane operator on a barge may have a higher wage than one working on land at a quarry.

Table 4. Job Titles and Median Wages for Occupations Essential to Oyster Reef Restoration Materials

First and Secondary Materials	
Job Titles	**Median Hourly Wage**
Assemblers and Fabricators, All Other	$13.17
Industrial Truck and Tractor Operators	$14.57
Construction Laborers	$14.90
Structural Metal Fabricators and Fitters	$15.34
Reinforcing Iron and Rebar Workers	$17.51
Crane and Tower Operators	$17.77
Welders, Cutters, Solderers, and Brazers	$19.54
Carpenters	$21.15
Operating Engineers and Other Construction Equipment Operators	$22.19
First-Line Supervisors of Office and Administrative Support Workers	$25.16
First-Line Supervisors of Production and Operating Workers	$25.62
First-Line Supervisors of Construction Trades and Extraction Workers	$29.99
Accountants and Auditors - Nonresidential Building Construction	$30.45
Cost Estimators - Nonresidential Building Construction	$31.33
Industrial Engineers	$33.52
Civil Engineers	$36.60
Mechanical Engineers	$38.65
Construction Managers	$40.88
General and Operations Managers	$51.73

Source: (BLS, 2010)

Some materials providers have trouble finding qualified help for manufacturing and transportation positions. Gulf Coast Aggregates says that many job seekers find the long hours and manual work involved in preparing materials for oyster reefs to be unappealing (Cook, 2011). Other firms mentioned having difficulties with employees not meeting general employment requirements, like taking and passing drug tests (Reardon, 2011).

Table 5. Job Titles and Median Wages for Occupations Essential to Oyster Reef Restoration Services

Services	
Job Titles	**Median Hourly Wage**
Laborers and Freight, Stock, and Material Movers, Hand	$12.02
Laborers and Freight, Stock, and Material Movers, Hand - Water Transportation	$14.46
Industrial Truck and Tractor Operators	$14.57
Surveying and Mapping Technicians	$15.59
Weighers, Measurers, Checkers, and Samplers, Recordkeeping	$16.31
Sailors and Marine Oilers	$16.78
Production, Planning, and Expediting Clerks	$16.92
Heavy and Tractor-Trailer Truck Drivers	$17.67
Dispatchers, Except Police, Fire, and Ambulance	$18.25
Excavating and Loading Machine and Dragline Operators	$18.35
Industrial Machinery Mechanics	$18.77
Installation, Maintenance, and Repair Occupations	$20.59
Pile-Driver Operators	$21.34
Motorboat Operators	$21.43
Crane and Tower Operators	$24.78
Riggers	$25.78
Surveyors	$27.38
Accountants and Auditors - Water Transportation	$27.89
Cost Estimators - Water Transportation	$29.62
Captains, Mates, and Pilots of Water Vessels	$30.16
Geoscientists, Except Hydrologists and Geographers	$33.07
Conservation Scientists	$34.93
Hydrologists	$37.38
Environmental Engineers - Architectural, Engineering, and Related Services	$37.72
Environmental Engineers - Research and Development in the Physical, Engineering, and Life Sciences	$42.86

Source: (BLS, 2010)

The small businesses involved in oyster reef restoration may have a hard time meeting salary expectations for marine services positions, due to competition from oil and gas companies (see Table 6). To attract and keep staff who could earn a higher salary, companies like LeBlanc Marine offer lifestyle benefits, such as more nights at home rather than on the tugboat.

Table 6. Hourly Wages for Oyster Reef Restoration v. Hourly Wages for Oil and Gas Extraction

Job titles	Oyster Reef Restoration Median Hourly Wage	Oil and Gas Extraction Median Hourly Wage	Difference
Laborers and Material Movers	$12.72	$12.18	$ (0.54) per hour
Crane and Tower Operators	$24.78	$30.97	$ 6.19 per hour
Captains, Mates, and Pilots of Water Vessels	$30.45	$47.36	$ 16.91 per hour
Geoscientists (541300)	$33.07	$60.27	$ 27.20 per hour

Source: (BLS, 2010)

In addition, a towing endorsement—the certification necessary to operate a tugboat—requires passing a written test. Ben LeBlanc of LeBlanc Marine says that there would be more tugboat captains with towing endorsements if the test format were changed to a more practical, unwritten format. As it is, tugboat captains may expect $80,000 a year—something many small businesses cannot afford.

Many jobs in oyster reef restoration are subcontracted, temporary hire, or even volunteer in nature. Until recently, the sporadic funding of oyster reef restoration projects has demanded that firms keep a lean staff. Many firms may not maintain full-time, year-round staff. Rather, businesses often keep a very small staff and hire subcontractors or short-term workers at the construction or staging location. Larry Beggs, president of Reef Innovations, estimates that he has kept five people fully employed while providing short-term work to dozens more (Beggs, 2011).

When their funding sources allow, nonprofits involved in oyster reef restoration will often hire local fishermen or other individuals to do a variety of tasks included in surveying, assembly, deployment, and monitoring. The North Carolina Coastal Federation employed more than 40 fishermen to deploy cultch for one of its projects (Weaver, 2012).

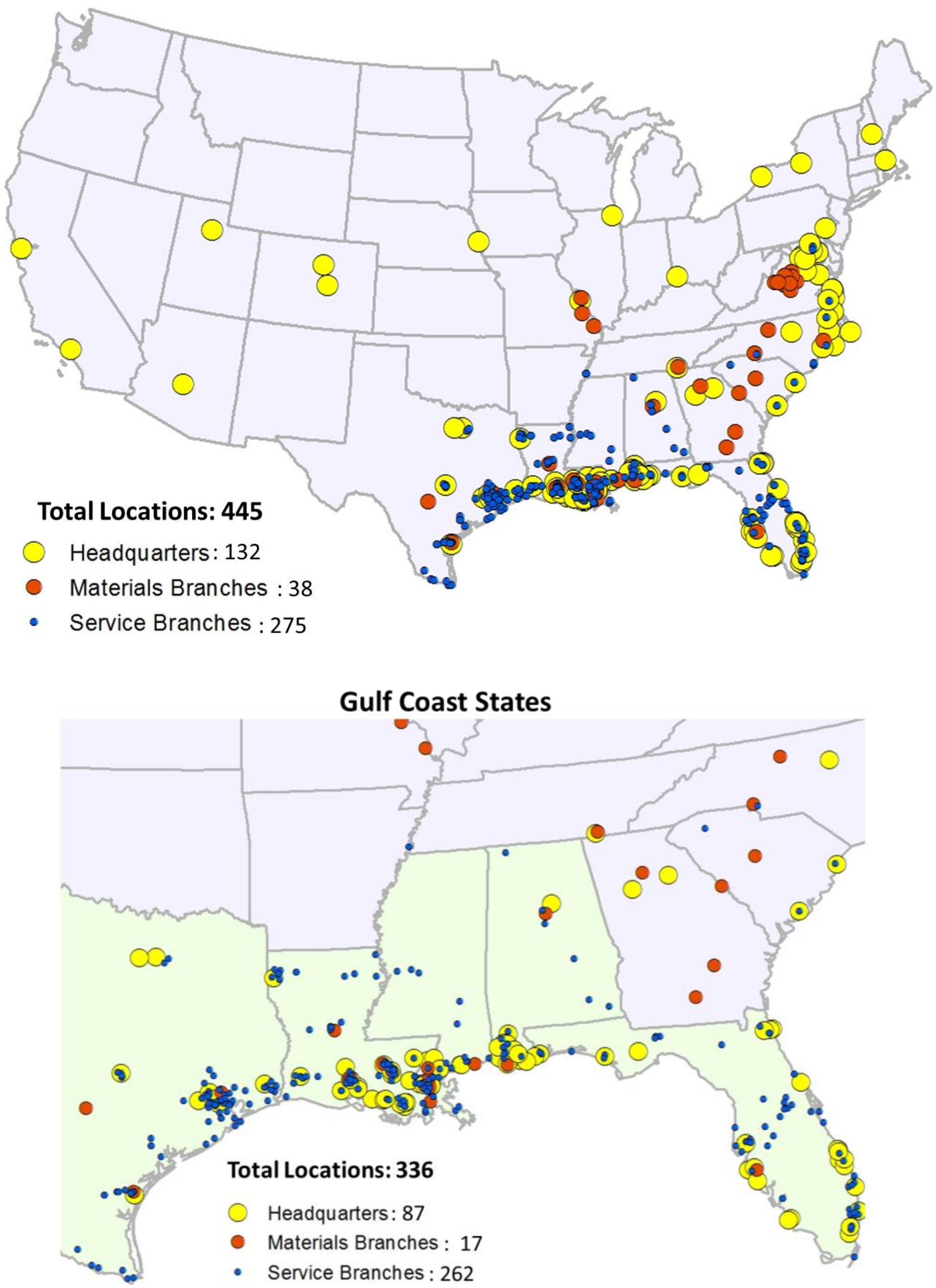
In addition, volunteers provide labor to many nonprofit oyster reef restoration projects. Nonprofit organizations such as TNC see volunteer participation as an important way to raise awareness and stretch grant money. TNC also has projects that do not use volunteers.

Geographic distribution of jobs

We identified 132 firms that have been involved with oyster reef restoration projects in the Gulf. These firms employ workers in 22 states and 445 locations—including branch offices and manufacturing plants.

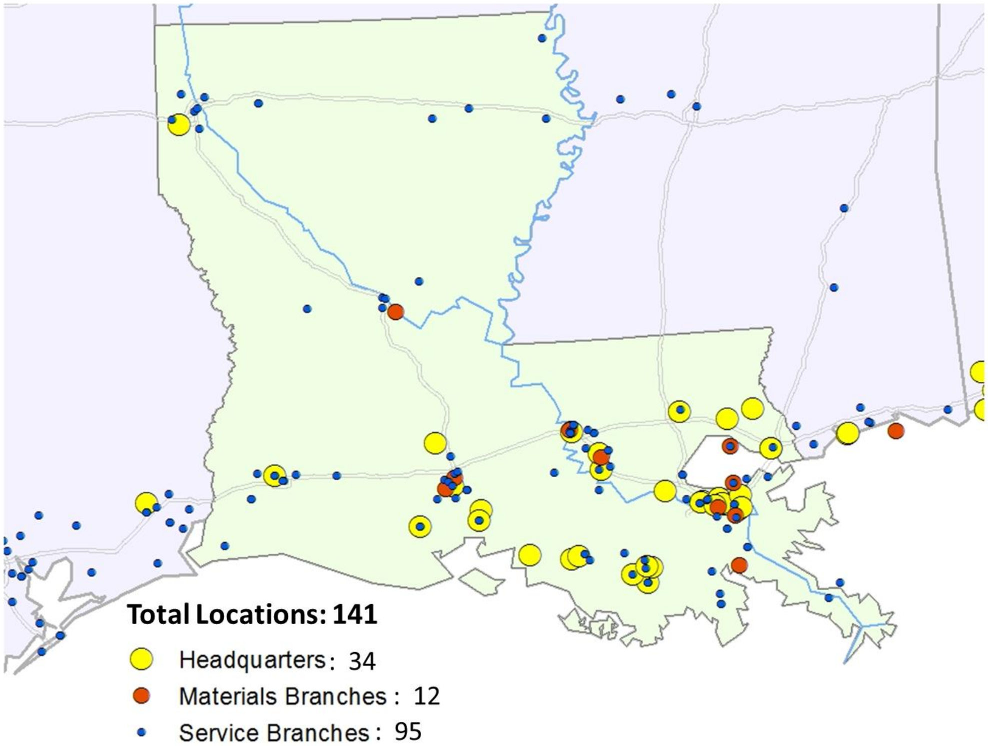
The maps in Figure 15 show the geographic distribution of these firms throughout the country. The first is a U.S. map, and the following three show firm locations in the Gulf Coast States, which have the majority of employee locations for oyster reef restoration. These firms all have headquarters, whether or not they also have branches. Branches are red or blue, to identify them as materials or service providers in the value chain. Two of the firms we identified have headquarters outside the United States.

Figure 15. Relevant U.S. Employee Locations of Firms Linked to Oyster Reef Restoration Projects

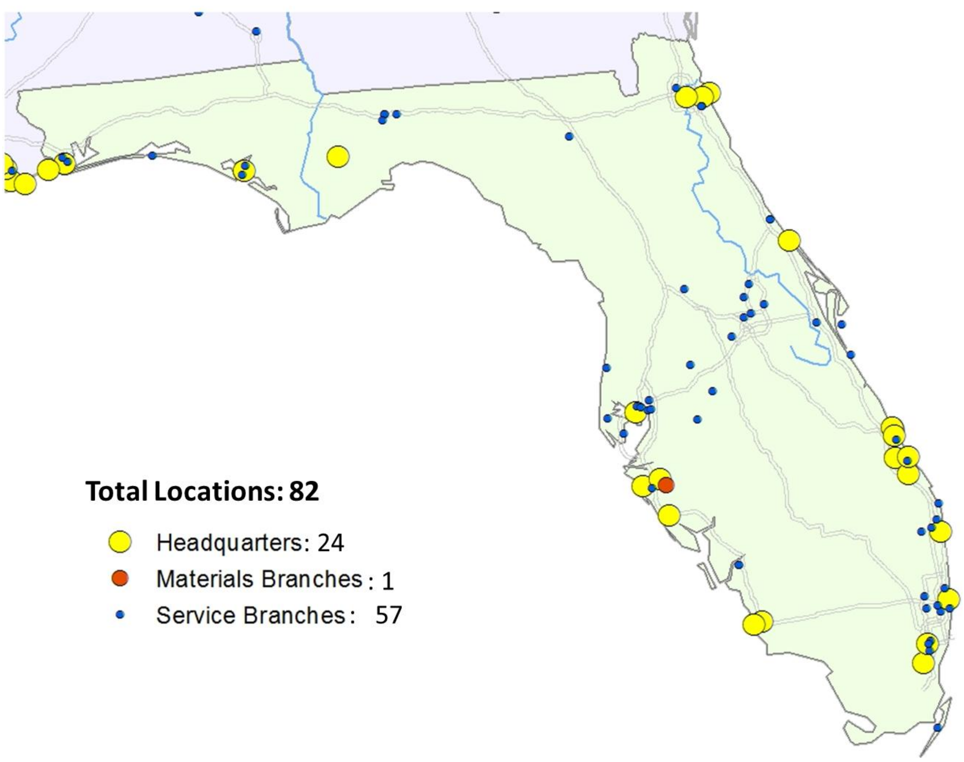


Source: CGGC, based on industry interviews, company websites, Hoover's database, and OneSource database.

Louisiana



Florida



Source: CGGC, based on industry interviews, company websites, Hoover's database, and OneSource database.

Employee locations by state and region

The firms involved in Gulf Coast oyster reef restoration are mainly located in the Gulf Coast States (see Table 7). Eighty-seven headquarters—or 65.9 percent of the 132 identified firm headquarters—are in Texas, Louisiana, Mississippi, Alabama, or Florida. Of all states, Louisiana has the highest number of headquarters (34). Louisiana also has the highest number of branch locations (107).

The Gulf Coast States have 366 of 445 total headquarters and branches—82.2 percent of all employee locations. In addition, Gulf States have the cities with the highest numbers of employee locations: 20 are in Houston, Texas; 10 are in New Orleans, Louisiana; 13 are in Baton Rouge, Louisiana; and 10 are in Houma, Louisiana.

Louisiana is the center of the oyster reef restoration industry. Within Louisiana, a high concentration of firms is involved with oyster reef restoration in the south of the state, in addition to a range of projects.

Table 7. Distribution of Firm Locations Linked To Oyster Reef Restoration

	Employee locations	U.S. HQ's	Materials HQ's	Materials firm branches	Service HQ's	Service firm branches
Total	**445**	132	**42**	**38**	**90**	**275**
No. of states with employee locations	24	22	12	11	20	11
Top states (outside Gulf Coast)	GA, MD, NC, VA	NC, VA	VA	GA, VA	NC, VA	NC, SC
Gulf Coast	366	87	28	17	59	262
Alabama	35	19	6	2	13	14
Florida	82	24	9	1	15	57
Louisiana	141	34	10	12	24	95
Mississippi	13	2	1	0	1	11
Texas	95	8	2	2	6	85
Top cities						
Houston, TX	20	3	2	0	1	17
New Orleans, LA	10	4	2	1	2	5
Baton Rouge, LA	13	1	1	1	0	11
Houma, LA	10	4	2	0	2	6

Source: CGGC, based on industry interviews, company websites, Hoover's database, and OneSource database.

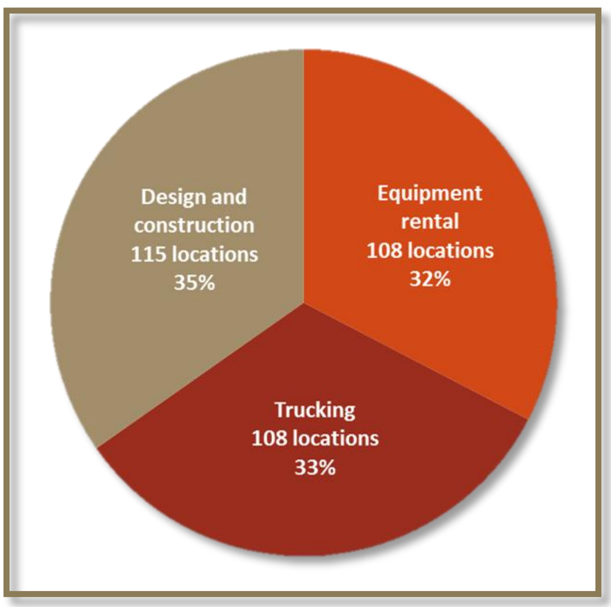
We identified 42 firms that primarily provide primary and secondary materials for oyster reef restoration projects in the Gulf.

These materials firms make up a minority of the total firms, composing 18% of employee locations and 31.8% of firm headquarters.

For the services that are part of oyster reef restoration, there are 41 headquarters with branches and an additional 49 single-location firms. Besides these 90 headquarters—which appear as yellow dots on the firm location maps—there are 275 branch locations.

Because of the large number of branch locations, land transportation firms and equipment rental firms make up a disproportionate number of the 365 service employee locations (see Figure 16). To understand the scale of the jobs they create for oyster reef restoration, the headquarter locations are a better indicator than the total locations. We identified 6 trucking and 18 equipment rental firms, which together compose 27 percent of all service firms in this study.

Figure 16. Service Employee Locations by Firm Type



Source: CGGC, based on industry interviews, company websites, Hoover's database, and OneSource database.

Future growth in oyster reef restoration

The greatest opportunity for growth in oyster reef restoration is in designing these artificial reefs so that they can be incorporated into conventional coastal restoration plans. Government agencies in Gulf Coast states are developing coastal restoration plans that call for dozens of projects worth billions of dollars. Artificial oyster reefs could be used in many of these projects for bank stabilization, barrier island restoration, shoreline protection, and projects with multiple features, providing a cost-effective means to incorporate an array of valuable ecosystem services into these states' plans.

Unfortunately, the growth of oyster reef restoration as an industry relies on two mutually dependent factors: the amount of funding, and the degree to which agencies believe oyster reef restoration projects benefit the coast. Because artificial oyster reefs for restoration are so new in the Gulf, they are caught in a dilemma: agencies will fund projects if they know the benefits, but agencies will only know the benefits if they fund projects and learn how they perform in different environments.

Our sources consistently reported that while most artificial reef designs are effective in the Gulf, little is known beyond that. Our sources concluded that engineers—especially those with the USACE Gulf Coast offices—are reluctant to use artificial oyster reefs rather than more traditional materials until the engineers can predict exactly how the reefs will perform. For engineers to fully understand how these designs work, agencies need to provide funding to carry out experiments. Each design may have its own strengths, and may perform differently depending on the environment. The more engineers know about various designs, the more likely they are to incorporate them into plans with confidence.

Increasingly, monitoring results are being published in peer-reviewed literature, enabling planners to better compare artificial oyster reefs to traditional "gray infrastructure" solutions to coastal erosion challenges (Brumbaugh, 2012). TNC and CWPPRA recently implemented some of the first demonstration projects to test how different structures perform in different environments (DeQuattro, 2011; Foret, 2011). The findings will be used to decide how oyster reef restoration may be engineered into conventional coastal restoration projects. Representatives at the Louisiana Office of Coastal Protection and Restoration (OCPR) are eager to know the results, as they would prefer to use restored oyster reefs to stabilize the shoreline instead of expensive non-native riprap stone walls (Belhadjali, 2012). While OCPR anticipates funding many more oyster restoration projects, they first want to know the optimal combination of artificial reef designs and project sites (Graham, 2011).

VII. Conclusion

Oyster reefs, when restored and managed as a resource rather than a commodity, can provide billions of dollars' worth of value to the national economy. However, Gulf oyster reefs have been destroyed by a variety of events, and they are too often managed only for commercial oyster meat. Ongoing threats to oysters mean we are in danger of losing the benefits oyster reefs provide—unless deliberate efforts are made to restore them.

A loosely organized industry has emerged to meet this need for oyster reef restoration, propelled in large measure by grants from NOAA's Community-based Restoration and American Recovery and Reinvestment Act (ARRA) funding. By designing artificial structures for growing oysters, making them, and placing them strategically, this industry contributes to the national economy, and especially to the Gulf Coast economy. It contributes directly as funds flow to firms and workers, and it contributes indirectly as oysters grow on the artificial reefs, once again providing an array of economic benefits.

Of the 132 firms linked to this industry, 85 percent qualify as small businesses. Oyster reef restoration projects are particularly important to these small businesses, providing much needed revenue in a fragile economy. In return, these small businesses are acting as agents of change for the larger economy, inventing new methods to improve the efficiency and effectiveness of implementing restoration projects. This innovation is taking place across nearly every type of firm identified in this report, from small startups, to established construction firms, to non-profit environmental organizations. To capitalize further on this opportunity, innovative oyster reef designs should be incorporated into the Gulf Coast States' coastal restoration and land conservation planning efforts.

For oyster reef restoration to be fully incorporated into coastal management plans, it needs to meet four main challenges. First, projects need to provide policymakers and funders with reliable data about reef design and effectiveness. Second, restoration efforts need to be coordinated and the technologies used to scale. Third, the innovation already taking place needs to be encouraged so that oyster reef restoration can be an effective strategy to meet a variety of goals for coastal areas. Fourth, adequate funds need to be available. While the first three challenges seem to depend entirely on the fourth, in fact each challenge is part of a cycle. Already, progress in all of these areas has generated practical support for oyster reef restoration.

Oyster reef restoration has the possibility of expanding rapidly if adequate funding becomes available. Most materials and service firms already involved in oyster reef restoration have sufficient capacity to meet increased demand. Many firms have the capability to enter the market for future projects.

The Gulf Coast has the opportunity to protect its shoreline and infrastructure, enhance its fisheries, and support its economy by investing in oyster reef restoration.

Appendix: Full Set of Firm-Level Data

Employees		Annual Sales ($U.S. millions)	
1-25	☺	0-1	$
25-100	☺☺	1-4.5	$$
101-500	☺☺☺	4.5-33	$$$
501-1,000	☺☺☺☺	33-100	$$$$
1,001 or more	☺☺☺☺☺	100-1,000	$$$$$
		1,000 or more	$$$$$$

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Primary Materials							
All County Earthmovers, Inc. 2004	Port St. Lucie	FL			$	☺	Cultch material
Allied Concrete 1949	Charlottesville	VA	Charlottesville	VA	$$$	☺	Concrete
			Culpeper	VA			
			Mineral	VA			
			New Canton	VA			
			Orange	VA			
			Stanardsville	VA			
			Staunton	VA			
			Troy	VA			
			Waynesboro	VA			
Ameripure Oysters 1995	Franklin	LA			$$$	☺	Oyster shell
Bell's Seafood	Cape Charles	VA				☺	Shell
Bernie's Conchs LLC 1974	Cheriton	VA			$	☺	Shell
Bertucci Contracting Corporation 1993	Jefferson	LA			$$$$	☺	Limestone, environmental dredging and disposal
Bevans Oyster Company 1966	Kinsale	VA			$$$	☺	Shucked oyster shell

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Primary Materials							
Bon Secour Fisheries, Inc. 1896	Bon Secour	AL			$$$	☺☺	Oyster shell
Cherrystone Aqua-Farms 1924	Norfolk	VA			N/A	☺☺	Clamshell
Chris Lovorn Pile Driving Inc	*See Marine Transport*						
Crystal Seas Seafood, LLC 1996	Pass Christian	MS			$$$	☺	Oyster Shell
Florida Dirt Source 2005	Naples	FL			$	☺	Cultch material
Gulf Coast Aggregates, LLC 2004	Carrabelle	FL			$	☺	Fossilized oyster shell
LaFarge 1956	Herndon	VA	Offices in 900 locations		$$$$$$	☺☺	Limestone and transport services
Luhr Brothers 1939	Columbia	IL	Alexandria Baton Rouge Cape Girardeau	LA LA MO	$$$	☺☺	Limestone
Marine and Industrial Supply Company, Inc. 1976	Mobile	AL	Prairieville	LA	$$	☺	Primary materials
Marine Solutions, LLC	Abita Springs	LA			$	☺	Fossilized oyster shell, OBAR
Martin-Marietta Materials	Raleigh	NC	Birmingham Augusta Suwannee Mandeville Charlotte Greensboro New Bern Columbia Humble San Antonio	AL GA GA LA NC NC NC SC TX TX	$$$$$$	☺☺☺☺	Limestone marl

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Primary Materials							
Modular Gabion Systems	*See Secondary Materials*						
Motivatit Seafoods 1972	Houma	LA			$$$	☺	Live Oyster Shell
Oldcastle Precast, LLC (parent company Oldcastle, Inc.) 1978	Atlanta	GA			$$$$$$	☺☺☺☺	Concrete
ORA Technologies 2004	Opelousas	LA			$	☺	OysterKrete
Pontchartrain Materials Corporation 1976	New Orleans	LA	Harvey	LA	$$$	☺	Crushed Concrete
Propex 2009	Chattanooga	TN	Nashville Ringgold Chattanooga	GA GA TN	$$$$$	☺☺☺☺	Geotextiles
Quality Seafood 1986	Elizabeth City	NC			$$$$	☺	Shucked oyster shell
Reef Innovations, Inc.	*See Secondary Materials*						
Reefmaker / Walter Marine	*See Assembly and Installation*						
RJT Environmental Services, LLC 2010	Prairieville	LA			$	☺	Shell, limestone for flat oyster beds
SMR Aggregates, Inc. 1976	Sarasota	FL	Sarasota	FL	$$	☺	Cultch material
Suncoast Contracting 2010	New Orleans	LA			$	☺	Crushed concrete
Tree Cycle	Fort Pierce	FL			N/A	N/A	Cultch material
Waterfront Construction	*See Assembly and Installation*						
Wayfarer Environmental Technologies, LLC	*See Secondary Materials*						

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (Sales | # of employees)		Products or services
Secondary Materials							
Allied Concrete	*See Primary Materials*						
Bailey-Sigler, Inc. 1962	New Smyrna Beach	FL			$	☺	Donut weights and "oyster grate"
CK Marine Construction, Inc	*See Assembly & Installation*						
Coastal Environments, Inc. 1967	Baton Rouge	LA	Biloxi Corpus Christi New Orleans	LA LA LA	$$	☺	ReefBlk, bagged oyster shell
Coastal Reef Builders, Inc.	Pensacola	FL			$$	☺	Building, deploying, and delivering Reef Balls
Construction Solutions International	*See Assembly & Installation*						
Ecological Associates, Inc	Jensen Beach	FL	Altamonte Springs Baton Rouge Greenville	FL LA SC	$$	☺	Secondary materials
Gahagan & Bryant Associates, Inc.	*See Planning & Engineering*						
Hesco Bastion Environmental Inc. (formerly Hesco Bastion USA) 2003	Hammond	LA			N/A	☺	Hesco Delta Unit
J&W Marine Enterprises, Inc.	*See Marine Transport*						
M & N of Alabama, LLC 1991	Magnolia Springs	AL			$$	☺	Signage
Matthews Brothers, Inc.	*See Marine Transport*						

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Secondary Materials							
Modular Gabion Systems (within C. E. Shepherd Company, L.P.) 1957	Houston	TX			$$$	☺☺	OBAR
Oldcastle Precast, LLC	*See Primary Materials*						
Reef Innovations, Inc. 1993	Sarasota	FL			$	☺	Building, deploying, and delivering Reef Balls
Reefmaker / Walter Marine	*See Assembly & Installation*						
Seament Shoreline Systems, Inc. 1995	King George	VA			$	☺	Concrete erosion control systems
Tideland Signal 1954	Houston	TX	Lafayette	LA	$$$	☺☺	Signage
Waterfront Construction	*See Assembly & Installation*						
Watermark Navigation Systems, LLC	Gilford	NH			$$	☺	Signage
Wayfarer Environmental Technologies, LLC 2004	Hunt Valley	MD			$	☺	Oysterbreak

<table>
<tr><th>Company name (Year Founded)</th><th colspan="2">U.S. Headquarters</th><th colspan="2">Other employee locations</th><th colspan="2">Company Size (Sales | # of employees)</th><th>Products or services</th></tr>
<tr><th colspan="8">Planning and Design Services</th></tr>
<tr><td rowspan="8">AECOM
1980</td><td rowspan="8">Los Angeles</td><td rowspan="8">CA</td><td>Miami</td><td>FL</td><td rowspan="8">$$$$$$</td><td rowspan="8">☺☺☺☺☺</td><td rowspan="8">Engineering and Contractor Oversight</td></tr>
<tr><td>Orlando</td><td>FL</td></tr>
<tr><td>Palm City</td><td>FL</td></tr>
<tr><td>Sarasota</td><td>FL</td></tr>
<tr><td>Sunrise</td><td>FL</td></tr>
<tr><td>Tampa</td><td>FL</td></tr>
<tr><td>West Palm Beach</td><td>FL</td></tr>
<tr><td>Shreveport</td><td>LA</td></tr>
<tr><td>Benchmark Ecological Services Inc.</td><td>Brookshire</td><td>TX</td><td>Katy</td><td>TX</td><td>$</td><td>☺</td><td>Engineering services</td></tr>
<tr><td>CK Marine Construction, Inc</td><td colspan="7">See Marine Transport</td></tr>
<tr><td rowspan="2">Coast and Harbor Engineering</td><td rowspan="2">San Francisco</td><td rowspan="2">CA</td><td>North Palm Beach</td><td>FL</td><td rowspan="2">$$</td><td rowspan="2">☺</td><td rowspan="2">Engineering and Contractor Oversight</td></tr>
<tr><td>Austin</td><td>TX</td></tr>
<tr><td>Coastal Environments, Inc.</td><td colspan="7">See Secondary Materials</td></tr>
<tr><td>Coastal Reef Builders, Inc.</td><td colspan="7">See Secondary Materials</td></tr>
<tr><td rowspan="3">CSA International, Inc. (of Continental Shelf Associates, Inc.)</td><td rowspan="3">Stuart</td><td rowspan="3">FL</td><td>Tampa</td><td>FL</td><td rowspan="3">$$$$</td><td rowspan="3">☺</td><td rowspan="3">Engineering</td></tr>
<tr><td>Houma</td><td>LA</td></tr>
<tr><td>Houston</td><td>TX</td></tr>
<tr><td rowspan="4">David Volkert & Associates Inc
1957</td><td rowspan="4">Mobile</td><td rowspan="4">AL</td><td>Birmingham</td><td>AL</td><td rowspan="4">N/A</td><td rowspan="4">☺☺☺</td><td rowspan="4">Engineering and Contractor Oversight</td></tr>
<tr><td>Foley</td><td>AL</td></tr>
<tr><td>Montgomery</td><td>AL</td></tr>
<tr><td>Tampa</td><td>FL</td></tr>
<tr><td rowspan="2">Dial Cordy and Associates, Inc
1996</td><td rowspan="2">Jacksonville</td><td rowspan="2">FL</td><td>Hollywood</td><td>FL</td><td rowspan="2">N/A</td><td rowspan="2">☺</td><td rowspan="2">Environmental consulting</td></tr>
<tr><td>Wilmington</td><td>FL</td></tr>
<tr><td rowspan="2">DQSI
1998</td><td rowspan="2">Covington</td><td rowspan="2">LA</td><td>New Orleans</td><td>LA</td><td rowspan="2">$$</td><td rowspan="2">☺</td><td rowspan="2">Engineering</td></tr>
<tr><td>Stennis Space Center</td><td>MS</td></tr>
</table>

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Planning and Design Services							
Ecology and Environment, Inc. 1970	Lancaster	NY	Altamonte Springs	FL	$$$$$	☺☺☺☺	Engineering and Contractor Oversight
			Miami Lakes	FL			
			Pensacola	FL			
			Tallahassee	FL			
			Baton Rouge	LA			
			Wellington	NY			
			Greenville	SC			
Fugro 1987	Amsterdam, Netherlands	N/A	Kenner	LA	$$$$$$	☺☺☺☺☺	Geotechnical engineering
			Lafayette	LA			
			Westlake	LA			
			Bay St. Louis	MS			
			Beaumont	TX			
			Houston	TX			
			Pasadena	TX			
Gahagan & Bryant Associates, Inc. 1974	Tampa	FL	Rosedale	MD	$$$$$	☺	Engineering and Contractor Oversight
			Wilmington	NC			
			Houston	TX			
Getting It Done, Inc.	Virginia Beach	VA			N/A	☺	Biogenic breakwaters
Gulf States Engineering, Inc. 1998	Mobile	AL	Gulfport	MS	$$$	☺	Engineering and Contractor Oversight
HDR 1917	Omaha	NE	Corpus Christi	TX	$$$$$$	☺☺☺☺	Engineering and Contractor Oversight
I.M. Systems Group, Inc.	Rockville	MD	Key Largo	FL	$$$$	☺☺	Planning and design services
			Miami Hurricane Center	FL			
			St. Petersburg	FL			
			Baton Rouge	LA			
			Gulfport	MS			
			Galveston	TX			

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Planning and Design Services							
Marine Environmental Sciences Consortium (Dauphin Island Sea Lab)	Dauphin Island	AL			$$$	☺	Planning and design services
Naismith Engineering, Inc. 1949	Corpus Christi	TX	Austin	TX	$$$	☺	Engineering and Contractor Oversight
			Brownsville	TX			
New Line Environmental 2003	Jefferson	LA			$$	☺	Engineering
ORA Technologies	*See Primary Materials*						
PBS&J Consultants (now Atkins Global) 1938	Doral	FL	Jacksonville	FL	$$$$$$	☺☺☺☺☺	Engineering and Contractor Oversight
			Austin	TX			
Pensacola Enviromental Services	Pensacola	FL			N/A	☺	Project management
Reef Ball Foundation 2010	Athens	GA			$	☺	Reef Ball planning, design
Sanborn Map Company, Inc.	Colorado Springs	CO	Cocoa Beach	FL	$$$$	☺☺	Planning and design services
			Charlotte	NC			
			Austin	TX			
South Coast Engineers 2008	Fairhope	AL			$	☺	Engineering and Contractor Oversight
Stevens Towing Co. of North Carolina, LLC	*See Marine Transport*						
The Nature Conservancy 1951	Arlington	VA	Mobile	AL	$$$$$	☺☺☺☺	Project management
			Indialantic	FL			
			Baton Rouge	LA			
			Jackson	MS			
			Corpus Christi	TX			
URS 1957	San Francisco	CA	Houston	TX	$$$$	☺☺	Engineering and Contractor Oversight

Company name (Year Founded)	**U.S. Headquarters**		**Other employee locations**		**Company Size (sales | # of employees)**		**Products or services**
Planning and Design Services							
Wayfarer Environmental Technologies, LLC	*See Secondary Materials*						
Weston Solutions, Inc. 1951	West Chester	PA	Miami	FL	$$$$$	☺☺☺☺	Engineering and Contractor Oversight
Woolpert	Dayton	OH	Orlando Corpus Christi Garland	FL TX TX	$$$$$	☺☺☺	Planning and design services
Assembly and Installation							
Allied Concrete	*See Primary Materials*						
American Pollution Control (AMPOL) 1994	New Iberia	LA			$$$$$	☺☺	OysterBreak
AP Reale & Sons (Reale A P & Sons Field Office) 2008	Ticonderoga	NY	Havelock Murrells Inlet	NC SC	$	☺	Reef construction
Apollo Environmental Strategies 1992	Beaumont	TX			$$$	☺	Assembly and installation
Aquaterra Contracting, Inc. 1999	Dallas	TX	New Orleans	LA	$	☺	Assembly and installation
Bertucci Contracting Corporation	*See Primary Materials*						
Boat People S.O.S. 2006	Bayou La Batre	AL			$	☺	Labor
Canal Barge Line	New Orleans	LA	Belle Chasse Sulphur	LA LA	$$$$	☺	Barges to rent
CK Marine Construction, Inc	*See Marine Transport*						
Coastal Environments, Inc.	*See Secondary Materials*						
Coastal Reef Builders, Inc.	*See Secondary Materials*						

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Assembly and Installation							
Construction Solutions International 1984	Creola	AL			$$	☺	OBAR assembly; barges, trackhoes, tugs, cranes; staging
Delta Towing 2001	Houma	LA			$$$	☺☺	
Esfeller Construction Co 1978	Irvington	AL	Coden	AL	$$$	☺	Assembly and installation
Hesco Bastion Environmental Inc.	*See Secondary Materials*						
Langenfelder Marine, Inc.	*See Marine Transport*						
LeBlanc Marine	*See Marine Transport*						
Luhr Brothers	*See Primary Materials*						
Matthews Brothers, Inc.	*See Marine Transport*						
McLean Contracting Company 1903	Glen Burnie	MD	Baltimore Chesapeake	MD VA	$$$$	☺☺	Assembly and installation
Modular Gabion Systems	*See Secondary Materials*						
MT2 (Metals Treatment Technologies) 2000	Arvada	CO			$$$	☺	Assembly and installation
Pearl River Navigation	Slidell	LA			$$$	☺	
Pontchartrain Materials Corporation	*See Primary Materials*						
Reef Innovations, Inc.	*See Secondary Materials*						
Reefmaker / Walter Marine 2007	Orange Beach	AL			$	☺	Reef construction, limestone
Resolve Marine Group 1986	Fort Lauderdale	FL	Theodore Hollywood	AL FL	$$$	☺	
Seament Shoreline Systems, Inc.	*See Secondary Materials*						

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Assembly and Installation							
Seaduce 1997	Cheriton	VA			$	☺	Assembly and installation
Suncoast Contracting	*See Primary Materials*						
Sycamore Construction, Inc. 1993	Fairhope	AL			$$	☺	Assembly and installation
W.F. Magann Corporation 1946	Portsmouth	VA			$$$	☺☺	Materials placement
Waterfront Construction 2000	Mobile	AL	Dauphin Island	AL	$$	☺	Assembly and installation, bagged oyster shell
Marine transport/ Deployment							
Bertucci Contracting Corporation	*See Primary Materials*						
Bottom Line Equipment, L.L.C. 2005	St. Rose	LA			$$	☺	Equipment for hire
Broussard Brothers 1947	Abbeville	LA			$$$	☺☺	Mobilization and demobilization
Cape Dredging 1976	Buxton	NC			$	☺	Marine transport/ deployment
Cashman Equipment 2007	Prairieville	IL			$$	☺	Equipment (barges) for hire
Central Boat Rentals 1964	Berwick	LA			$$$	☺☺	Mobilization and demobilization
Chris Lovorn Pile Driving Inc 1995	Mobile	AL			$	☺	Staging, equipment, and signage
CK Marine Construction, Inc 2004	Fort Pierce	FL			$	☺	Barge, tugboats, skiff, crew, permit services, and project management

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Marine transport/ Deployment							
Coastal Environments, Inc.	*See Secondary Materials*						
Coastal Marine Contractors, LLC 2004	Slidell	LA			$	☺	Tugboats and barges
Coastal Reef Builders, Inc.	*See Secondary Materials*						
Conmaco 1907	Belle Chasse	LA			$$	☺☺	Equipment for hire
Construction Solutions International	*See Assembly & Installation*						
Cross Group Incorporated 2001	Houma	LA	Houston	TX	$$	☺	Mobilization and demobilization
Crowder Gulf 2005	Theodore	AL			$$$	☺☺	Barges, staging area, tugboats
Crystal Seas Seafood, LLC	*See Primary Materials*						
Eastman Aggregate Enterprises 1954	Lake Worth	FL			$$	☺	Marine transport
Eric Pake, Jr. Construction, Inc 1985	Beaufort	NC			$	☺	Deploying cultch
Essex Crane 2008	Buffalo Grove	IL	Alabaster Tampa Arcola	Al FL TX	$$$$	☺☺	Equipment for hire
Four Seasons 2001	N/A		Tampa Dallas Houston	FL TX TX	$$$	☺	Equipment for hire
Gazzier Marine Services (J.R. Gazzier, LLC) 2010	Theodore	AL			$	☺	Trackhoes, barges, staging
J&W Marine Enterprises, Inc. 1997	Bayou La Batre	Al			$$	☺	Mobilization and demobilization; bagged oyster shell
J.R Grey Barge Inc. 1940	Houma	LA			$$	☺	Marine vessels

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Marine transport/ Deployment							
Jemison Marine (T M Jemison Construction Co Inc) 1991	Bayou La Batre	AL			$$$	☺	Tugboats, barges, cranes, and trackhoes
LaFarge	*See Primary Materials*						
Langenfelder Marine, Inc. 2002	Stephensville	MD			$$	☺	Dredging and marine construction; equipment to wash dredged shells
LeBlanc Marine 2004	New Iberia	LA			$$	☺	Marine and land transport and deployment
M & N of Alabama, LLC	*See Secondary Materials*						
Magnolia Quarterbarges, Inc. (Magnolia Holdings, Inc.) 1988	Saint Rose	LA			$$	☺	Mobilization and demobilization
Matthews Brothers, Inc.	Pass Christian	MS			$$	☺	Tugs, cranebarges, artificial reef assembly
McCulley Marine Services 1990	Fort Pierce	FL			$$	☺	
McDonough Marine Service (Marmac, L.L.C.) 1945	Metairie	LA			N/A	☺	Mobilization and demobilization
Mike Hooks, Inc. 1946	Westlake	LA			$$$$	☺☺	Dredging

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Marine transport/ Deployment							
Morgan City Rentals (T & J Enterprises LLC) 1970	Morgan City	LA	Broussard Golden Meadow	LA LA	$$$$$	☺	Equipment for hire
Pungo River Lime Company 2002	Belhaven	NC			$	☺	Marine transport/ deployment
Reef Innovations, Inc.	*See Secondary Materials*						
Resolve Marine Group	*See Assembly and Installation*						
Robert Smith Construction 2003	Trussville	AL	Eight-Mile	AL	$$	☺	Barges, trackhoes, staging area
RSC Equipment Rental, Inc 1992	Scottsdale	AZ	3 Alabama locations 26 Florida locations 19 Louisiana Locations 5 Mississippi locations 27 Texas locations		$$$$$$	☺☺	Equipment for hire
Scott Machinery 1968	Salt Lake City	UT	9 Louisiana locations Baytown Nederland	 TX TX	$$$	☺☺☺	Equipment for hire
Stevens Towing Co. 2004	Yonges Island	SC	Edenton	NC	$$$	☺	Barge transport, project management
W.F. Magann Corporation	*See Assembly & Installation*						
Zito Co., LLC 1980	New Orleans	LA			$$$	☺☺	Mobilization and demobilization

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (Sales | # of employees)		Products or services
Land Transport							
Acme Truck Line, Inc. 1960	Gretna	LA	Mobile 2 Florida Locations 21 Louisiana locations Laurel 18 Texas locations	Al MS 	$$$$$	☺☺☺☺	Trucking
Aggregate Transport / Cato Enterprises, Inc. 1952	Panama City	FL			$$$	☺	Trucking
American Machinery Movers Inc. 1930	Jefferson	LA			$$$	☺	Trucking
Bengal Transportation Services, LLC 1995	Geismar	LA			$$$	☺	Trucking
Coastal Reef Builders, Inc.	*See Secondary Materials*						
E & J Trucking	Elizabeth City	NC			N/A	N/A	Trucking
Harvey B. Yancey Trucking Co., Inc. 1973	Maysville	NC			$	☺	Trucking
Landstar System, Inc 1988	Jacksonville	FL			$$$$$$	☺☺☺☺	Trucking
LeBlanc Marine	*See Marine Transport*						
Lone Star Transportation, LLC 1988	Fort Worth	TX			$$$$$	☺☺	Trucking
LTA Logistics, Inc. 2006	Miami	FL			$$	☺	Trucking
R.J. Langley, Inc.	Reserve	LA			$	☺	Trucking
Reef Innovations, Inc.	*See Secondary Materials*						
Riccelli Enterprises, Inc. 1991	Syracuse	NY	New Orleans	LA	$$$	☺☺	Trucking

Company name (Year Founded)	U.S. Headquarters		Other employee locations		Company Size (sales | # of employees)		Products or services
Land Transport							
Robert Smith Construction	*See Marine Transport*						
Soil Tech 1988	Naples	FL			$	☺	Trucking
Tango Transport, LLC 1991	Shreveport	LA	Shreveport Sibley West Memphis	LA LA AR	$$$$$	☺☺☺	Trucking
United Vision Logistics	Lafayette	LA			$$$$	☺	Trucking
West Coast Aggregate Haulers 1997	Venice	FL			$$	☺	Trucking

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