2011

Developing a Gulf-wide oyster reef restoration plan: identification of spatial, socio-economic and geo-political constraints

Elizabeth Ashby Nix
Louisiana State University and Agricultural and Mechanical College

DEVELOPING A GULF-WIDE OYSTER REEF RESTORATION PLAN: IDENTIFICATION OF SPATIAL, SOCIO-ECONOMIC AND GEO-POLITICAL CONSTRAINTS

A Thesis
submitted to the Graduate Faculty
of the Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Environmental Sciences

by

Elizabeth Ashby Nix
B.S., Mercer University, 2006
December 2011

ACKNOWLEDGEMENTS

I would like to thank my advisors, Dr. Megan LaPeyre and Dr. Margaret Reams, for their faith in me as a graduate student, as well as for their excellent guidance through this new experience. I thank Dr. Bryan Piazza and Mike Wascom for serving on my graduate committee. I thank The Nature Conservancy for funding this project, and TNC staff (Bryan Piazza, Seth Blitch, Richard Martin, Judy Haner, Jeff DeQuatro, Ann Birch, Mark Dumesnil, Tom Mohrman, Laura Geselbracht, Jorge Brenner, Zach Ferdana, and Melissa Jenks) for their unwavering support and assistance. I thank Luke Laborde for sharing his time and expertise with me. I thank Janis Landry, Patrick Banks, Lance Robinson, John Mareska, Chris Denson, Mark Berrigan, Steve Brown, Scott Gordon and the many other Gulf of Mexico State employees who provided essential data and information to this project. Finally, I would like to thank my parents, Paul and Cathy Nix, for encouraging me to be whatever I wanted, and for being so supportive every step of the way.

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ABSTRACT

Oyster reefs have recently been identified as one of the most endangered coastal ecosystems, fueling efforts to restore and enhance these systems. Oyster reefs located in the northern Gulf of Mexico have been identified as some of the healthiest of reefs globally, and current efforts focus on devising an approach to Gulf-wide restoration of these reefs. As with all natural resource management and restoration, success is dependent on more than simply understanding the biological requirements of the resource; rather, they are equally dependent on understanding and working within the social and political context in which these management and restoration activities must occur. This project has developed a framework for setting Gulf-wide oyster reef restoration goals by identifying the geo-political, socio-economic, and spatial context in which restoration will occur. Specifically, this project assesses key political and socio-economic factors affecting oyster reef restoration in the Gulf by 1) exhibiting differences and similarities in state requirements for oyster reef restoration, and view points among oyster reef restoration project leaders in each state 2) determining stakeholder and various user groups perception of oyster reef restoration and 3) providing a spatial tool to aid decision making regarding oyster reef restoration in the Gulf. Results show that there are currently differences among the states in their oyster reef restoration policies and requirements, and differences in project leader goals that may make it difficult to create a region wide oyster reef restoration plan. There is also variation in how various stakeholder groups prefer for oyster reef restoration to occur, though there is unanimous stakeholder support for oyster reef restoration. Important biological and socio-economic spatial information identifies areas that are suitable for oyster reef restoration, allowing decision makers to more fully understand the potential success or effects of

restored reefs. These studies show that there are socio-economic, geo-political and biological differences across the northern Gulf of Mexico that can ultimately create constraints as well as opportunities for a regional oyster reef restoration plan. This knowledge can help inform oyster reef restoration planners by guiding their restoration actions more efficiently and effectively, enabling them to achieve their desired outcomes.

CHAPTER 1. INTRODUCTION

1.1 Estuarine Restoration

The loss of many of the world's key ecosystems remains one of the most pressing challenges today. Much of this loss is due to increased human pressure on and use of the natural resources. With habitat loss being the single greatest threat to biodiversity, it is predicted that this and many other threats to flora and fauna will only increase over time (Wilcove et al., 1998). For estuarine systems, habitat loss and degradation have resulted in high stress on 70% of commercial valuable fisheries worldwide, and contaminant and nutrient overloads that affect large nearshore areas such as the North Sea. These are just a few of the numerous environmental issues that affect our coastal systems today (Seaman, 2007).

With such significant ecosystem change occurring globally, ecological restoration has become increasingly important as a means to reverse the degradation and create resilient ecosystems that can handle future disturbances (Lotze et al., 2006). Ecological restoration aims to restore an ecosystem to a previous state, resulting in the creation of a functional ecosystem from one that has been degraded, damaged or destroyed (Seaman, 2007). Restoration can occur at a variety of spatial scales and use a variety of methods, ranging from localized storm water restoration projects that employ alternative drainage methods in urban cities (i.e. Melbourne, Australia) (Walsh et al., 2005) to large efforts to restore entire ecosystems, such as the Everglades in south Florida, which aims to restore ecosystem structure and function while providing flood protection, bringing water to south Florida, and establishing forests for threatened species such as the Florida panther (Berger, 1992; Geist & Galatowitsch, 1999).

With high population pressure, coastal ecosystems are heavily impacted, with high rates of habitat loss, and are in critical need of restoration (Weinstein, 2008). Coastal systems are subject to many pressures that threaten their integrity including land loss, overfishing, coastal development, and pollution (Wilcove et al., 1998). For example, nutrient input from runoff creates offshore hypoxic zones around the world, and can have detrimental effects on the health of local inshore waters and their organisms (Kirby, 2004; Rabalais et al., 2010). Additionally, effects from climate change such as increased storm frequency, temperature, sea level, flooding and precipitation (Anthony et al., 2009) further threaten the fragile coasts, and are predicted to escalate with increasing greenhouse gases (Wilcove et al., 1998). Restoration ecologists and coastal managers are focusing their efforts on how to best restore and reverse these trends, while maintaining ecological functions in a human dominated landscape (Weinstein, 2008). The value that humans place on restoration of these systems can be seen in various social, scientific, and legislative mandates which aim to sustain and replenish ecological goods and services (Wyant et al., 1995), such as the Estuary Restoration Act, Title 1 of the Estuaries and Clean Waters Act of 2000, which was created to promote restoration of coastal and estuarine habitats (Thayer & Kentula, 2005). While these legislative mandates have largely focused on intertidal and exposed vegetated marshes and beach areas, significant focus in recent years has turned to sub-tidal habitats, such as submerged aquatic vegetation beds and shellfish reef habitats, as we begin to understand their role as essential habitat supporting valuable fisheries, and providing valuable ecosystem services (Coen et al., 2007; Grabowski & Peterson, 2007; Beck et al., 2009a;NMFS, 2007).

1.2 Oyster Reefs

Oyster reefs have recently become the recent focus of estuarine restoration efforts (Coen et al., 2007). A recent global assessment of the condition of oyster reefs concluded that approximately 85% of the worlds oyster reefs have been lost, making this one of, if not the most, imperiled marine habitat (Beck et al., 2011). A dramatic decline in oysters in North America can be attributed to lack of hard substrate for suitable habitat by larval oysters, causing both stocks and harvest numbers to decrease to an all time low (Breitburg et al., 2000; Coen et al., 2007). Furthermore, erosion, coastal development, boat traffic, destructive harvesting practices, overharvesting and mismanagement can disturb and degrade habitats and are cited as being largely responsible for the decline of oyster reefs, and the loss of the services they provide (Coen et al., 2007; Grabowski & Peterson, 2007).

Oyster reefs serve as critically important ecosystems due to the fact that they provide a multitude of functions such as essential fish habitat, shoreline protection, and water filtration while supporting commercial and recreational use (Coen et al., 2007). As the only hard substrate available in many estuaries (Grabowski & Peterson, 2007), oyster reefs serve as habitat for over 300 species that directly or indirectly rely on them (Wells, 1961; Tolley et al., 2006; Barnes et al., 2007). Oysters affect nutrient cycling by diverting nutrients to the benthos and have the ability to remediate eutrophic systems (French McCay et al., 2003). Likewise, oysters can decrease the microbial, micro-algal, planktonic, and sediment and pollutant loads in the water (Newell, 1988; Newell & Langdon, 1996; Grabowski & Peterson, 2007), enabling light penetration which is essential for submerged aquatic vegetation (Barnes et al., 2007). The reefs created by oysters can serve as breakwater for waves and diminish the harmful effects of storms by preventing erosion and catching sediment (Meyer, 1997;Piazza et al., 2005). Oyster reefs also

provide important aesthetic, research, and educational value for local communities (Powers et al., 2009). Recognition of threats to these oyster reefs and the vital goods and services they provide has given rise to an increased focus on restoration and conservation efforts.

The northern Gulf of Mexico region is of primary concern for future oyster reef conservation and restoration due to its status as one of the only "fair condition" reefs in the United States (Beck et al., 2011). This region supports large areas of oyster reefs, which helps support the northern Gulf of Mexico's rich and culturally important commercial and recreational fisheries. For example, in 2009, over $618 million in commercial landings of all fish species (NMFS, 2011) were brought in from the northern Gulf of Mexico, and this region accounted for over 90 % of the national eastern oyster (*Crassostrea virginica*) landings (Figure 1), valued at over $70 million dollars (Figure 2) (NMFS, 2011). Even more critical is the recognition that northern Gulf of Mexico oysters, and the reefs they create, potentially contribute to shoreline protection through erosion control and wave attenuation (Meyer et al., 1997; Henderson & O'Neil, 2003; Piazza et al., 2005) provide habitat for juvenile fish and crustaceans (Grabowski, & Peterson, 2007;Scyphers et al., 2011), provide food for a variety of important recreational and commercially important species (Barnes et al., 2007; Grabowski & Peterson, 2007) contribute to local and regional water quality (Grabowski & Peterson, 2007), potentially contribute to carbon (Peterson & Lipcius, 2003; Hall et al., 2011) and nutrient sequestration (Grabowski & Peterson, 2007), establish places for recreation, inspiration and education (Roberts et al., 2003a), and serve as important economic goods to the region and nation (Grabowski & Peterson, 2007; NMFS, 2011). Despite all these services that these oyster reefs potentially provide, reefs along the northern shore of the Gulf of Mexico remain threatened by harvest practices, natural (Hurricane

Katrina) and man-made disasters (Deepwater Horizon Oil Spill), and environmental stresses resulting from hypoxia, coastal management practices (i.e., diversions) and climate change.

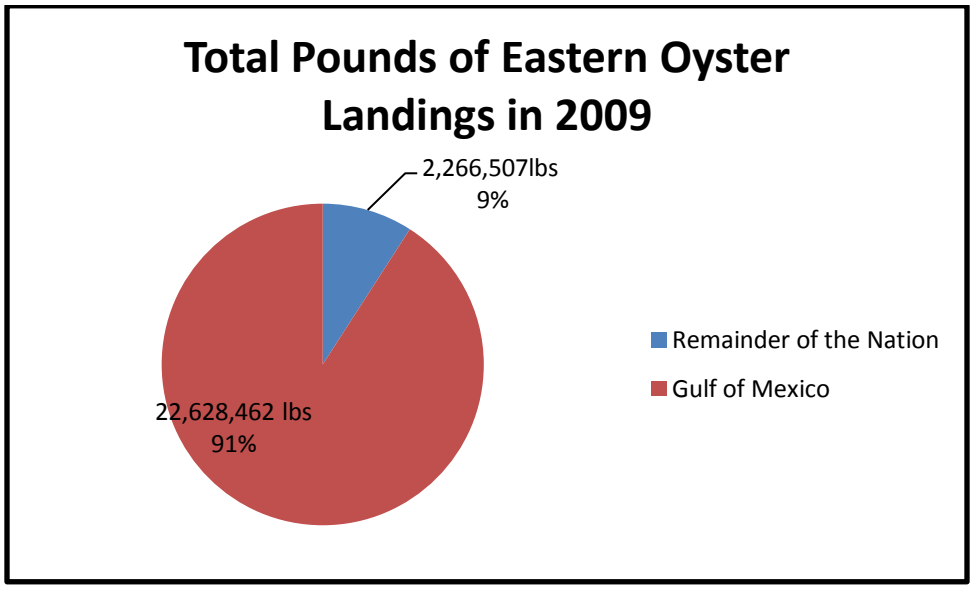

Figure 1. The total pounds and percentage of eastern oyster landings in 2009 for both the U.S. and the northern Gulf of Mexico (NMFS, 2011).

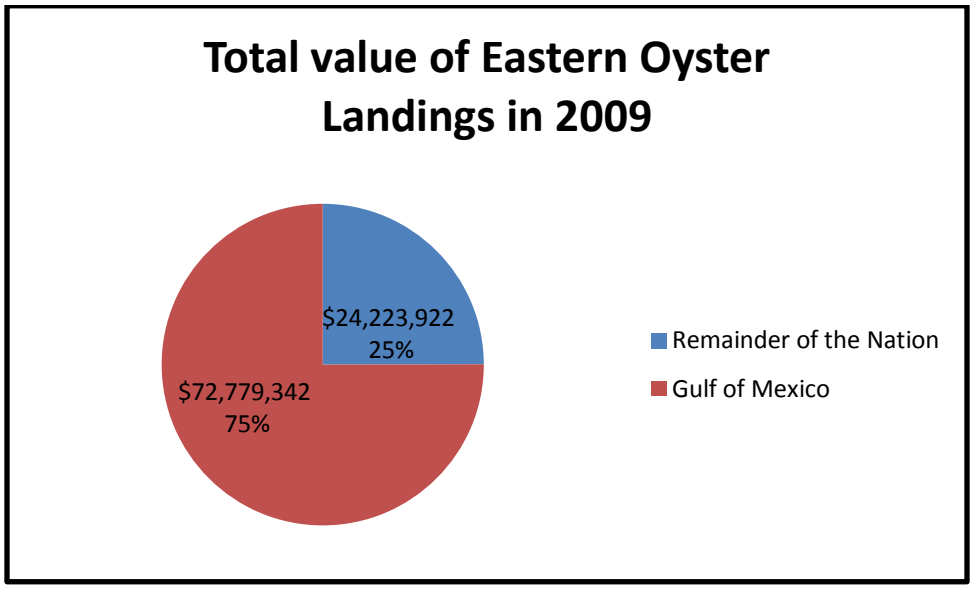

Figure 2. The total value and percentage of eastern oyster landings in 2009 for both the U.S. and the northern Gulf of Mexico (NMFS, 2011).

1.3 Gulf Coast Oyster Reef Restoration

The significant loss of oyster habitat has fueled recent efforts at the local, state, and national level to develop oyster reef restoration plans (Brumbaugh et al., 2010). Historically, oyster reef restoration focused on enhancing existing fisheries (Coen & Luckenbach, 2000; Grabowski & Peterson, 2007; Seaman, 2007), and the term oyster reef restoration is often still viewed by locals and managers as a method of improving fisheries. However, with increased understanding of the important role of oysters and their reefs in estuaries, restoration efforts are now focusing more on revitalizing and reestablishing ecosystem services and restoring a critical estuarine habitat instead of simply enhancing commercial oyster fisheries (Grabowski & Peterson, 2007). Recent efforts are being spearheaded by a variety of parties ranging from federal and state agencies to non-profit/non-governmental organizations, and private landowners, with a variety of strategies and end-goals. These strategies include establishment of spawn sanctuaries and no-take zones for export of larval spat and enhancement of local harvest areas, the establishment of complex, three-dimensional artificial reef structures, and the implementation of community-based projects which get local residents involved in growing, monitoring and protecting restored reefs (Brumbaugh et al., 2000).

Artificial reef structures have been built with several different of methods and materials. Materials are either placed on the estuary floor (Seaman, 2007) or placed exposed along the bank in the intertidal zone (Powers et al., 2009) to create hard substrate for oyster attachment and growth. Materials used include fresh or fossilized bivalve shell (often the most successful, common and desired material) (Gregalis et al., 2008), limestone marl and coal ash pellets (Coen & Luckenbach, 2000; Powers et al., 2009), and rebar, rip rap and cement in various forms and arrangements (Scyphers et al., 2011). Reef structures may vary from tall, three-dimensional,

complex vertical structures (which have been shown to be important in areas of hypoxia but more susceptible to damage from fishing gear) (Gregalis et al., 2008), to thin layers of shell scattered upon the seafloor, varying in density and arrangement (Powers et al., 2009). Still another approach is 'oyster gardening', where oysters are grown off of private docks, to promote the establishment of a local oyster population (Rossi-Snook et al., 2010).

Oyster reef restoration efforts have historically been small scale projects that, though very important, may fail to provide the large-scale benefits of fully functioning ecosystems (Manning et al., 2006). Currently, efforts are underway to create large scale restoration projects in the northern Gulf of Mexico. However, to successfully implement large-scale oyster reef restoration, it is essential to understand what factors are most important to the long-term success and viability of an oyster reef. For example, while studies documenting the historic abundance and location of reefs are useful, substantial environmental changes may have occurred in many areas that may make historic locations no longer suitable to support sustainable and viable oyster populations, and these changes can be natural, human-induced, or both. Human-induced changes in environmental conditions often result from political decisions that consider social, economic, and legal factors, making these factors critical to the success of oyster reef restoration. Such is the case in Chesapeake Bay where overfishing and disease have caused the decimation of the eastern oyster, and now efforts to restore the historical oyster beds are inhibited by the human induced eutrophication of the waters (Kemp et al., 2005). Therefore, it is critical to understand not only the biological and environmental factors that govern the establishment and growth of oyster reefs but also the socio-economic factors that can govern project establishment and management and make or break efforts to implement large-scale restoration.

1.4 Social and Spatial Considerations

Successful restoration requires not just understanding the biological needs of the ecosystem, but must also include consideration of the social, economic and political constraints to the project. In the past, restoration projects have been deemed unsuccessful partly due to planners neglecting to incorporate these constraints (Choi, 2004), making them difficult and frustrating to remediate (Weeks & Packard, 1997). For instance, while restoration can be politically driven by the public's desire to restore areas damaged by development, it is also the public's willingness to pay for restoration that often limits these efforts (Hackney, 2000). In order to change the management paradigm and develop a restoration program that values the ecosystem services of oyster reefs, project planners must incorporate both ecological knowledge and stakeholder's social and economic concerns in the beginning of the decision making process that determines the outcome for a project (Higgs, 1997). By examining the entire socio-economic and geo-political landscape then restoration can be conducted that is conducive ecologically, given local biological constraints, and conducive socially, given local values (Wyant et al., 1995).

Restoration of oyster reefs is constrained by a set of biological variables that dictate the establishment and long-term viability and sustainability of the oyster population. Temperature, salinity, and their synergistic effects have the most profound effects on oyster survival (Shumway, 1996). These factors influence virtually every aspect of oyster biology including feeding, respiration, predation, growth, disease, spawning and recruitment (Shumway, 1996). For example, while oysters are well known for their wide tolerance to salinity for establishment (5 to 40) and growth (optimum range 14 to 28) (Galstoff, 1964), most oyster production along the northern Gulf of Mexico coast occurs in a much smaller salinity range (5 to 15) because of

excessive mortality due to *P. marinus* infections (Craig et al., 1989), and predation from oyster drills at salinities above 15 (Galstoff, 1964; Breithaupt & Dugas, 1979; Mackenzie et al., 2009). Thus, natural or anthropogenic changes in hydrology, such as increased freshwater flow by diversions or increased rainfall, can significantly impact oyster survival and growth in the region (Powell et al., 2003; Roberts et al., 2003b). In addition, variations in food concentrations, pH and light may also be key in the success of oyster restoration projects. Shipping channels, pipelines, and other human disturbances can alter or prevent the settlement of oysters in what would otherwise be suitable habitat (Roberts et al., 2003a). These and many other environmental variables can ultimately determine the placement and success of a viable oyster reef.

The northern Gulf of Mexico is also characterized by a rich and complex arrangement of resources and culturally diverse, resource-dependent people who use the estuary for often competing purposes. For example in Louisiana, diverse communities and cultures (Houma, Cajun, Creole, African American, Vietnamese, and Canary Island Spaniards) share the coastal ecosystem, often using it for subsistence and cultural traditions that can vary greatly between communities (Tidwell, 2003; Anthony et al., 2009). Therefore, the human landscape and accompanying socio-economic factors are important to the success of oyster restoration projects and programs in the region. Assessment of the societal values of these stakeholders occurs infrequently, but it is crucial to understanding this human landscape in which many restoration projects are proposed (Thayer & Kentula, 2005). As such, decisions about ecosystem management projects should not only incorporate data about the project region and its ecological and social climate, but should also determine how this information can be prioritized in restoration projects (Endter-Wada et al., 1998), resulting in "higher quality decisions, higher

levels of legitimacy of decisions, more resilient communities, acceptance of implementation, and compliance with measures" (Menzel & Teng, 2009).

1.5 Objectives of Study

This project seeks to develop a framework for setting Gulf-wide oyster reef restoration goals by identifying the geo-political, socio-economic and spatial context in which restoration will occur. Specifically, this project will (1) document state specific processes and current attitudes towards oyster reef restoration through targeted interviews (Chapter 2); (2) assess key political and socio-economic factors influencing the perception of oyster reef restoration and management activities through a Gulf-wide stakeholder survey (Chapter 3); and (3) develop a spatial tool that combines known biological needs of oysters, and socio-political and physical factors that may affect the long term success of reef restoration projects in order to help identify areas of high opportunity for successful oyster restoration projects (Chapter 4).

Chapter 2 reports on interviews conducted with identified state and non-profit oyster reef restoration program leaders for each Gulf of Mexico State (Texas, Louisiana, Mississippi, Alabama, and Florida). This information gives insight into how each state differs in their oyster reef restoration activities, their requirements and obstacles and the various viewpoints of the oyster reef restoration process, goals and methods that would need to be reconciled for the development of a gulf-wide restoration program.

Chapter 3 reports on a survey mailed to key stakeholder groups in all five states (oyster harvesters, shrimp trawlers, coastal scientists, regulatory agency employees, and environmental organization members). The survey assessed key political and socio-economic factors influencing oyster reef management and restoration activities. The results of the survey will shed light on potential conflicts, obstacles and opportunities for oyster reef restoration in the northern

Gulf of Mexico by asking about public use, perceptions, knowledge, and preference of oyster reef restoration.

Chapter 4 outlines a spatial web-based decision support tool which incorporates informative map layers to help guide decision makers on oyster reef restoration project placement. This tool was developed in collaboration with The Nature Conservancy, and will serve as a guide for decision makers on coastal and oyster reef restoration in the northern Gulf of Mexico.

Collectively, this work helps to identify the political, socio-economic and biological constraints and opportunities for oyster reef restoration in the northern Gulf of Mexico region. By understanding the opportunities and obstacles of a regional or estuary-specific plan, a restoration strategy may be developed that is more efficient and effective in achieving desired outcomes.

CHAPTER 2. COMPARISON OF OYSTER REEF RESTORATION APPROACHES AND REGULATIONS ACROSS THE GULF OF MEXICO STATES

2.1 Introduction

State governments are mandated by the Coastal Zone Management Act of 1972 to manage their coastal zone region. Each coastal state serves as the central decision making authority for its coastal zone region through federally approved Coastal Zone Management (CZM) Programs (30 total in U.S), which aim to conduct land use planning and control coastal uses, while taking into account the value of the environment, natural hazards, and development pressure in the region (Randolph, 2004). These programs also include regulation of various coastal zone resources, including oysters. Because each state has separate authority over management and restoration of oyster resources, each state also has a distinct history with regards to oyster management, as well as a distinct regulatory agency that presides over them. Consequently, oyster reef restoration and the management of oyster resources can vary greatly between each state. Issues often arise in oyster reef restoration because of the lack of consistency between rules, regulations, and procedures amongst political jurisdictions such as the differences in the disposition toward and length of time and complexity in obtaining a restoration permit in each state (Brumbaugh & Coen, 2009; Tomicevic et al., 2010). In developing a gulf-wide strategy for restoration, it is crucial to thoroughly understand these differences and similarities between states so that region-wide planning accounts any special process requirements and potential obstacles that may affect efforts for region-wide restoration.

While each coastal state may be primarily responsible for the activities in its coastal zone, there are many other organizations that are implementing restoration initiatives, including oyster reef restoration, and are leading the efforts to combat the loss of important or jeopardized coastal habitats in the northern Gulf of Mexico. These groups vary from local governments (i.e., Plaquemines Parish, Louisiana), to non-profits (i.e., The Nature Conservancy, Coastal Conservation Association) and academic institutions (i.e. University of Southern Alabama, Louisiana State University), to private consultants. Each of these groups may vary in their intentions and desired goals, but they all have included oyster reef restoration as a viable option and method for restoring the Gulf coast.

While numerous parties engage in oyster reef restoration, their activities are directed by different priorities, and influenced by different constraints (Murray, 1994). For example, most shellfish restoration efforts by state agencies appear to be focused on enhancing populations of commercially viable product for fisheries (Coen & Luckenbach, 2000). Conversely, non-profits and private organizations are beginning to pursue oyster reef restoration to not only restore oyster populations where they have been degraded but also to revive the associated ecological services and functions that were lost. For-profit companies, such as environmental contractors and consultants are becoming involved in oyster reef restoration as they see increased demand for restoration along the coast.

The objective of this research is to gain insight into the current oyster restoration climate in the northern Gulf of Mexico to guide future cross-state oyster restoration plans. To do this, we interviewed key state oyster program managers as well as oyster restoration program managers from The Nature Conservancy, a leading non-profit organization restoring oysters in the northern Gulf of Mexico. We documented the current state of and goals for oyster restoration

amongst groups, differences and commonalities of legal and regulatory requirements between states, and opinions and obstacles that may affect future oyster restoration efforts. Documenting this material from key players in oyster reef restoration in the northern Gulf of Mexico allows for insightful comparison and greater understanding of the various perceptions and positions on oyster reef restoration in the northern Gulf of Mexico and identifies areas of future conflicts and constraints, commonalities, and possible improvements in future restoration efforts.

2.2 Methods

We conducted a phone or e-mail interview with state oyster managers and TNC staff from each Gulf state (TX, LA, MS, AL, FL). To do this, we first identified the lead individual in each state program and TNC chapter responsible for oyster management and restoration (Table 1). Once identified, these individuals were then sent an initial e-mail with a description of the project, a copy of the questions (Figure 3), and a request for either a phone interview or the option to respond via e-mail to the questions. If a phone interview was preferred, then answers to questions were written down during the phone conversation and all interviews were conducted by the same individual.

Answers were summarized for ease of comparison and analysis. The results of the interviews are presented as a synopsis of the opinions and knowledge of the respondents. When possible, facts were checked for accuracy, but much of what is presented is based solely on the views and opinions of respondents. Any incorrect or misleading information may be the result of the misinterpretation of the interviewee comments. References listing interviewees refer to information taken from interviews conducted as part of this study.

Table 1. List of state agency and TNC program managers who participated in either a telephone or e-mail interview. Also shown are the job titles and affiliation of respondents.

Name	Title	Affiliation
Lance Robinson	Coastal Region 1 Director	Texas Parks and Wildlife
Patrick Banks	Biologist, Oyster Program Manager	Louisiana Department of Wildlife and Fisheries
Scott Gordon	Shellfish Bureau Director	Mississippi Department of Marine Fisheries
John Mareska	Marine Biologist	Alabama Department of Conservation and Natural Resources
Mark Berrigan	Bureau Chief of Division of Aquaculture	Florida Department of Agriculture and Consumer Services
Mark Dumesnil	Upper Gulf Coast Program Manager	The Nature Conservancy Texas
Seth Blitch	Director of Coastal and Marine Conservation	The Nature Conservancy Louisiana
Thomas Mohrman	Marine Program Manager	The Nature Conservancy Mississippi
Judy Haner & Jeff DeQuattro	Marine Program Director & Coastal Projects Manager	The Nature Conservancy Alabama
Anne Birch	Coastal Restoration Director	The Nature Conservancy Florida

2.3 Results and Discussion

2.3.1 Current State of Oyster Reef Restoration Program

Each of the five Gulf of Mexico states is engaged in oyster reef restoration in its coastal waters. Many of the state programs have been in existence for several decades, although several states have just recently created informal oyster reef restoration programs. Some of these states have implemented long term reef restoration activities that have served as the principle management tool for maintaining commercial harvest reefs. Most states that currently restore reefs for commercial harvest purposes do so by establishing low profile reefs of two to six inches

CURRENT STATE OF OYSTER RESTORATION PROGRAM

1. Does the state have an oyster reef restoration program?
2. Please name the organizations that conduct oyster reef restoration in your state.

DEFINITION OF OYSTER REEF RESTORATION

3. What is your definition of oyster reef restoration? What is the reason for oyster reef restoration?

LEGAL SETTING

4. Please explain the process that one must go through to conduct oyster reef restoration (i.e. permits, legal requirements, time) and what agencies handle these requirements.
5. What limitations/requirements are there to conducting oyster reef restoration (i.e. materials, signage, and locations)?
6. If not conducted by the state, is it preferred that oyster reef restoration incorporate the permitting agency as a partner?
7. Are oyster reefs allowed to be restored in poor water quality areas?
8. Is oyster reef conservation allowed through lease holding, such as "no take" leases?

ISSUES/OBSTACLES

9. What do you think are some of the strengths and weaknesses of the current management, policies, or actions of the oyster reef restoration program?
10. Please explain what you believe needs to be improved or changed in the oyster reef restoration program.
11. What issues or concerns do you have if oyster reef restoration becomes a more popular and common method of coastal restoration?
12. What do you think are the biggest obstacles that prevent oyster reef restoration from being more successful or popular?

FUTURE

13. Is oyster reef restoration a priority for you or your agency and in the long term plans?
14. What do you perceive the future of oyster reef restoration to be in your state?

Figure 3. Interview questions presented to ten state agency and TNC oyster program managers from the give Gulf of Mexico states. Respondents were given the choice to answer questions over the telephone or via e-mail communication.

that can be reseeded and harvested by dredge or tong. For instance, the Louisiana Department of Wildlife and Fisheries oyster reef restoration program has a long history of success, providing a high return on investment and ecological benefits to the surrounding area. The Department will soon be experimenting with reseeding areas with hatchery spat to boost both commercial and ecological benefits. Officials in Mississippi feel fortunate to have such a suitable natural environment for growing oysters, but the state also supplies cultch material (substrate for oyster larvae to settle upon) on its oyster beds to supplement natural growth. The State of Florida's oyster reef restoration program has been self-sustaining, self-funded, and self-reliant for the past 60 years, and continues to be so today. The State of Alabama uses oyster reef restoration as the key component in its oyster management program and now uses an oyster gardening program to supplement its restoration efforts. This fairly new approach involves growing oysters locally by various means such as in floating cages off personal docks. The oyster gardening program also hopes to be integrated into the aquaculture curricula of local high schools to foster restoration stewardship. Alabama has also recently made law changes to fund routine supplemental cultch plantings or cultivation of existing cultch on its oyster beds. In the past, Texas oyster reef restoration was primarily done to mitigate the effects of shell dredging operations. However, in 2007, the state created an official oyster reef restoration program.

In each of these Gulf States artificial reef programs are also restoring oyster reefs. The National Fishing Enhancement Act of 1984 (33 USC § 2103, *et seq)* gives the states the task of enhancing fish habitat through artificial reefs, and those reefs can be located inshore or offshore. For instance, the Mississippi Artificial Reef Bureau aims to create both offshore and inshore reefs for fish habitat and recreational fishing activities. Offshore reefs are often made of abandoned oil rigs and sunken derelict vessels, while near shore or in shore reefs are often

created with oyster shell or other material with the aim of attracting oyster larvae. Maps and coordinates of these reefs are published online for each state to encourage recreational fishermen to visit and use the reefs. Though these artificial reef programs may be increasing oyster habitats and associated ecosystem services, they are primarily intended for recreational fishing use.

In recent years, The Nature Conservancy (TNC) has become engaged in oyster reef restoration, with all five Gulf States now having dedicated reef restoration staff. TNC's involvement in oyster reef restoration was spurred by its Global Marine Team and their finding that 85% of oyster reefs have been lost globally (Beck et al., 2009a). Today, TNC is restoring reefs from North Carolina to Texas, with numerous projects in each state. From quilt-like mat structures in Indian River Lagoon in Florida, to several tons of oyster shell being loosely deposited in Copano Bay in Texas, TNC's oyster restoration efforts across the northern Gulf of Mexico aim to address the loss of ecological services by creating complex, three dimensional reef structures. TNC's presence in each of the Gulf States has enabled it to become a key player in the effort to restore coastal ecosystems, using oyster reef restoration as one of its primary methods of achieving this goal.

State fisheries management agencies and TNC are just two of the many organizations conducting oyster reef restoration in the northern Gulf of Mexico. Others include federal and local entities programs such as U.S. Coast Guard, U.S. Fish and Wildlife Service, various U.S. Army bases, and the Florida Department of Environmental Protection, Ecosystem Restoration Section and local municipal entities such as St. Bernard Parish, Louisiana. Other non-profits include the Tampa Bay Foundation, the Coalition to Restore Coastal Louisiana, and universities such as Florida Gulf State University and University of Central Florida.

2.3.2 Definition of Oyster Reef Restoration

State agencies identify the goal of reef restoration primarily as restoring and enhancing commercial production of the oyster fishery in areas that have historically had oyster reefs. Secondarily, they identify the goal of promoting the ecological services that these reefs provide. The primary goal of oyster reef restoration according to TNC is to restore historic reefs to produce fully functioning, three-dimensional reef systems that provide associated ecosystem services and biological functions, such as marine biodiversity, shoreline protection, sediment trapping, water-quality improvement, and recreational fishing opportunities. A compatible goal is for projects to support the state commercial oyster fishery, through projects that may have the ability to provide a commercially harvestable product while also providing important ecological benefits to the surrounding area.

2.3.3 Legal Requirements

In order to conduct oyster reef restoration, the group implementing the project must comply with applicable federal and state statutes and regulations. The information below is not a legal review of all requirements, and thus does not provide specific legislative or case law references, but rather is intended as an overview of some of the regulations and the myriad of legal issues encountered by both state government and non-profit organizations involved in reef restoration.

Oyster reef restoration permitting procedures are not defined as separate and distinct subject matter in state and federal laws and regulations. Therefore, one must look to other regulated categories to determine how to obtain a permit to build an artificial reef. All states are subject to federal regulations for performing work within the waters of the United States (defined as any navigable waterway, including those which are subject to ebb and flow and extends to a

few miles offshore), pursuant to section 10 (33 USC § 403) of the River and Harbors' Act of 1899. Therefore, artificial reef projects in each state require a permit issued by the United States Army Corps of Engineers (USACE) because the material used to create these reefs is often considered "fill" material, and therefore constitutes "dredge and fill activity" which is regulated under section 404(b)(1) of the Clean Water Act (33 USC § 1344). Occasionally, "living shorelines" restoration projects, or those projects which are conducted as an alternate method of arming the shoreline by using natural materials (The Nature Conservancy, 2011b), may be exempt from obtaining this permit if the project is considered a shoreline stabilization activity rather than dredge and fill activity. Rip-rap and other materials, which are not considered "fill" material, fall under the category of stabilization material are also sometimes exempt from the permit requirements (Blair, 2011). This fine line between oyster reef restoration and "living shorelines" makes it difficult to understand what restrictions may apply.

A joint Coastal Zone Management section 404 permit is issued by the U.S. Army Corps of Engineers (USACE) and the state regulating agency for coastal water bottoms. State regulating agencies include the Louisiana Department of Natural Resources, Mississippi Department of Marine Resources, Florida Department of Environmental Protection, Texas General Lands Office, and Alabama Marine Resources Division. This joint permit is required in order to conduct oyster reef restoration in any of the coastal states and requires an applicant to provide information such as a description and purpose of the activity, details of fill material to be used, and efforts planned to minimize environmental impact. This permitting process also may require a Clean Water Act section 401 Water Quality Certification. Landowner consent and "to scale" drawings of planned activities, and details of environmental conditions are also required (USACE, 2011). As oyster restoration projects are often conducted to address shoreline erosion,

and accretion of the land may occur, then it is important that the landowner consent to the activity and that there is agreement as to who owns any land that is accreted from the project. Explicit rules and definitions regarding land ownership and use are needed. If the permit is approved by both the state and federal parties, the applicant is issued a standard permit (which is followed by a public notice and comment period), a general permit, or a letter of permission. General permits are given to several projects that are similar in nature and have little impact and can be issued on a nationwide basis for activities such as invasive species removal. Oyster reef restoration projects are often given these general, nationwide permits. The letter of permission is used if the proposed work is minor and similar projects have been conducted in the past (i.e. docks, bulkheads, etc.) (EPA, 2011).

For the permit to be approved, the restoration project must also be in compliance with other federal laws and regulations. This includes acts such as the Endangered Species Act of 1966 (16 U.S. C. § 1531(a)(3)), which aims to conserve ecosystems which are necessary for the preservation of endangered species (Ferrey, 2010). This Act is in effect in areas where endangered species are located such as Charlotte Harbor, Florida (a known saw tooth shark, *Pristis pectinata,* habitat) and the Mississippi coast, home to the endangered Gulf Sturgeon (*Acipenser oxyrinchus*). Restoration projects in areas subject to the Endangered Species Act require proof that the activity will not harm the endangered species, and permits must be obtained from the National Marine Fisheries Service. If oyster reef restoration is conducted on federally-owned property, such as property controlled by the National Park Service, then the applicant needs to obtain a National Park Service “research and restoration" permit. If the project is conducted by a federal department, such as the USACE, or if a significant amount of funding is received from a federal agency, then a completed Environmental Impact Statement

and a NOAA Biological Assessment may be required. If the project is conducted by the USACE, then a construction permit is not required. If the restoration is in proximity to any federal water channel, such as a major port like that in Mobile Bay, then the Port Authority and U.S. Coast Guard must be consulted. Each of these federal requirements must be met by project leaders in all coastal states in order to legally conduct oyster reef restoration.

If an oyster reef restoration project poses a threat to navigation, such as with building high vertical relief reefs, then the applicant must abide by the protocols of the U.S Coast Guard, because it is the federal agency responsible for maintaining commercial and recreational mobility in the nation's waters. The restoring agency must provide appropriate and adequate signage about the presence of restored reefs to ensure the safety of maritime travel. There are restrictions on the vertical height of reefs so that navigation is not impeded. Additionally, there are limitations on how far from shore the reefs can be built and limitations on the impacts of restoration project construction and deployment to the shoreline. These regulations may be from the federal level, but also vary at the state level. For instance, Alabama requires pilings and signage wherever oyster reefs are restored for commercial purposes. At many of TNC's restoration sites (such as in Louisiana) signage is placed at restored reefs to make sure that they are not an impediment to navigation, because potential lawsuits from boaters, users and homeowners are a concern. As coastal areas with retreating wetlands are being restored with oyster reefs, liability issues may become more prevalent where reefs are built in areas of retreating wetlands, as the potential for someone to run into an unmarked reef increases.

A state may also have statutes and regulations unique to its jurisdictional waters. For instance in Texas, if a lease is required by the state in order to construct the restoration project, then the applicant must get permission from the Texas General Land Office (TGLO). In Texas,

reefs are generally restored in water bottoms where they were historically present because leasing new water bottoms would remove areas from potential use for other needs such as oil and gas leases. In Florida, restoring reefs in Aquatic Preserves requires additional permits, as does restoring reefs in approved water quality areas. Living shorelines often grow a variety of species of mangroves (*Avicennia germinans*, *Rhizophora mangle*, and *Laguncularia racemosa*) in states like Florida. This effect triggers regulations that pertain to the alteration of mangroves (Blair, 2011). If the restoration project involves moving live organisms, such as larval spat or spawning oysters, from one location to another then the appropriate state jurisdictional agency must also be notified (i.e., Florida Fish and Wildlife Conservation Commission). If restoration will involve aquaculture of the oysters, or growing oysters for consumption, then state shellfish aquaculture departments must be notified (i.e. Florida Department of Agriculture and Consumer Science). Each state may have additional unique requirements or restrictions for oyster reef restoration in their coastal waters, but determining these is beyond the scope of this paper due to the fact that most are neither explicitly documented nor available to the public. Also, many individuals who were interviewed did not elaborate specifically on those rules or regulations that are unique to their states.

Though it is not required, it is recommended, by both the states and TNC, that the permit applicants enroll the applicable state department and other involved agencies as partners in the project. These agencies can work with the applicant to help alleviate potential issues by assisting in choosing an appropriate location for reef establishment and approved materials for building the reef, as well as ensuring that projects are sited away from navigation channels and other restricted areas. Additionally, several agencies are often required to comment on the proposed project, so the permitting and restoration process can be expedited by establishing open

communication from the beginning and building a relationship between the project group and the regulatory agencies. Partnering with these agencies allows the project group to understand exactly what is required of them for oyster reef restoration, as much of this material is not readily available to the public online or otherwise documented. Occasionally, the permit application process is contracted to private businesses, allowing valuable time and resources to be spent elsewhere. Though this may be a logical and efficient use of resources, contracting this portion of a project may prevent agencies from understanding the vast array of challenges that one must overcome in order to obtain required permits.

In the Gulf States, state managers and non-profit organizations clearly disagree as to whether oyster reef restoration should be allowed to occur in waters that are not approved for harvest. This divide stems from the differing goals of state and non-profit restoration programs. Whereas the former conducts restoration for harvesting purposes and therefore seeks approved water quality areas, the latter conducts restoration for ecological purposes, often in regions of unapproved water quality, with the goal of helping improve water quality. Restoration in these unapproved areas is often conducted by various non-governmental organizations to help restore and rehabilitate habitat in environmentally impaired areas. In Alabama, The Nature Conservancy is allowed to restore reefs in unapproved waters if the project is considered a "living shoreline" and if there is little oyster shell used in building the base for the reef. When restoring reefs in unapproved water, particular attention must be paid to the human health component. Education of both commercial and private fishermen is necessary to ensure that oysters from projects in unapproved areas will not be consumed or illegally harvested and sold. If proper signage and precautions are not taken to ensure that this oyster product is not consumed, it could jeopardize the reputation of the state oyster product. This reputational risk is

already a major concern for human health and seafood agencies such as the Interstate Shellfish Sanitation Conference and Federal Drug Administration, and will only increase as oyster reef restoration for the sole purpose of restoring ecological services becomes more common. Public perception of Gulf seafood is of great importance, as demonstrated in the aftermath of the Deepwater Horizon oil spill, when the safety of Gulf seafood was publicly scrutinized. This concept of restoring oyster reefs in areas of unapproved water quality needs to be comprehensively addressed with each state's public health division.

Another method of oyster restoration is the purchase and management of "no take" leases. Many states encourage or require leaseholders to improve oyster habitat by investing in substrate and planting oyster shell to maintain the sustainability of the lease and product. Leaseholders may then choose not to harvest, and this option may be suitable for restoration programs in the future. In Texas, no-harvest leases must get Texas Parks and Wildlife Department commission approval. Obtaining an oyster lease can be difficult in some states, such as Louisiana and Texas, due to moratoriums on new leases and lease applications. Further, the likelihood of finding an available lease may be slim as these often are held by long-term holders. Establishing new leases in Mississippi and Alabama may also be difficult because much of the suitable oyster habitat already has oysters present and is leased, and there are few, if any, new private leases available. Many respondents believe that it will be a challenge to restore reefs and keep them un-harvested, as typically oysters are harvestable where they are currently found. These issues may inhibit future oyster reef restoration projects where the goal is to restore reefs for the purpose of restoring lost ecological services rather than for human consumption.

2.3.4 Issues and Obstacles

As oyster reef restoration has become a more popular and common method of restoration, the program shortfalls and obstacles that prevent program success have become apparent. Obtaining permits is often described as a complicated and difficult process that can take a long period of time to complete, and the time it takes to complete and receive an approved permit (up to 12 to 18 months) can significantly impede the restoration process. There are also issues with expired permits for constructed reefs, such as in the case of Alabama, where there is some uncertainty regarding who will take over the reefs after its five year permit term is expired. The current permitting process was not intended for projects such as long-term habitat restoration but rather for short-term construction type activities. This process could be made more efficient if the regulatory agencies would agree to general permitting guidelines and work with the applicants. Streamlining this process is especially critical because there are often multiple projects being conducted at one time, and reefs need to be planted during spat fall seasons to encourage rapid colonization of artificial reef structures. There is now quite a bit of discussion about this issue by both the permitting agencies and the practitioners, as more people are beginning to realize the benefits that oyster reef restoration can bring to the coast. For example, Florida is creating permitting guidelines to aid this process. Expedited permits may be another option, authorized on a case by case basis by the USACE (EPA, 2011).

As with the permitting process, it is important to TNC that each state regulatory agency support and collaborate on projects implemented by other organizations to ensure successful project outcomes. For example, getting resource managers and the shellfish industry on board with the concept of restoring oyster reefs for the primary goal of ecological services, rather than commercial harvest, is crucial to groups like TNC, else political influence may delay the

permitting process. Also, as mentioned previously, there are differing perceptions between resource managers and non-profit groups on the goal of oyster reef restoration and the acceptable methods used to restore reefs. Fortunately, there appears to be good communication among the agencies, and the contractors with which they work, as well as a push for new and innovative technologies and methods for oyster reef restoration. Increased support by agencies, managers, and the public would allow more funding to be available for these projects and allow more projects to be put on the ground.

Funding is often the "lynchpin" of successful oyster reef restoration for both state and non-profit organizations. Without adequate funding, there can be no purchase of cultch material, equipment or labor for installation. Secured funding, funding which is appropriated and designated for a specific purpose, is needed to restore and maintain current oyster reefs. Secured funding would allow states like Louisiana to scale up creation of three-dimensional oyster reefs and to establish "no take" leases which would provide both ecological and commercial benefits. The state of Texas oyster reef restoration program is now able to receive funds from a 20 cent tax on oyster sacks as a result of recent legislation. Funding is sometimes sporadic, as in the aftermath of Hurricanes Andrew and Katrina, facilitating primarily large but infrequent projects. The state of Florida has been able to use Emergency Disaster Recovery funds to support much of its restoration, and these funds have been key in past successes. Several members of TNC believe that it is both important to identify the financial risks of oyster reef restoration, and then to minimize these risks to facilitate more effective project implementation.

A lack of funding can also affect the ability to obtain oyster shell, which is the preferred material for oyster reef restoration projects. Availability of large quantities of oyster shell is a limiting factor for oyster reef restoration in many states, and the high demand for shell has

increased its cost, making it even more difficult to obtain. If this continues to be the case, alternative cultch materials such as rebar and concrete must be used in lieu of shell, and these materials may take longer to establish a natural reef habitat. Use of alternative cultch materials creates more restrictions on suitable restoration sites because heavy materials may sink into soft sediment and non-native materials may be heavily scrutinized to discourage excessive dumping of "junk" in the water. In Florida, the high demand for oyster shell has created controversy over who owns the shell. While oyster shell is the preferred material for practitioners across all Gulf States, only Mississippi and Florida claim to have good and reliable suppliers for shell.

There is hope by non-profit organizations such as TNC that increased awareness of the importance of oyster reefs and their benefits, beyond harvest, will instigate more funding and support to create more reefs. Several of TNC's project leaders believe that people, particularly in the science-based organizations, are becoming more familiar with the purpose of oyster reef restoration, are embracing it, and generally want it to occur particularly in states such as Louisiana with high rates of erosion and coastal land loss.

Oyster reef restoration as a coastal restoration method is fairly new and most restored reefs are young (5-10 years old). Therefore, though project monitoring is being conducted, there is still uncertainty regarding the success of these projects. It is crucial to allow time to establish the success of these restoration projects and hopefully create trust and more opportunities for collaboration among partners, such as state agencies.

Selecting an appropriate project site and restoration method can often be a difficult task. Oysters are highly dependent on suitable environmental conditions, and many areas that are suitable for oyster restoration already contain oysters and may not need restoration. In areas free of oysters, it can be difficult to find suitable substrate that can hold the weight of cultch material

and yet are free from obstructions like oil pipelines. Also, it can be challenging for states like Louisiana to obtain the appropriate equipment for site-specific jobs. Once a project is sited, care must be taken that restoration is done appropriately and in a manner that is aesthetically appealing, and this may mean tailoring the methods for a particular site and incorporating sound site-specific scientific information to ensure project success. Monitoring restoration projects closely and consistently with methods that evaluate ecosystem services is critical to ensuring the quality of these projects.

Forces that affect oyster survival and growth can be natural (i.e., Hurricane Katrina), anthropogenic (i.e., Deepwater Horizon oil spill, dams, freshwater diversions) or both (i.e., climatic variability and change). These forces have created a changing and therefore challenging environment in which to restore oyster reefs in the Gulf. Specifically, these forces create a constantly shifting ecosystem, in particular with regard to hydrology and salinity regimes, which can jeopardize short-term success, or long term sustainability of oyster reefs. For example, the effects of global climate change must be considered when establishing reefs in historical footprints where oyster reefs may not be sustained in the future. In another example, if water is restricted by dams or levees, then oyster areas will move closer to the shore and potential pollution sources. Some respondents fear that the cost of learning how all these factors affect project success may be expensive, especially if big projects do not attempt to take these factors into account.

2.3.5 Future

Oyster reef restoration is a priority to the agencies involved in the Gulf States and is being incorporated into their long term plans. Reef restoration activity almost certainly will

increase in the upcoming years, both for commercial and ecological purposes, but this is dependent on interest by the public, funding, the economy, and education of stakeholders regarding its numerous benefits. With state agencies focusing on commercially harvestable oyster reefs, there is an opportunity for groups such as TNC to address oyster reef restoration for non-harvest benefits. As the role of oyster reefs in supporting ecosystem health and resiliency is better understood, more focus on their restoration is occurring.

2.4. Conclusion.

Highlighting the issues and obstacles to oyster reef restoration at the state level not only gives insight into to what needs improving and remediating, but can also help guide agencies on what steps should be taken to create a more conducive restoration climate prior to oyster reef restoration plans that cross state jurisdictional boundaries. There are currently efforts being made to address identified problems with restoring oyster reefs such as expedited permitting procedures, liability clarification and risk assessment, and education and outreach. These efforts to improve the future of oyster reef restoration have resulted in more communication among project leaders and states, which will ultimately benefit restoration efforts.

An ecosystem based management plan may be an effective method for the future use and restoration of oyster resources in the northern Gulf of Mexico. Ecosystem management is often used as a method of restoring ecosystems and their associated functions while incorporating communities and stakeholders who are reliant on these systems (Szaro et al., 1998). For instance, the Chesapeake Bay, a water body that crosses many jurisdictional boundaries, has implemented a Chesapeake Bay Oyster Management Plan, which was created by multiple partners including federal and state agencies, academia, environmental organizations, and the

oyster industry to address the restoration of their critically decimated oyster population (Chesapeake Bay Program, 2008). Perhaps a similar approach may be appropriate for the northern Gulf of Mexico; this approach would involve integrating differences in state permitting requirements, coordinating restoration goals, identifying common site specific issues and targeting key ecological functions to restore into a unified vision for restoring oyster populations.

CHAPTER 3. STAKEHOLDER PERCEPTION OF OYSTER REEF RESTORATION – A SURVEY

3.1 Introduction

The socio-economic conditions of the local people and their relationship with natural resources, perception of natural resource management, and attitudes about conservation are crucial to consider when conducting restoration or conservation of natural resources (Tomicevic et al., 2010). Traditionally, however, very little stakeholder input has been incorporated into restoration project planning (Higgs, 1997). This is because involving stakeholders in natural resource planning is difficult. Stakeholders often differ in their perceptions of ecosystem characteristics, attitudes and norms about the environment (Turner et al., 2003), and there is often no way to satisfy all stakeholders, maximize all competing uses, or gain consensus in the politics and economics of the coastal zone (Weinstein, 2008). These stakeholder issues can and often do, to the dismay of many scientists, affect the management of a resource and influence restoration activities, particularly when neighboring communities are negatively affected by a project (Weeks & Packard, 1997; Buckley & Crone, 2006). Stakeholders with social and economic concerns can provide input into project planning in ways that do not compromise biological integrity, but they must be involved from the beginning (Roberts et al., 2003a). Stakeholders can provide socio-economic information that can be beneficial to guiding education, outreach and communication efforts, and their input can increase local support for restoration efforts (Endter-Wada et al., 1998). Involving stakeholders in project planning enables managers and policy makers to gain a thorough understanding of local peoples' attitudes, and also builds trust with local groups, which subsequently aids in the overall success of a restoration project (Roberts et al., 2003a; Buckley & Crone, 2006).

Previous studies involving marine ecosystems and artificial reef creation identified multiple stakeholders and assessed their user interests and input through surveys (i.e., Ramos et al. 2007, Vella et al. 2008). For example, a study of a Marine Protected Area (MPA) off the coast of Malta categorized its stakeholders as commercial (fishers, hotel industry, etc), government (fisheries management, environmental regulatory agencies, etc), public/NGO's (ecotourism, conservation and recreational interests), and research and education (educators and the scientific community). These stakeholders were surveyed to measure the effectiveness of integrated coastal management, and results from the survey were used to help ensure that an ecosystem based approach was effectively implemented (Vella et al., 2008). Similarly, a study of artificial reef deployment in the southeastern U.S. identified its users as sport fishers, sport divers, commercial fishers and environmental communities. These stakeholders were surveyed to assess perception and support for the artificial reef program in their state. This outreach enabled better reef management by providing knowledge of how these programs were perceived by the public, and this knowledge was then used to maximize benefits to the public (Murray & Betz, 1994). These examples demonstrate how the inclusion of stakeholder perceptions and input is critical to the success of coastal conservation projects.

Across the northern Gulf of Mexico, there are numerous stakeholders and agencies involved in efforts to restore and protect valuable resources. With newly focused attention on oyster reefs as a critical resource, and the creation and expansion of oyster-specific restoration programs, there is a push among numerous local, state and gulf-wide organizations to develop oyster reef restoration plans that are politically, socially and economically feasible. Despite this desire for public acceptance, there is very little knowledge regarding how different user groups

and stakeholders view reef restoration efforts or larger gulf-wide planning efforts related to oyster reefs.

A better understanding of the views, goals and biases of different user groups would inherently improve oyster restoration planning efforts. Support of the local community is essential if there is not strigent enforcement of marine areas (Kennish et al., 2002). Therefore, input from local fishers and a better understanding of their complex and often controversial harvesting areas, as well as their willingness to trade one ecosystem service benefit for another, can help minimize conflict with the fishing industry (Clarke et al., 2002).

In the case of oyster reef restoration, there are often competing users and uses of water bottoms, and commercial fishers are often affected by changes in those water bottoms. Oyster harvesters have important knowledge of the oyster resource due to their regular use of estuarine areas. These individuals also have a high potential for being beneficially or adversely affected by oyster reef restoration projects because their livelihood is very vulnerable to changes in environmental conditions and coastal management decisions that affect the way they harvest their reefs or the public oyster resource. Shrimp trawlers also have important local knowledge and effects on this industry are linked more to oyster reef type and placement. Oyster reef restoration may ultimately benefit shrimp fisheries by providing essential habitat for juveniles. However, artificial reefs may also be impediments to trawling gear, as nets can get caught and torn on their hard, sharp structure. Additionally, new reefs built on the bay floor decrease the area where trawlers can fish. Therefore, the need for the stakeholders support in oyster reef restoration projects is great.

Aside from groups with direct economic stakes in the outcome of restoration activities, other stakeholder groups may also have influence in the planning process. Non-profit

environmental organizations such as The Nature Conservancy (TNC), the Audubon Society, and the Coastal Conservation Association have members that donate money, time, and assistance to restoration projects; therefore knowing their perception and preferences is important as they can determine where funding goes. Regulatory agency employees are also stakeholders because of their knowledge of the statutory and regulatory process and their role in managing our natural resources. Scientific researchers are considered stakeholders because of their knowledge of the ecological and biological affects of restoring oyster reefs, as well as their knowledge of various restoration methods.

Stakeholders may differ in their opinions about various impacts of artificial reefs. It has been suggested that for natural resource issues, scientists tend to be optimistic, whereas fishermen take a more skeptical view (Ramos et al., 2007). Furthermore, stakeholder groups can differ demographically by education, age, and employment and these factors can influence attitudes and values about conservation (Tomicevic et al., 2010).

To help inform natural resource management and guide restoration planning across the northern Gulf of Mexico, this study aims to assess key geo-political and socio-economic factors influencing oyster management and reef restoration activities by surveying key stakeholders in the region. This information will be crucial to understanding not only the social landscape in which restoration occurs, but also the attitudes and preferences held by those most affected and interested in oyster reef restoration.

The main objectives of this study are to:

1. Determine stakeholder recognition of and level of importance of oyster reef ecological functions and services
2. Determine stakeholder perception of the state of oyster reefs

3. Determine stakeholder preference for implementation of oyster reef restoration
4. Determine stakeholder perception of the management of oyster reef restoration
5. Determine stakeholder support for oyster reef restoration
6. Determine the best way to communicate with various stakeholder groups about oyster reef restoration

3.2 Methods

3.2.1 Survey Instrument

We conducted a survey of key decision-makers and stakeholders in the northern Gulf of Mexico with the purpose of gaining a greater understanding of stakeholder perception of oyster reef restoration. A letter explaining our objectives and inviting the stakeholders to take the survey online (www.rnr.lsu.edu/oystersurvey) was mailed in June 2011. A follow-up mailing that included a paper copy of the survey was sent to non-respondents two weeks later. Additional follow-up mailings were sent to each non-respondent about every two weeks with a total of up to 4 mailings per stakeholder. We followed standard methods for the mailing system and survey outreach (Dillman et al. 2009) (See Appendix A for survey materials).

The survey contained five sections of questions which addressed stakeholder perception of oyster reef restoration including: 1) knowledge of ecological services, 2) views of oyster reef restoration, 3) implementation of oyster reef restoration, 4) administration of oyster reef restoration, and 5) stakeholder demographics. The survey included approximately 18 questions (see Appendix A for complete survey) which were used to gauge the stakeholders views and perception of oyster reef restoration. Over one half of the questions used the Likert scale format, a psychometric scale commonly used in questionnaires in order to determine participant's level

of agreement or preferences. The remainder of the questions assessed demographic information and preferences using non-Likert scale format.

3.2.2 Survey Recipients

The survey was mailed out to randomly sampled individuals within five *a priori* identified stakeholder groups: oyster harvesters, shrimp trawlers, scientific researchers, regulatory agency employees, and non-profit environmental organization members. To ensure that members of one stakeholder group who may participate in activities associated with another group (i.e. shrimpers often also harvest oysters) did not receive multiple surveys, all stakeholder lists were carefully cross-checked. Mailing addresses for sampled individuals were obtained from various sources Gulf-wide (Table 2).

Table 2. List of stakeholder groups by Gulf State and source of addresses used for survey mail outs.

STATE	GROUP	MAIL ADDRESS DATA SOURCE	COUNT
TEXAS	Oyster Harvesters	Texas Parks and Wildlife Department	100
	Shrimp Trawlers	Texas Parks and Wildlife Department	100
	Env.Org member	TNC Texas office	98
	Reg. Agency employee	Agency Website	10
	Scientific Researcher	Gulfbase.org	10
LOUISIANA	Oyster Harvesters	Louisiana Department of Wildlife and Fisheries	100
	Shrimp Trawlers	Louisiana Department of Wildlife and Fisheries	100
	Env.Org member	TNC Louisiana office	99
	Reg. Agency employee	Agency Website	10
	Scientific Researcher	Gulfbase.org	10

(Table 2 continued)

MISSISSIPPI	Oyster Harvesters	Mississippi Department of Marine Fisheries	100
	Shrimp Trawlers	Mississippi Department of Marine Fisheries	100
	Env.Org member	TNC Mississippi office	28
	Reg. Agency employee	Agency Website	10
	Scientific Researcher	Gulfbase.org	10
ALABAMA	Oyster Harvesters	Alabama Department of Conservation of Natural Resources – Alabama Marine Resources	100
	Shrimp Trawlers	Alabama Department of Conservation of Natural Resources – Alabama Marine Resources	100
	Env.Org member	TNC Alabama office	100
	Reg. Agency employee	Agency Website	10
	Scientific Researcher	Gulfbase.org	10
FLORIDA	Oyster Harvesters	Department of Agriculture and Consumer Services – Division of Aquaculture	100
	Shrimp Trawlers	Florida Fish & Wildlife Conservation Commission – Fish & Wildlife Research Institute	100
	Env.Org member	TNC Florida office	100
	Reg. Agency employee	Agency Website	10
	Scientific Researcher	Gulfbase.org	10

TOTAL: 1525

3.2.3 Survey Analysis

Surveys were analyzed using chi-square analysis, one-way ANOVA (factor: user group) or binary logistic regression. Unless indicated otherwise for specific questions below, chi-square analysis was run using the Monte-Carlo randomization test of independence statistics in order to account for large sample sizes with poorly distributed data, was used to determine if there were differences in response by user group. When indicated, one-way ANOVA (Factor: user groups) was conducted using separate GLMMs (Generalized Linear Mixed Models; SAS Proc GLIMMIX) using a normal distribution with a log link for questions that were grouped to compare means. Significant ANOVA tests were followed by Tukey's HSD post-hoc test used to determine significant differences between user groups. Similarly, binary logistic regression was conducted using a separate GLMM with a binary distribution (SAS Proc GLIMMIX) to test for differences between user groups. A significance level of 0.05 was used for all tests, unless indicated otherwise. Majority response is defined as either a majority of responses in one response category, or if there was not a majority in one response category, then adjacent directional categories were combined for evaluation. References to question number (i.e. Q1.2) refer to the specific question and results that may be found in Appendix B.

a) Demographics

Survey responses were tabulated and analyzed, and care was taken to preserve the anonymity of each respondent. Demographic variables (age, education, state, ethnicity and self-identified user group) were compiled to determine the overall demographic profiles of the respondents. Chi-square analysis was conducted on the demographic variables by user group to determine if demographics varied significantly by user group.

b) Stakeholder Level of Importance and Recognition of Oyster Reef Ecological Functions and Services

We first determined stakeholder views regarding the importance of ecological services and the potential for oyster reefs to provide these ecological services in the northern Gulf of Mexico. To do this, respondents were asked to respond to a series of questions on a three or four point Likert scale that aimed to identify the value of 13 potential ecological services (Q1.1 "Importance") and the potential for oyster reefs to provide these services (Q1.2). The mean score was calculated by respondent, and responses were analyzed with a one-way ANOVA (factor: user groups).

Next we determined how stakeholders perceived the benefits of oyster reef restoration. To do this, respondents were asked to respond to a series of questions on a five point Likert scale that identified level of agreement with a series of 12 statements that identify various services and benefits provided by restored oyster reefs (Q2.1). Chi-square analysis by user group, specifically using the Monte-Carlo randomization test of independence statistics in order to account for large sample sizes with poorly distributed data, was used to determine if there were differences in response by user group. We used binary logistic regression analysis to determine whether stakeholder level of agreement with four key questions regarding oyster reefs, restoration, and familiarity with restored oyster reefs (Q1.29, Q2.11, Q2.110, and Q2.111) could be predicted by user group.

c) Stakeholder Perception of the State of Oyster Reefs

We determined stakeholder views on the need for restoration of coastal areas, and specifically for oyster reef restoration in the northern Gulf of Mexico. To do this, respondents were asked to respond to a series of questions on a three point Likert scale that aimed to identify

the need for restoration of 13 ecological services (Q1.1 "Need for Restoration"). The mean score was calculated by respondent, and responses were analyzed with a one factor ANOVA (factor: user groups).

Next, we determined stakeholder perceptions of the threats to oyster reefs. To do this, respondents were asked to respond to a series of questions on a five point Likert scale that identified the level of threat of nine potential threats to the health of oyster reefs (Q1.3). Chi-square analysis by user group was used to determine if there are differences in response by user group.

d) Stakeholder Preference for Implementation of Oyster Reef Restoration

We determined stakeholder prioritization for oyster reef restoration location. To do this, respondents were asked to respond to a series of questions on a five point Likert scale that aimed to identify the level of priority of 13 locations in which oyster reefs may be restored (Q3.1). Chi-square analysis by user group was used to determine if there are differences in response by user group.

We requested input on specific locations across the northern Gulf of Mexico that could benefit from oyster reef restoration. To do this, respondents were asked to suggest a state and body of water in the northern Gulf of Mexico that would benefit from oyster reef restoration (Q3.2). A list was compiled and a map created in order to show where restoration sites are most often suggested.

We determined outcomes stakeholders are willing to accept in exchange for oyster reef restoration. To do this, respondents were asked to respond to a series of questions on a five point Likert scale that aimed to identify the level of acceptance of 11 outcomes stakeholder's may be

willing to accept (Q4.1). Chi-square analysis by user group was used to determine if there are differences in response by user group.

e) Stakeholder Perception of the Management of Oyster Reef Restoration

We determined stakeholder views on the importance of issues which need addressing in order for oyster reef restoration to be successful. To do this, respondents were asked to respond to a series of questions on a five point Likert scale that aimed to identify the level of importance of nine potential issues (Q4.2). Chi-square analysis by user group was used to determine if there are differences in response by user group.

We determined stakeholder perception of the need for improvement of current oyster reef restoration management practices. To do this, respondents were asked to respond to a series of questions on a four point Likert scale that aimed to identify the level of improvement of seven current management practices (Q4.3). Chi-square analysis by user group was used to determine if there are differences in response by user group.

f) Stakeholder Support for Oyster Reef Restoration

We determined stakeholder perception of support for oyster reef restoration. To do this, respondents were asked to respond to a series of questions on a five point Likert scale that aimed to identify the level of agreement for five statements regarding the support for oyster reef (Q2.2). The mean score was calculated by respondent, and responses were analyzed with a one-way ANOVA (factor: user groups).

We used binary logistic regression analysis to determine whether stakeholder level of agreement with "I personally support oyster reef restoration" (Q2.25) could be predicted by user group.

g) Communication with Various Stakeholder Groups about Oyster Reef Restoration

In order to determine the best way to communicate to stakeholders and specific user groups about oyster reef restoration, a summary of communication method preferences was created.

3.3 Results

a) Demographics

We received a response rate of 30% (1,525 surveys sent; 426 usable returns) (Table 3). Non-response error and bias is beyond the scope of this paper and is therefore ignored. Stakeholders in Louisiana (30%) and Florida (24%) provided the most returns by state, and the greatest response by user group was from members of an environmental group (37%) and shrimp trawlers (30%). A majority of respondents (53%) was over the age of 56 years old, held at least a bachelor degree (52%), and was of Caucasian ethnicity (76%). All state and user groups gave over a 20% response rate, with the exception of regulatory agency employees, who only provided an 11% response rate.

Age, education level, state and ethnicity varied significantly by user group (Table 4). The majority of shrimp trawlers (54%), oyster harvesters (60%), and regulatory agency employees (54%) were between the ages of 31-55 years old, and environmental organization members and scientific researchers represented the oldest groups, with a majority over 56 years old (80% and 55% respectively).

Education also differed significantly by user group. The majority of regulatory agency employees (64%), scientific researchers (95%), and environmental organization members (62%) held a graduate degree, and the majority of shrimp trawlers (81%) and oyster harvesters (86%) held education levels of high school degree or less.

Table 3. Summary of stakeholder response rate to the survey by user group, age, state and ethnicity.

Demographic variable		Total Surveyed (#)	Respondents (#) N=426	% of N	% Overall response rate
User Group	Environmental organization member	425	157	37	37
	Shrimp trawler	500	128	30	26
	Oyster harvester	500	109	26	22
	Scientific researcher	100	21	5	21
	Regulatory agency employee	100	11	3	11
State	Texas	318	63	15	20
	Louisiana	319	126	30	40
	Mississippi	248	62	15	25
	Alabama	320	74	17	23
	Florida	320	101	24	32
Age Group	18-30 years old	N/A	16	4	N/A
	31-55 years old	N/A	178	43	N/A
	Older than 56 years	N/A	218	53	N/A
Education	High school/GED or less	N/A	193	48	N/A
	Bachelor's degree	N/A	82	20	N/A
	Graduate degree	N/A	131	32	N/A
Ethnicity	Cajun/Creole	N/A	26	6	N/A
	Vietnamese/SE Asian	N/A	30	7	N/A
	Eastern European	N/A	5	1	N/A
	American Indian	N/A	12	3	N/A
	Hispanic/Latino	N/A	9	2	N/A
	African American	N/A	8	2	N/A
	Caucasian	N/A	308	76	N/A
	Other	N/A	10	3	N/A

A majority of respondents were of Caucasian ethnicity (90% of regulatory agency employees, 95% of scientific researchers, 65% of shrimpers, 55% of oyster harvesters, and 95%

of environmental organization members). However, 17% of shrimpers identified as Vietnamese/Southeast Asian ethnicity and 11% identified as Cajun/Creole. Among oyster harvesters, 9% identified as Vietnamese/Southeast Asian, 9% identified as Creole/Cajun, and11% of oyster harvesters identified as American Indian.

In addition to *a priori* group affiliation, based on the database origin of contact information (i.e., licensed oyster harvesters, environmental organization members), each respondent was also asked to self-identify with up to three additional stakeholder groups, and many respondents affiliated themselves with multiple groups (Table 4). A majority of respondents identified themselves with the *a priori* group affiliation, but also identified with other groups, with some clear affiliations among certain groups. Approximately 20% of scientific researchers also identified themselves as regulatory agency employees, and approximately 36% of regulatory agency employees also stated that they were scientific researchers and 27% identified as recreational fisher persons. Approximately 34% of environmental organization members also identified themselves as recreational fisher persons. Oyster harvesters also identified themselves with other commercial fishing groups (57% shrimp trawlers and 42% other commercial fisheries). Likewise, shrimp trawlers also identified with other fishing groups (35% oyster harvester, 29% other commercial fisheries, and 28% recreational angler).

b) Stakeholder Level of Importance and Recognition of Oyster Reef Ecological Functions and Services

Overall, stakeholders indicated that potential ecological services provided by oyster reefs are important in the northern Gulf of Mexico (Table 5). Every ecological service listed was rated by over 87% of respondents as either mildly or very important. Approximately 90% of the

Table 4. Summary of the demographic makeup (percentage of respondents) of survey respondents by user group. This table includes age, education and ethnicity of respondents as well as the other stakeholder groups to which respondents identified.

	Environmental Organization Member (%)	*Oyster Harvesters (%)*	*Shrimp Trawler (%)*	*Scientific Researcher (%)*	*Regulatory Agency Employee (%)*
18-30 years old	*0*	*12*	*2*	*0*	*0*
31-55 years old	*20*	*61*	*54*	*45*	*54*
Older than 56 years	*80*	*26*	*44*	*55*	*45*
High School/GED or less	*2*	*86*	*81*	*0*	*9*
Bachelor's Degree	*36*	*9*	*12*	*5*	*27*
Graduate Degree	*62*	*5*	*7*	*95*	*64*
Cajun/Creole	*1*	*9*	*11*	*5*	*0*
Vietnamese/SE Asian	*0*	*9*	*17*	*0*	*0*
Eastern European	*<1*	*4*	*0*	*0*	*0*
American Indian	*0*	*11*	*<1*	*0*	*0*
Hispanic/Latino	*0*	*4*	*5*	*0*	*0*
African American	*1*	*5*	*<1*	*0*	*0*
Caucasian	*95*	*55*	*65*	*95*	*90*
Other	*1*	*5*	*2*	*0*	*10*
Shrimp Trawler	*<1*	*57*	*95*	*0*	*0*
Oyster Harvester	*4*	*98*	*35*	*0*	*20*
Recreational Fisher person	*33*	*26*	*28*	*0*	*27*
Environmental or conservation organization member	*77*	*3*	*4*	*10*	*20*
Regulatory Agency	*1*	*<1*	*0*	*20*	*73*
Scientific Researcher	*9*	*<1*	*<1*	*85*	*36*
Other Commercial fisheries	*<1*	*42*	*29*	*0*	*0*
Other	*21*	*13*	*2*	*0*	*10*

stakeholders believe that provision of marine habitat and maintenance of water quality are very important ecological services, while only 61% believe that recreational fish production is a very

important service. Additionally, only 65% of respondents believe that coastal heritage and culture associated with oyster reefs are very important.

Table 5. Summary of stakeholder response (% of total respondents) to the question "Please indicate your view of the level of importance of ecological services in your state". (Survey Question 1.1)

Ecological Services	Not important (%)	Mildly Important (%)	Very Important (%)	Not sure/Don't know (%)
Oyster production for harvest	1	10	84	5
Oyster production for ecosystem health	1	8	84	7
Water quality	0	6	90	4
Marine habitat	1	6	90	3
Shoreline stabilization	2	19	71	8
Biodiversity (or variety of species) in coastal landscapes & ecosystems	1	15	73	11
Fish production for commercial fisheries (shrimp, crab, fin-fish)	1	10	84	5
Fish production for recreational fisheries	7	26	61	6
Scientific research on coastal ecosystems	2	18	72	8
Coastal heritage and culture	3	26	66	5
Coastal economy	1	10	85	4
Coastal wetlands	1	10	84	5
General environmental education	2	21	71	6

ANOVA analysis indicated that user groups differed significantly in their perception of the importance of oyster reefs for provision of ecological services. Oyster harvesters and environmental organization members ranked ecological services highest (2.85 and 2.83 out of 3.0, respectively), and the response of these groups differed significantly from scientific researchers, who ranked ecological services the lowest (2.69 out of 3.0). This low ranking, however, still indicated that scientific researchers considered ecological service value of reefs to be important.

The majority of stakeholders (over 70%) agreed or strongly agreed that oyster reefs provide the listed suite of ecological services (Table 6). However, there was least agreement with the statements that 1) oyster reefs are an important buffer to climate change (only 36% agree or strongly agree) and 2) oyster reefs impede navigation (only 19% agree or strongly agree). Most respondents either indicated that they neither agreed or disagreed with these statements, or indicated that they were not sure or did not know (Table 6). ANOVA analysis indicated there was no significant difference in user group level of agreement with statements reflecting the ecological services provided by oyster reefs.

Table 6. Summary of the respondents level of agreement (% of total respondents) with statements reflecting the ecological services provided by oyster reefs. (Survey Question 1.2)

Statement	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree (%)	Strongly Agree (%)	Not sure/ Don't know (%)
Oyster reefs improve the water quality	1	0	6	29	52	11
Oyster reefs provide shoreline protection	1	2	6	35	44	11
Oyster reefs provide good marine habitat	1	0	2	29	62	6
Oyster reefs support the sustainability of oysters	1	0	2	27	64	6
Oyster reefs promote biodiversity in the landscape and ecosystems	1	1	6	28	48	15
Oyster reefs are an important buffer to climate change	4	7	16	15	21	37
Oyster reefs increase fish production	0	2	8	30	45	14
Oyster reefs impede navigation	14	31	19	14	5	17
Oyster reefs are an indicator of a healthy coast	1	1	6	26	57	9

Stakeholders were asked to indicate their level of agreement with a series of statements pertaining to oyster reef restoration (Table 7). More than 80% of respondents agreed or strongly agreed that 1) coastal restoration is important to them; 2) oyster reef restoration is important to maintaining healthy oyster populations; 3) oyster reef restoration would benefit local commercial fishermen, oyster harvesters, and communities; and 4) oyster reef restoration is necessary for a sustainable commercial oyster harvest. More than 60% agreed or strongly agreed that oyster reef restoration would benefit local recreational fishermen, help the recovery of local fisheries from natural disasters such as hurricanes, and the Deepwater Horizon oil spill.

Chi-square analysis indicated significant differences in response to the benefits of oyster reef restoration by user groups. All user groups were in agreement (over 57% of each group) that oyster reef restoration would help the recovery of local fisheries from natural disasters, but only scientific researchers were less in agreement with the statement about the oil spill, with more respondents indicating disagree (24%), neither agree nor disagree (29%) or were not sure or did not know (24%). A majority of environmental organization members (54%), oyster harvesters (60%) and shrimp trawlers (52%) agreed that their awareness of the importance of oyster reefs has increased since the Deepwater Horizon oil spill, while a majority of scientific researchers (76%) and regulatory agency employees (55%) disagreed.

Chi-square analysis showed that responses to Q2.1 differed significantly by user group for each of the statements about the potential benefit oyster reefs can provide, with the exception of "Coastal restoration is important to me". In general, differences by user groups were largely due to greater disagreement and response variation among scientific researchers. Where other stakeholder groups marked "strongly agree", researchers most frequently marked the response

"agree". Overall, there was agreement (over 70%) on most statements regarding the benefits oysters can provide

Table 7. Summary of the respondents level of agreement (% of total respondents) with statements reflecting the potential benefits of restored oyster reefs. (Survey Question 2.1)

Statement	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree (%)	Strongly Agree (%)	Not sure/Don't know (%)
Coastal restoration is important to me	1	0	4	28	6	4
Oyster reef restoration is important to maintaining a healthy oyster population	0	1	3	27	64	5
Oyster reef restoration would benefit the local commercial fishermen (crab, fin-fish, shrimp)	0	2	6	30	52	10
Oyster reef restoration would benefit the local oyster harvesters	0	1	2	26	66	4
Oyster reef restoration would benefit the local recreational fishermen	2	2	7	32	45	12
Oyster reef restoration would help the coastal community	0	2	4	31	57	7
Oyster reef restoration would help the recovery of local fisheries from natural disasters such as hurricanes	1	2	8	29	49	12
Oyster reef restoration would help the local fisheries recover from the Deepwater Horizon oil spill	2	6	6	21	46	19
Oyster reef restoration is necessary for sustainable commercial oyster harvest.	1	3	6	26	57	8
My awareness of the importance of oyster reefs has increased since the Deepwater Horizon oil spill.	9	16	16	26	27	7
I am personally familiar with the location of restored oyster reefs	5	11	7	29	30	18
I use restored oyster reefs for recreation and/or commercial purposes	14	18	15	19	22	13

Logistic regression analysis revealed that agreement or disagreement to the questions "Coastal restoration is important to me" and "Oyster reefs are an indicator of a healthy coast" do not significantly differ by user group (> 80% agreement among all groups combined) (Table 8). On the other hand, there were significant differences in the number of respondents that were personally familiar with and use restored reefs, and this difference was driven largely by oyster harvesters being more familiar with the location and using these reefs (Table 9, 10). Oyster harvesters and scientific researchers were more likely (over 4 times and over 6 times respectively) to be familiar with the location of restored oyster reefs than were environmental organization members. Oyster harvesters and shrimp trawlers were more likely (over 27 times and over 6 times respectively) to use restored oyster reefs than were environmental organization members.

Table 8. Logistic regression results regarding agreement by user group with statements related to oyster reefs.

Statement	P-value
Oyster reefs are an indicator of a healthy coast	0.53
Coastal restoration is important to me	0.06
I am personally familiar with the location of restored oyster reefs	<0.01
I use restored oyster reefs for recreation and/or commercial purposes	<0.01

Table 9. Percent agree and disagree by user group to the question "I am personally familiar with the location of restored oyster reefs".

User Group	Agree (%)	Disagree
Oyster harvester	77%	4%
Environmental organization member	44%	33%
Shrimp Trawler	56%	6%
Scientific Researcher	76%	19%

Table 10. Percent agree and disagree by user group to the question "I use restored oyster reefs for recreation and/or commercial purposes".

User Group	Agree	Disagree
Oyster harvester	81%	6%
Environmental organization member	12%	61%
Shrimp Trawler	46%	15%
Scientific Researcher	10%	52%
Regulatory agency employee	30%	30%

c) Stakeholder Perception of the State of Oyster Reefs

A majority of stakeholders believe that oyster reefs should be restored for ecological services as well as for commercial harvest. Chi-square analysis shows that user groups differed significantly in their perception of the purpose of restoration. A majority of environmental organization members and scientific researchers agree that oyster reefs should primarily be restored for ecological services, while in contrast, a majority of oyster harvesters and regulatory agency employees agree that oyster reefs should primarily be restored for commercial harvest. Shrimp trawlers bridged the gap by having a majority vote for both purposes.

Over 70% of respondents indicated that the listed ecological services are in need of restoration (Table 11). Oyster production for harvest and coastal wetlands were identified as needing the most restoration, while fish production for recreational fisheries and biodiversity were less in need. ANOVA analysis shows that the identified need for restoration of ecological services varies significantly by user group for all the mentioned ecological services. Environmental organization members and oyster harvesters ranked the need for restoration highest (2.72 and 2.67 respectively) and the response of these groups differed significantly from regulatory agency employees and scientific researchers (2.43 and 2.42 out of 3.0, respectively). This low ranking, however, still indicated that regulatory agency employees and scientific researchers considered ecological services in need of restoration in their state.

Table 11. Summary of stakeholder response (% of total respondents) to the question "Please indicate your view of the need for restoration of ecological services in your state". (Survey Question 1.1)

Ecological Service	No restoration needed (%)	Minor restoration needed (%)	Major restoration needed (%)	Not sure/Don't know (%)
Oyster production for harvest	1	16	68	15
Oyster production for ecosystem health	1	17	64	18
Water quality	2	22	59	17
Marine habitat	2	23	60	16
Shoreline stabilization	3	23	56	18
Biodiversity (or variety of species) in coastal landscapes & ecosystems	5	26	45	23
Fish production for commercial fisheries (shrimp, crab, fin-fish)	5	28	52	15
Fish production for recreational fisheries	12	31	39	18
Scientific research on coastal ecosystems	7	22	51	21
Coastal heritage and culture	13	29	42	16
Coastal economy	3	23	63	11
Coastal wetlands	3	18	67	12
General environmental education	9	23	51	17

Hurricanes, coastal development and land use, freshwater diversions and disruption of water supply (i.e., dams, canals) were identified by a majority of respondents as moderate to high threats to the health of oyster reefs in the Gulf States (Table 12). In contrast, recreation and commercial fishing were identified by a majority as posing no to low threat. Threats with the most response variation were sea level rise (37% little to no threat, 38% moderate to high threat, 26% unsure) and oyster harvesting practices, which was evenly split (41% little to no threat, 41% moderate to high threat).

Table 12. Summary of stakeholder response (% of total respondents) to the question "How much of a threat are the following to the health of oyster reefs in your state?" (Survey Question 1.3)

Potential Threats	Not a threat (%)	Low threat (%)	Moderate threat (%)	High Threat (%)	Not sure/Don't know (%)
Commercial fishing (crabs, fin-fish, shrimp)	36	23	17	7	17
Recreational fishing	41	27	11	6	15
Hurricanes	3	8	26	55	9
Oyster harvest practices (shell dredging, tonging, etc)	17	24	22	19	18
Disease & natural predation	3	18	32	27	21
Coastal development & land use	4	13	22	47	14
Freshwater diversions	5	10	21	48	16
Sea Level Rise	17	20	21	17	26
Disruption of water supply (dams, canals, irrigation, etc)	6	12	23	42	17

Chi-square analysis shows that the perceived threat level varies significantly by user group for all the mentioned threats to oyster reefs health (Table 13). Oyster harvesters and shrimp trawlers tended to identify commercial fishing, recreational fishing and oyster harvest practices as lower threats to oyster reefs as compared to all the other groups. Oyster harvesters also identified freshwater diversions as a higher threat to oyster reef health as compared to other user groups. Lastly sea level rise was identified as a moderate to high threat to oyster reefs by environmental organization members, but as little to only moderate threat by all other user groups.

Table 13. Perceived threat to oyster reef health, determined by user group majority responses

	Environmental Organization Member	Oyster Harvester	Shrimp Trawler	Scientific Researcher	Regulatory Agency Employee
Commercial fishing	L-M*	N	N	L-M	L
Recreational fishing	N-L*	N	N	L	L
Oyster harvesting practices	M-H*	N-L	N-L	L-M-H	L-M
Hurricanes	M-H	H	H	M-H	H
Disease & natural predation	M*	M-H	M-H *	M	M
Coastal development and land use	H	M-H	M-H *	H	L-M-H
Freshwater diversions	M-H *	H	M-H	M-H	M-H
Sea level rise	M-H *	L-M	N*	L-M	L-M
Disruption of water supply	M-H	M-H	M-H *	M-H	M-H

Note: Asterisks represents over 20% were not sure or did not know, N=Not a threat, L=Low threat, M=Moderate Threat, H=High Threat

d) Stakeholder Preference for Implementation of Oyster Reef Restoration

Highest priority (medium to high) areas for future oyster reef restoration identified by a majority (over 80%) of respondents were: 1) areas with the most depleted oyster reefs, 2) historical reef areas and 3) current oyster reef areas (Table 14). Interestingly, more than 60% of respondents identified highest priority needs (medium to high) in areas where oysters will provide three critical ecological services – shoreline stabilization (areas with currently stable wetlands; areas with eroding shorelines), fishery improvement (areas near existing oyster leases and existing fishing grounds); and water filtration (areas in need of water quality improvement).

Table 14. Summary of stakeholder response (% of total respondents) to the question "Please help us prioritize locations for oyster reef restoration". (Survey Question 3.1)

Locations	Not a priority (%)	Low priority (%)	Medium priority (%)	High priority (%)	Not sure/Don't Know (%)
Areas without freshwater diversions	4	10	21	35	30
Areas without heavy shoreline development	6	12	21	40	21
Areas that are resistant to change (stable wetlands, consistent salinity, etc)	3	11	20	46	20
Areas of most depleted oyster reefs	1	3	12	69	15
Areas of easy public access	15	26	23	18	18
Areas in need of shoreline stabilization	5	11	27	41	17
Areas near existing oyster leases (public and private)	6	10	26	40	18
Areas near existing fishing grounds	6	13	31	30	21
Areas near current structures (bridges, piers, etc)	13	21	23	17	26
Areas where oyster reefs were historically located (reef footprints)	1	4	14	69	12
Areas where oyster reefs are currently present	2	5	20	61	12
Areas where no oyster reefs exist but the environment is suitable	3	10	30	42	15
Areas in need of water quality improvement	6	10	26	38	20

Chi-square analysis shows that the location prioritization preference was significantly different by user group (Table 15) for all locations except areas without heavy shoreline development ($p = 0.12$) and areas in need of shoreline stabilization ($p = 0.15$) which a majority agreed should be of medium or high priority. In contrast, locations without freshwater diversions were ranked as high priority by regulatory agency employees (73%) and scientific researchers (68%), and lower priority by all other user groups. Additionally, scientific researchers were split across responses in their prioritization of stable areas, and this differed from other groups that tended to rank these areas as a high priority (> 50% of respondents). Lastly, commercial fishing

groups (oyster harvesters and shrimp trawlers) ranked areas of easy public access as lower priority compared with other groups.

Table 15. Prioritization of locations for oyster reef restoration, determined by user group majority responses.

	Environmental organization member	Oyster harvester	Shrimp Trawler	Scientific Researcher	Regulatory Agency employee
Areas without freshwater diversions	M–H*	M–H *	M–H *	M–H	M–H
Areas without heavy shoreline development	M–H *	M–H *	M–H *	M–H	M–H
Areas that are resistant to change	M–H *	H	M–H *	L-M-H	H
Areas of most depleted oyster reefs	H	H	H	M–H	H
Areas of easy public access	L-M*	L-H	L-M	N-L	L-M
Areas in need of shoreline stabilization	M–H	M–H	M–H *	M–H	M–H
Areas near existing oyster leases	M–H *	H	M–H	M–H	M–H
Areas near existing fishing grounds	M–H *	M–H	M–H *	M	L-M
Areas near current structures	M*	L-M-H	M*	N-L	L-M
Areas where oyster reefs were historically located	H	H	H	H	H
Areas where oyster reefs are currently present	H	H	H	M–H	H
Areas where no oyster reefs exist but the environment is suitable	M–H	M–H	M–H	M–H	L-M
Areas in need of water quality improvement	M–H	M–H	M–H *	M	L-M

Note: Asterisks represents over 20% were not sure or did not know, N=Not a priority, L=Low Priority, M=Medium Priority, H=High Priority

Areas near current structures (bridges, piers, etc) were preferred to be no to low priority by a majority of scientific researchers (65%) and low or medium priority to regulatory agency

employees (63%). Most environmental organization members and shrimpers either felt that it should be of medium priority (25% and 25% respectively) or that they were not sure or did not know (22% and 26% respectively). Oyster harvesters were very split in their responses, ranging from no priority to high priority.

Areas where oyster reefs were historically located (reef footprints) were chosen by a vast majority of all groups as being of high priority, with over 50% of respondents identifying it as high priority. Scientific researchers also had 35% mark that these areas should be of medium priority. Areas where oyster reefs are currently present was also marked by a vast majority of user groups as high priority, with over 50% of respondents identifying it as high priority. An area where no oyster reefs exist but the environment is suitable was chosen as a medium or high priority by a majority (over 50%) of respondents in each user groups, with the exception of most regulatory agency employees (72%) who preferred for these areas to be a low or medium priority. A majority of oyster harvesters believe that area's near existing oyster leases should be of high priority.

Stakeholders were given the option to suggest a body of water in the northern Gulf of Mexico that would benefit from oyster reef restoration. Of the 426 respondents of the survey, 303 (71%) answered with either a state or state and specific water body (Table 16; Figure 4). More than 96% of these respondents chose a restoration location in the state in which they reside, and Louisiana was chosen most frequently (30% of the time).

When presented with a list of potential restrictions or changes to fishing or harvest pressure on oyster reefs as means to help restore oyster populations, over 60% of the respondents

Table 16. Stakeholder suggested locations that would benefit from oyster reef restoration in the northern Gulf of Mexico. (Survey Question 3.2)

State	Most popular (number of respondents suggesting location)	Others
Texas	Galveston Bay (12) Corpus Christi Bay (3) Matagorda Bay (4)	Bayou Texar, Galveston West Bay, Galv-East-Trinity, San Antonio Bay, Aransas & Copano, Lavaca Bay, Lower Laguna Madre
Louisiana	Barataria Bay (5) Calcasieu lake (5) Grande isle (4) Coastal Plaquemines Parish (3) Black bay (3) East side of Miss River (3) Lake Bourne (2) Big Lake - West Cove (2) Barataria-Terrebonne Estuary (2) East & West Timbalier Bay (2)	Area 3-15-16, State Public Seed Grounds, Cocodrie, Lake Fortuna/Drum Bay, Cameron, Black Bay Ar 6-7, Grand Bank, South of Houma, Bretton Sound, Lake Bare, Terrebonne Parish, American Bay, St. Bernard Parish, Big Lake, Lake Boerne, Lake Pelto, Catfish Bay Area, St. Mary Parish, Sister & Machne lakes, Dulac, Venice, Nickel Reef south of Marsh Island, Vermilion /Terrebonne
Mississippi	Pass Christian (6) Mississippi Sound (3) Bay of St. Louis (2) Biloxi (2) Pascagoula (2) Ocean springs (2) Bayou Heron, East Jackson County (2)	GraveLine Bayou, and between east and West Pasagoula, singing river island and west to west river, Bayou Cunbest, Bayou Heron, Western Sound, Bangs Lake, Jackson Co, Henderson Point, Telegraph Key, Bayou Cumbest, Alabama state
Alabama	Mobile Bay (19) Mississippi Sound (6) Dauphin Island (4) Bayou la Batre (4) Grand Bay (4) Portersville Bay (4) Bon Secour Bay (2) Cedar Point Reef (2)	South mobile county, Alabama Port, Perdido Bay, South & Eastern Bay, Heron Bay, Lower end of reef, South Mobile Bay, Northside of Ft. Morgan
Florida	Apalachicola (15) Choctawhatchee Bay (6) Pensacola Bay (4) Franklin Co (2)	Choctawhatchee bay, Entrance to Joes Bayou, Marler Bayou, Indian Bayou, Areas on north side of bay east of Mid Bay Bridge, Charlotte Harbor, Gulf Breeze, Escambia Bay, East Bay, Panhandle - Santa Rosa County to Franklin County, Perdido Bay, Pensacola to Apalachicola, Panama City East Bay, Wahulla Co, East Bay/East Point, Panhandle - Santa Rosa County to Franklin County, Bayou Chico

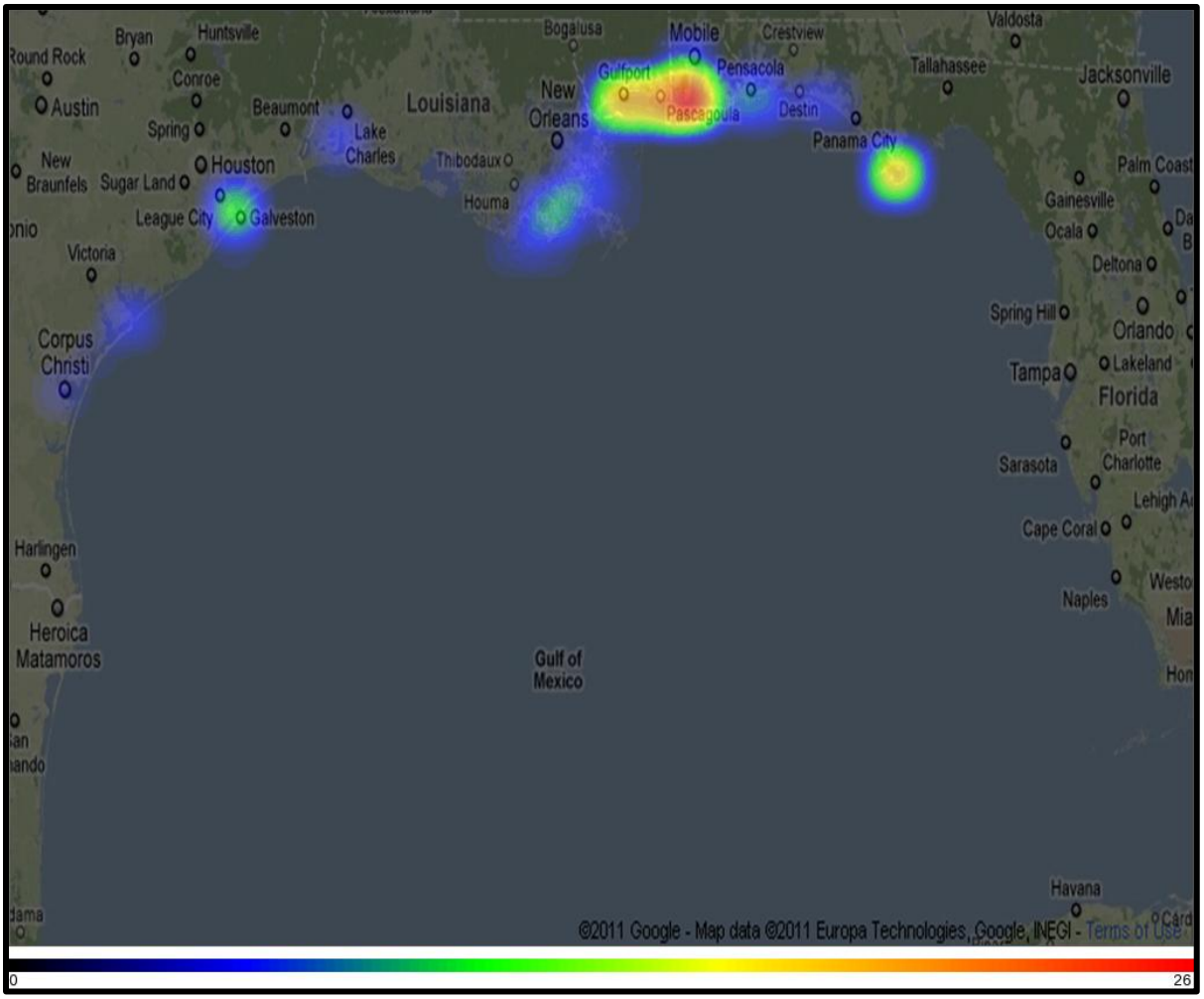

Figure 4. Mapped areas identified by respondents as in need of oyster reef restoration. Colors indicate the number of respondents indicating each location, ranging from 0 (black) to 26 (red) respondents (heat map).

considered all but two of the options to be at least sometimes acceptable (Table 17). The two options that were not acceptable or only sometimes acceptable to more than 50% of the respondents involved changes to oyster sack limits. However, there were significant differences in level of acceptability for all potential options by user group (Table 18). Most differences were driven by the uncertainty of environmental organization members and a clear split about harvest limits among stakeholders. Commercial fishing groups (oyster harvesters and shrimp trawlers) were less likely than scientific researchers and environmental organization members to accept

options that restrict harvest or restrict gear use. Interestingly, the opinions of regulatory agency personnel to restrictions and changes to harvest pressure often bridged the gap.

Table 17. Summary of stakeholder response (% of total respondents) to the question "Please choose which outcomes you would be willing to accept in order to support oyster reef restoration". (Survey Question 4.1)

Restrictions	Not acceptable (%)	Sometimes acceptable (%)	Acceptable (%)	Fully acceptable (%)	Not sure/Don't know (%)
Oyster sack limit maintained at current levels	6	14	36	15	29
Oyster sack limit reduced from current levels	22	24	13	10	30
Oyster sack limit increased from current levels	22	23	15	9	31
Incentives for private restoration (oyster harvesters)	9	10	29	34	18
Restriction of commercial fishing on restored oyster reefs	19	21	25	20	16
Restriction of recreational fishing on restored oyster reefs	20	22	26	19	14
Daily time restrictions of restored oyster reefs	12	19	28	20	22
Restricted seasons on restored oyster reefs	6	18	31	29	15
Rotating annual reef closure to allow stocks to rebuild	3	10	35	40	11
Permanent reef closure for production of seed	20	19	23	20	19
Restriction of gear used on restored oyster reefs	12	14	29	29	17

e) Stakeholder Perception of the Management of Oyster Reef Restoration

Over 70% of respondents agreed on the importance (important to very important) of public involvement (support, law enforcement, communications, and permitting), funding,

science, and design to the success of oyster reef restoration projects (Table 19). Interestingly, the importance of property rights was questioned most (23% slightly or not important; 15% unsure); however 62% of respondents believed it to be an important factor to the success of oyster reef projects.

Table 18. Outcomes stakeholders are willing to accept in order to support oyster reef restoration, determined by user group majority.

	Environmental organization member	Oyster harvester	Shrimp Trawler	Scientific Researcher	Regulatory Agency employee
Oyster sack limit maintained at current levels	*	*A-FA*	*A-FA* *	*A-FA*	*A-FA*
Oyster sack limit reduced from current levels	*	*NA-SA*	*NA-SA**	*SA*	*SA-A*
Oyster sack limit increased from current levels	*	*NA-SA*	*S A**	*SA*	*NA-SA*
Incentives for private restoration	*A-FA*	*A-FA*	*FA**	*A-FA*	*A*
Restriction of commercial fishing on restored oyster reefs	*A-FA*	*NA-SA*	*NA**	*SA-A-FA*	*SA-A*
Restriction of recreational fishing on restored reefs	*A-FA*	*NA-SA*	*A**	*SA-A*	*SA*
Daily time restrictions on restored reefs	*A-FA* *	*A-FA*	*SA-A* *	*SA-A* *	*A-FA*
Restricted seasons on restored reefs	*A-FA*	*A-FA*	*SA-A*	*A*	*SA-A-FA*
Rotating annual reef closure to allow stocks to rebuild	*A-FA*	*A-FA*	*A-FA*	*A-FA*	*A-FA*
Permanent reef closure for production of seed	*A-FA* *	*NA-SA*	*NA-A**	*A-FA*	*SA*
Restriction of gear used on restored oyster reefs	*A-FA* *	*A-FA*	*NA-A**	*A-FA*	*A-FA*

Note: Asterisks represent over 20% were not sure or did not know, NA= Not Acceptable, SA=Sometimes Acceptable, A= Acceptable, FA=Fully Acceptable

Table 19. Summary of stakeholder response (% of total respondents) to the question "What issues must be addressed to ensure the success of oyster reef restoration". (Survey Question 4.2)

Issues	Not Important (%)	Slightly Important (%)	Important (%)	Very Important (%)	Not sure/Don't Know (%)
Public support	2	6	33	53	7
Enforcement & protection	3	3	26	62	6
Permits (state and federal)	5	6	35	42	11
Appropriate location	0	2	28	63	7
Property rights	7	16	30	32	15
Scientific knowledge	1	5	24	61	9
Public communications	1	8	36	47	8
Adequate funding	1	2	19	71	7
Oyster reef design	2	7	27	52	12

Chi-square analysis showed that user group opinion of the importance of all issues were differed significantly except public communications (p=.09) and oyster reef design (p=.10) (Table 20). These differences were driven by a divide between the opinions of scientific researchers and regulatory agency employees, who consistently viewed these issues as important, and those of shrimpers, who tended to either place less importance on these issues or were unsure of the importance of these issues.

A vast majority (over 70%) indicated the need of improving the number of restored reefs, education and outreach to the public about restored reefs, maintenance and monitoring of restored reefs, research to understand the role of oyster reefs on the coast, and research on methods of oyster reef restoration (Table 21). Stakeholder input and enforcement also were identified as needing improvement (by over 60% of respondents), but several (over 36%) also were not sure about whether this needed improving or believed it needed no improvement.

Table 20. Total percent of respondents that believe issues are important or very important

	Environmental Organization Member (%)	Oyster Harvester (%)	Shrimp Trawler (%)	Scientific Researcher (%)	Regulatory Agency Employee (%)
Public Support	90 (5)	85 (4)	77 (13%)	95 (0)	99 (0)
Enforcement and Protection	94 (5)	92 (3)	74 (11%)	100 (0)	100 (0)
Permits	84 (14)	79 (94)	64 (15%)	90 (0)	100 (0)
Appropriate location	94 (6)	95 (5)	82 (11%)	95 (0)	100 (0)
Property rights	66 (14)	67 (12)	51 (23)	66 (0)	72 (9)
Scientific knowledge	93 (5)	65 (7)	72 (15)	100 (0)	82 (9)
Adequate funding	95 (4)	91 (5)	79 (17)	100 (0)	100 (0)

Note: Parenthesis represents percent who are not sure or don't know

Chi-square analysis showed that groups differed in their opinion of what could be improved with current management practices (Table 22). Most notably, environmental organization members, oyster harvesters and shrimpers all indicated that more stakeholder involvement in the process was critical (significant improvement needed > 55% of respondents), while the other user groups only believed it needed some improvement (>50%). Regulatory agency employees believe that education and outreach to the public is in more need of significant improvement compared to all other groups. Scientific researchers believe that research on maintenance and monitoring is in need of significant improvement. Oyster harvesters listed most of the management practices as needing significant improvement. Environmental organization members and shrimp trawlers had high responses of don't know or not sure, which explain many of the differences between groups.

Table 21. Summary of stakeholder response (% of total respondents) to the question "What should be improved with the current management practices for oyster reef restoration?". (Survey Question 4.3)

Management Practices	Needs No Improvement (%)	Needs Some Improvement (%)	Needs Significant Improvement (%)	Not Sure/Don't Know (%)
Number of restored oyster reefs	1	24	52	24
Enforcement and protection of restored oyster reefs	12	26	39	24
Stakeholder input & involvement	6	29	34	31
Research to understand the role of oyster reefs on the coast	9	29	41	21
Education and outreach to the public about restored oyster reefs	6	31	47	15
Maintenance and monitoring of restored oyster reefs	5	29	46	20
Research on methods of oyster reef restoration	5	27	44	24

Table 22. Level of improvement needed for current management practices, determined by user group majority

	Environmental Organization Member	Oyster Harvester	Shrimp Trawler	Scientific Researcher	Regulatory Agency Employee
Number of restored oyster reefs	S-I*	I	S-I *	S-I	S
Enforcement and protection of restored oyster reefs	S-I *	I	S-I *	S-I	S-I
Stakeholder input and involvement	S-I *	S-I	S-I *	S	S
Research to understand the role of oyster reefs on the coast	S-I *	I	S-I *	I	S
Education and outreach to the public about restored oyster reefs	I*	I	S-I *	S-I	I
Maintenance and monitoring of restored oyster reefs	S-I *	I	S-I *	I	S
Research on methods of oyster reef restoration	S-I *	I	S-I*	I	S

(Table 22 continued)
Note: Asterisks represents over 20% were not sure or did not know, N=Needs no improvement, S=Needs Some Improvement, I=Needs Significant Improvement

Most respondents (87%) believe that funding for oyster reef restoration should be a government responsibility, and the federal government was identified as the level at which most of that responsibility (41% of respondents) lies (Table 23). Interestingly, corporations were identified more than state and local governments as having a funding responsibility. Planning and monitoring were identified as the primary responsibility of universities, conservation organizations, and oyster advisory boards. Construction and maintenance of reefs were not listed as the primary responsibility of any entity but rather were split among entities.

Table 23. Summary of stakeholder response (% of total respondents) to the question "Who should be primarily responsible for specific phases of oyster reef restoration?". (Survey Question 4.4)

Question	Planning (%)	Funding (%)	Construction (%)	Maintenance (%)	Monitoring (%)
Local government	24	19	16	19	23
State government	18	27	18	18	20
Federal government	15	41	14	12	18
Conservation organizations	25	16	15	16	27
Industry associations	25	20	18	19	18
Individual users	25	15	16	24	21
Corporate users	19	29	17	20	15
Universities	34	6	12	12	37
Oyster advisory board	32	10	13	16	29

Three main patterns arise when these data are viewed by stakeholder group (Table 24). First, funding was unanimously identified as a federal government responsibility. Next, monitoring was unanimously identified as a university responsibility. Lastly, the project

planning responsibility was split between universities and oyster advisory boards. Interestingly, one of the groups that preferred that planning be handled by oyster boards was scientific researchers. Construction responsibility was split between state government and industry.

Table 24. Primary responsibility of each phase of oyster reef restoration, as determined by majority in user group (percent given).

	Planning	Funding	Construction	Maintenance	Monitoring
Shrimp Trawlers	University (35%)	Federal (46%)	State Govt (18%) & Industry Association (18%)	Individual Users (25%)	University (40%)
Oyster Harvesters	University (33%)	Federal (45%)	Individual Users (20%)	Individual Users (25%)	University (37%)
Regulatory Agency employees	Oyster advisory board (35%)	Federal (46%)	State government (21%)	State government (21%)	University (53%)
Scientific Researchers	Oyster advisory board (41%)	Federal (50%)	State government (19%)	Individual Users (33%)	University (34%)
Environmental Organization members	University (35%)	Federal (35%)	Corporate Users (19%), Individual Users (19%), State Govt (19%)	Individual Users (22%)	University (33%)

f) Stakeholder Support for Oyster Reef Restoration

Approximately 90% of respondents personally support oyster reef restoration (Table 25). A vast majority (over 60%) believe that there is both strong oyster industry support as well as strong community support for this restoration. Though a majority believe that there is strong fishing industry support, many (24%) also were not sure or didn't know. Governmental support for oyster reef restoration is less clear, with responses varying from agree (31%) to disagree (23%) to not sure don't know (29%).

Table 25. Summary of stakeholder response (% of total respondents) to the question "Please indicate your level of agreement with the following statements regarding support for oyster reef restoration". (Survey Question 2.2)

Question	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree (%)	Strongly Agree (%)	Not sure/Don't Know (%)
There is strong community support for oyster reef restoration	2	7	11	36	25	19
There is strong governmental support for oyster reef restoration	3	20	17	22	9	29
There is strong fishing industry support for oyster reef restoration	1	8	14	31	21	24
There is strong oyster industry support for oyster reef restoration	1	3	7	30	41	17
I personally support oyster reef restoration	1	0	5	25	64	4

ANOVA analysis shows that the support for oyster reef restoration varies significantly by user group for all the mentioned support for restoration. Specifically, regulatory agency employees and oyster harvesters agreed the strongest (4.34 and 4.13 respectively) compared to environmental organization members (3.77) and scientific researchers (3.71). This was out of a possible ranking of 5, indicating that this lowest score still indicated that that these groups believe that there is overall support for oyster reef restoration.

Logistic regression analysis reveals that agree or disagree response to the questions "I personally support oyster reef restoration" does not significantly differ by user group ($p= 0.65$). Approximately 89% of all user groups agree that they personally support oyster reef restoration.

g) Communication with Various Stakeholder Groups about Oyster Reef Restoration

Stakeholders were asked to identify the best ways to communicate to them about restored oyster reefs (Table 26). Overall, a majority of the stakeholders prefer to be communicated about oyster reef restoration via U.S. Mail (letters, newsletters, etc.) (56%) and local newspapers (51%). Approximately 9% of those surveyed prefered to not be informed about restored oyster reefs.

Table 26. Summary of stakeholder response (% of total respondents) to the question "Please specify which are the best ways to communicate to you about restored oyster reefs". (Survey Question 4.5)

Communication Methods	Response #	%
I do not want to be informed about restored oyster reefs	37	9
Association meetings	129	33
Social media (facebook, twitter, etc)	65	16
U.S. mail (letters, newsletters, etc)	222	56
Local newspapers	202	51
Websites	144	36
Dockside bulletin boards	90	23
Local/community meetings	126	32
Fishing magazines	83	21
E-mail (letters, newsletters, etc)	154	39
Phone	76	19

User groups had different preferences for communication (Figure 5). Over 80% of regulatory agency employees and 70% of scientific researchers prefer to be communicated to via e-mail, but websites may also be sufficient as over 60% chose this as an acceptable method. Oyster harvesters and shrimpers indicated that the best way to communicate to oyster harvesters and shrimp trawlers about oyster reef restoration is through the U.S. mail. Local newspapers

may also serve as a useful way to communicate to these groups, as it was the second most popular method of communication to these groups, and the best way to communicate to environmental organization members. Over 10% of shrimp trawlers marked that they would not want to be informed about restored oyster reefs.

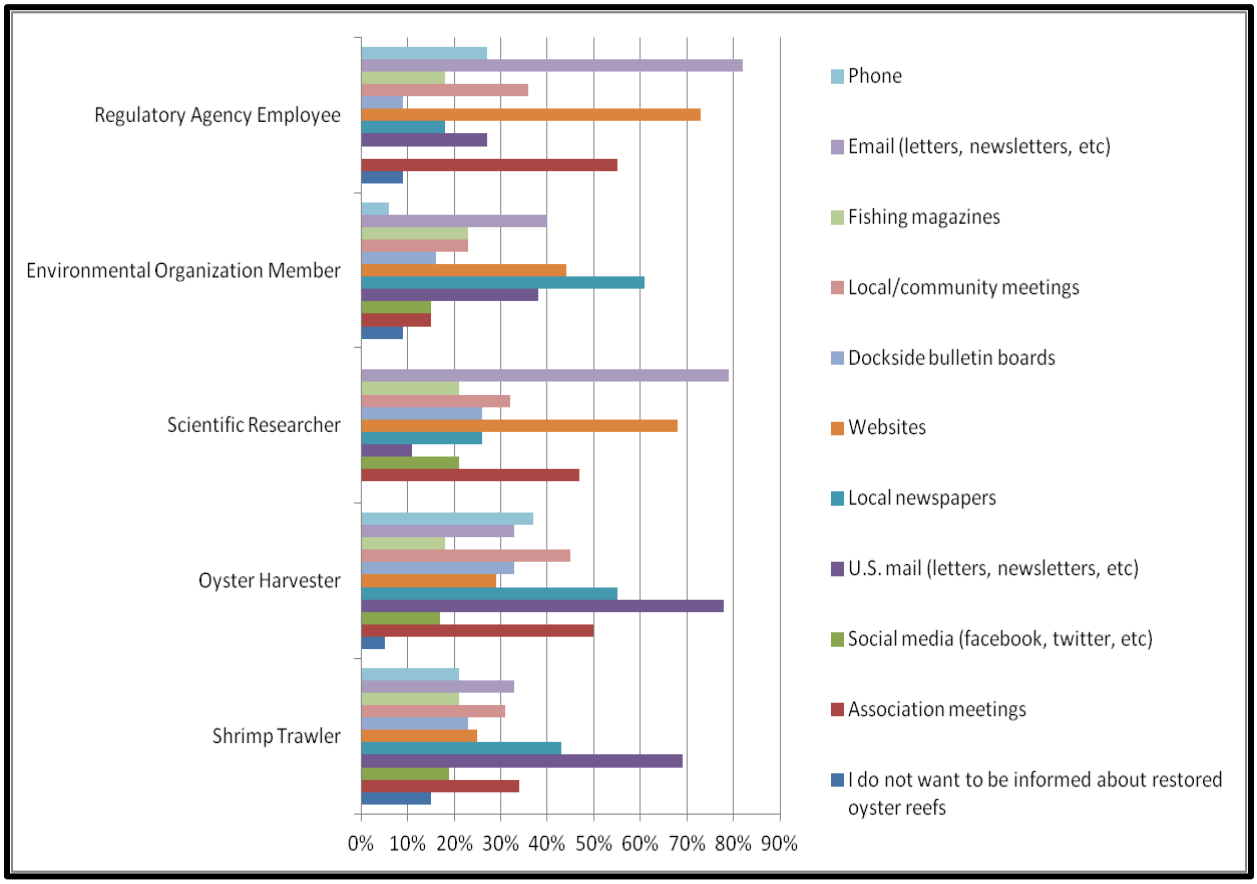

Figure 5. Preferred method of communication with each user group, as determined by majority in user group (percent given).

3.4 Discussion

Since both public and private funding are being spent on creating restored oyster reefs for various purposes, it is important that stakeholders' preference and beliefs about oyster reef restoration be known and incorporated into future plans and projects. This was the first study of

stakeholder perception of oyster reef restoration across the northern Gulf of Mexico. We found that, in general, all user groups strongly supported both coastal and oyster reef restoration in the northern Gulf of Mexico. Across all user groups, a majority of stakeholders feel strongly that oyster reef restoration is not only important to sustaining a healthy oyster population and commercial harvest, but would benefit numerous parties including recreational and commercial fishermen, oyster harvesters, and the coastal community. Interestingly, those most split, or most cautious in ranking the benefits of oyster reefs were scientific researchers. This may be due to the fact that there was a greater percentage of older individuals (56 years +) in this user group compared to others, and their various experiences and training have led to mixed beliefs or more skepticism about the overall ability of oyster reefs to combat the impacts of such events as the oil spill.

Knowing the specific stakeholder knowledge related to the resource to be managed is critical in understanding their responses and support for management and restoration of the resource in question (i.e., oyster reefs) (Endter-Wada et al., 1998). Overall, all user groups believe that ecological services provided by reefs are important in the northern Gulf of Mexico region, and in particular, to maintaining estuarine habitat and water quality. Oyster harvesters and environmental organization members ranked reefs as more critical for these two services compared to scientific researchers, but all believe that they are important. This difference may be due to the large number of oyster harvesters and environmental organization members (over 34% in each group) who responded from the state of Louisiana, where reliance on these ecological services to provide for successful fisheries is important. All user groups also believe that oyster reefs provide many of these ecological services, but a significant number are not sure if they are important buffers to climate change and this likely reflects the state of general knowledge and/or

familiarity with the resources, as environmental organization members and shrimpers were most likely to fail to agree with this statement related to climate change.

While restoration of oyster reefs appears to be strongly supported by all user groups, there was a clear indication that funding for this type of restoration was felt to be primarily the responsibility of the federal government. As funding often limits restoration work, it is interesting that the federal government is preferred to be the party responsible, and may explain why local and state entities often have a hard time justifying or getting approval for expenditures on these types of activities. This response may also reflect a view that reef restoration is seen as a larger gulf-wide endeavor, and federal funding tends to be available in larger amounts, and puts less strain on already stretched states and county and municipal budgets. Monitoring and planning reefs were identified largely to be the responsibility of universities, which often have numerous researchers and students with interest and expertise in monitoring oyster reef ecosystems, likely because they are believed to be able to provide unbiased information. Planning was also believed to be the responsibility of the oyster advisory board (by regulatory agency employees and scientific researchers), as these groups tend to have the knowledge and expertise with oyster reefs restoration. Many regulatory agency employees and scientific researchers who responded to the survey resided in Texas or Louisiana, where there is an oyster advisory board or the like that is available to make planning decisions. Other roles, such as maintenance and construction were found to be less well defined with stakeholders not clearly identifying a key player to be in charge of any of these phases. Clearly, more discussion, and understanding of the reef restoration process is required, with focus on defining the exact steps needed, and the appropriate roles of different levels of government, private industry and non-profit groups.

Differences did exist by user group in terms of their preferences for the implementation and management of oyster reefs, beliefs of the purpose of restoration, perceived threats to oyster reef health and preferred methods of communication. Many of these differences can be attributed to differences in specific knowledge of the oyster reef resources along the coast, and dependence on the resource for their livelihood. For example, many oyster harvesters and shrimp trawlers have livelihoods that are very dependent upon these natural resources, while the other groups are less resource dependent. Some differences are also explained by some potentially confounding demographic variables of education level and age differences among the groups. A majority of scientific researchers and environmental organization members tended to have older respondents as compared to other groups, and most scientific researchers, environmental organization members and regulatory agency employees hold graduate degrees while few oyster harvesters and shrimp trawlers hold graduate degrees. Also of note is the fact that when allowed to self-identify their groups, most users selected two to three groups with many oyster harvesters indicating that they are also shrimp trawlers, and many regulatory agency employees that are scientific researchers. While these differences were not a focus of this study, these variables are used to help explain some of the observed patterns.

User group dependence on the natural resources, and /or familiarity with coastal issues and climate change explains user group differences. Though overall, most stakeholders view hurricanes and other water resource issues as threats to oyster reef health, oyster harvesters and shrimp trawlers tended to believe that commercial and recreational fishing and oyster harvesting were not threats, while environmental organization members and scientific researchers ranked these as low or moderate threats. Most user groups have mixed feelings about the threat sea level rise has on oyster reefs, ranging from shrimp trawlers feeling it is not a threat (but many are

not sure or don't know), to environmental organization members believing it to be a moderate or high threat to oyster health. This high ranking by environmental organization members may reflect a focus of many environmental organizations on climate change issues, including sea level rise.

Stakeholder preferences for implementation and management of restored oyster reefs also differed by user group, with oyster harvesters and shrimp trawlers being less likely to accept management practices that restrict or limit their access to reefs through time restrictions, or setting certain areas off limits. Overall, commercial fisher groups (i.e., oyster harvesters and shrimp trawlers) were less likely to find changes to sack limit changes, daily time restrictions, permanent reef closures, and restrictions on commercial or recreational fishing acceptable compared to the other groups. Many shrimp trawlers and environmental organization members found that they were not sure or did not know if these outcomes were acceptable or not, and this is most likely due to their lack of interaction with the resource compared to the other groups. That said, the majority of respondents were willing to make many trade-offs to support oyster reef restoration, with most indicating a willingness to accept rotating reef closure to allow stocks to rebuild, restriction of gear used on restored reefs, restricted seasons on these reefs and incentives for private restoration (oyster harvesters).

Equally important for gaining stakeholder support is understanding their motivation for supporting reef restorations (Clarke et al., 2002, Kennish et al., 2002). This survey found two differing views: a majority of environmental organization members and scientific researchers believe that oyster reefs should be restored primarily for ecological purposes, while a majority of oyster harvesters and regulatory agency employees believe that they should be restored for commercial purposes. This displays the dichotomy between those who believe oyster reef

restoration is a method of restoring for commercial benefit, as has historically been done to enhance fisheries and those who believe that oyster reefs need restoring for their important ecological benefits. This dichotomy has important implications for planning and necessitates engaging various stakeholder groups in the process (Endter-Wada et al., 1998).

Interestingly, most respondents indicated stakeholder involvement and public education and outreach to be critical for reef restoration management and success of reef restoration, and most in need of improvement. Communication and outreach to stakeholders is identified as critical, and thus the methods to correspond with the different user groups are also critical. E-mail correspondence will reach a majority of regulatory agency employees and scientific researchers, while local newspapers will reach most environmental organization members. There is regular communication by e-mail for these groups through their workplaces. U.S. mail is the preferrred method of communication to oyster harvesters and shrimp trawlers, as their occupation does not routinely require accesss to the internet. A portion of shrimp trawlers do not wish to receive information about restored reefs, which may not be relevent to their commercial success.

3.5 Conclusion

Perceptions of oyster reef restoration can vary by stakeholder group, as verified through a survey sent to various stakeholders across the northern Gulf of Mexico. Though user groups often have competing uses of oyster reefs, the recognition that oyster reefs provide important ecological services and that these services need restoring in the northern Gulf of Mexico, is shared among all stakeholder groups. Though there is unanimous support for oyster reef restoration amongst the user groups, the user groups vary in what they are willing to accept in

order to support oyster reefs restoration, who they believe should be responsible for particular phases of the restoration process, their perception of threats which are significant to the health of oyster reefs, and their overall familiarity with oyster reef restoration. These groups even differ as to the communication methods they prefer regarding restored oyster reefs. Taking into account these similarities and differences in user groups is essential to the success of future oyster reef restoration in the northern Gulf of Mexico, and results of the survey suggest that some basic issues need to be resolved regarding the process of oyster reef restoration

Information regarding the various stakeholder preferences and beliefs about oyster reef restoration should be incorporated into future oyster reef restoration plans. Having communities and user groups that are supportive of these restoration efforts will ensure their sustainability and success (Tomicevic et al., 2010, Turner et al., 2003). As marine systems are common pool resources, compliance and trust with user group ideals is essential in order for efforts to be worthwhile and effective. Stakeholder perception of oyster reef restoration, in conjunction with science, can guide future policy and restoration decisions concerning what resources are the most important to restore because of value and need, which methods of restoration are acceptable, what needs improving with the management of these resources, and which locations for oyster reef restoration the public will find appropriate. Knowing the best ways to communicate with particular groups can provide guidance to projects planners, educators, and fundraising groups in order to maximize their restoration efforts. If oyster reef restoration is going to be an important method of coastal restoration for the northern Gulf of Mexico, then gaining support of the public and the user groups that may affect its success is of utmost importance.

CHAPTER 4: SPATIAL DECISION SUPPORT TOOL

4.1 Introduction

It is important to take into account the ecological and socio-economic contexts, such as local landscapes, land use, and cultural functions when considering oyster reef restoration in the northern Gulf of Mexico (Wyant et al., 1995; Haveh, 2005). Appropriate spatial information about the biological and physical environment ensures that restoration is conducted in the most appropriate locations, and socio-economic information can identify where we are limited in our efforts, as socio-economics can often influence decisions that affect success of restoration projects more than ecological factors (Roberts et al., 2003a, Walters 1997). Therefore, it is imperative that potential restoration sites be chosen based on a combination of both social and biological criteria (Roberts et al., 2003b). Reliable scientific information and spatial tools can help guide restoration to where it is most appropriate, necessary, and potentially successful.

In the face of a number of coastal stressors including climate change, coastal resilience and ecosystem-based adaptation are important concepts for decision makers and stakeholders to consider. Decision support tools have been implemented to provide decision makers with the critical information needed to make informed management decisions (Ferdana et al., 2010). These interactive decision support tools are often used in marine spatial planning to provide transparency and stakeholder engagement by keeping data centralized, and conveying the effects of management decisions and tradeoffs of various management scenarios to stakeholders and managers (Conservancy, 2007). For example, as part of The Nature Conservancy (TNC) Coastal Resilience project, a Future Scenarios Mapper was created to allow local decision makers in the Long Island region to examine current ecological, biological, socio-economic and management information alongside accurate and current information on the projected extent of sea level rise

across the region (Ferdana et al., 2010). These decision support tools also enable stakeholders to explore the real world implications of various management decisions (Beck et al., 2009b), enabling better informed and collaborative decision making on activities such as the restoration of habitats.

A web-based Gulf of Mexico Restoration Decision Support Tool was developed as an additional component in the Coastal Resilience project. It incorporates important and appropriate scientific knowledge related to oyster reefs and other coastal habitats that can help inform and guide scientists, natural resource managers and other decision makers in their efforts to restore northern Gulf of Mexico coastal ecosystems (The Nature Conservancy, 2011a) . To maximize both the socio-economic and ecological benefits of restoration, this tool aims to: 1) identify ecological criteria that define where restoration can be successful; 2) identify socio-economic criteria that determine when restoration is most feasible and beneficial; 3) collect, process and analyze spatial data that represent those criteria; and 4) deliver that information across the web in a user-friendly mapping application (The Nature Conservancy, 2011a). This interactive visual tool will not only allow the user to view pertinent spatial information but also to create various restoration scenarios based on a number of ecological and socio-economic data layers collected from across the Gulf coast, therefore enabling informed decision making about restoration locations, options and conditions. Ultimately the goals are to maximize project benefits and achieve the greatest return on investment of funds used for restoration (The Nature Conservancy, 2011a).

An oyster reef restoration ‘blueprint’ is needed for the northern Gulf of Mexico to help establish goals and guide how and where oyster restoration efforts and funding should be focused to restoring reefs on a large scale. The Gulf of Mexico Restoration Decision Support (DS) Tool

can enable oyster reef projects to be implemented in the most favorable regions by knowing which areas would promote optimal oyster growth and ecological services and have the most socio-economic advantages. The complex arrangement of biological, political and socio-economic factors in coastal Louisiana make it an ideal place to test the use of a decision support tool to determine placement of oyster restoration in the area. Therefore, the coastal region of Louisiana can be used as an example of what biological and socio-economic layers affect the choice of future oyster reef restoration or conservation sites because this state has a vulnerability to oyster reef degradation from its thriving oyster industry, altered freshwater flows, human and natural disturbances as well as its multiuse coastal zone (Turner, 2006). Louisiana was responsible for 65% of the total U.S. Eastern Oyster landings in 2009 (Figure 6), which was worth over $50 million (Figure 7). This tool will undoubtedly guide the restoration of Louisiana oyster reefs aimed at remediating the multitude of coastal issues that affect the state.

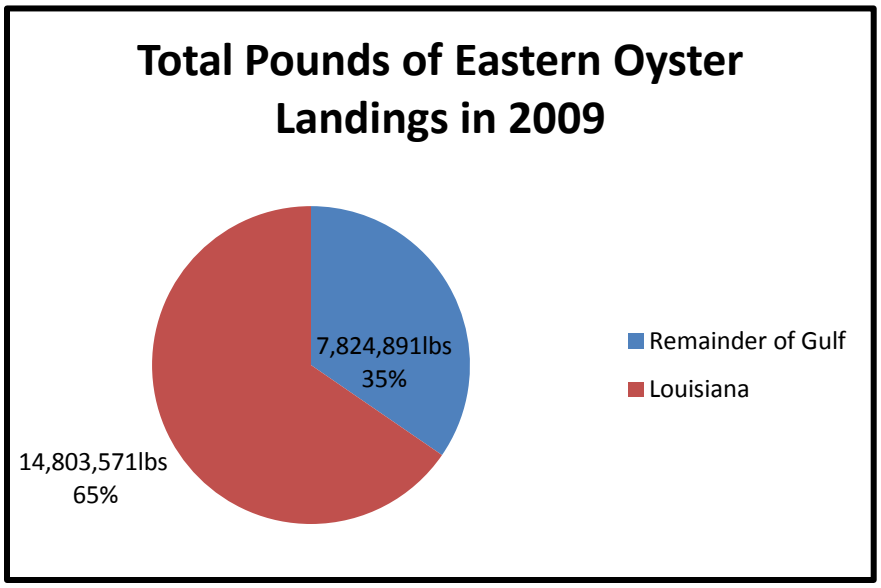

Figure 6. Total pounds of Eastern Oyster landings in 2009 for both Louisiana and the Gulf of Mexico (NMFS, 2011).

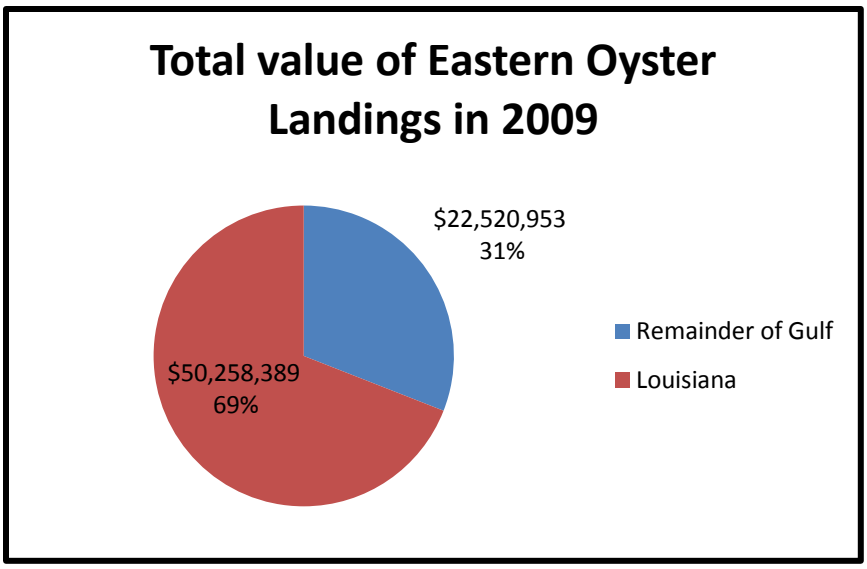

Figure 7. Total value of Eastern Oyster landings in 2009 for both Louisiana and the Gulf of Mexico (NMFS, 2011).

The objectives of this project are to

1. Identify, locate, collate and determine the best use and projection of appropriate spatial layers pertaining to the important biological and socio-economic factors to consider in oyster reef restoration and conservation in the northern Gulf of Mexico, and in particular, Louisiana.
2. Develop an informative user guide to be made widely available to any potential stakeholders.

4.2 Methods

4.2.1 Data Layers

A list of biological, socioeconomic and political data that might influence the short and long-term success of oyster reef restoration in coastal Louisiana was generated based on a review

of peer-reviewed and gray literature, and from discussions with experts currently involved in oyster restoration. Once the list was generated, appropriate spatial data to represent the identified information was sought and collated from various governmental and public sites. The data were sent to the TNC Decision Support team who then analyzed, processed and projected these layers on the development site (http://dev.gulfmex.coastalresilience.org/) for discussion and review on how to best interpret and display the information. Based on these discussions, the selected layers were then posted on the main website after confirming the ideal conditions for successful oyster reef growth, how the data can best be used to direct oyster restoration efforts, and the optimum ways to project the information to ensure user friendly use and interpretation (http://gulfrestorationds.org/).

4.2.2. User Guide

To ensure that this tool was user-friendly and available to the end-user (state, local, federal managers and restoration experts), a user guide was created to demonstrate how to navigate and use features provided in the decision support tool. The Nature Conservancy staff of the Louisiana Field Office served as trainees for an online training session about the tool, which was recorded along with the display for later use in creating online training modules. Future audio/video simulations will demonstrate how this model can be used to help make decisions regarding oyster reef restoration in Louisiana and throughout the northern Gulf of Mexico. The training event also provided insight into potential problems with the interpretation and understanding of the data, technical issues, and the general user-friendliness of the model. These were identified using feedback from trainees. The results of the training session were used to further clarify the user guide, which will be distributed widely to users. Training these

individuals, who have established relationships with many of the future potential users of this site, allows them to thoroughly understand the capabilities of this site and allows them to effectively pass along this information; ultimately bringing the decision support tool to those individuals for whom it was intended.

4. 3 Results

4.3.1. Data Layers

Spatial layers that may provide important information to oyster reef restoration projects, plans and efforts were collated for the state of Louisiana. Over 35 data layers in eight categories were identified as critical to this effort (Table 27). These data were evaluated for inclusion in the decision support tool. These layers, their sources, and the category in which each lies in the decision support tool are listed in the table below.

For spatial processing and inclusion in the decision support tool, each layer had to be spatially collated in terms of how the data are useful in identifying good reef restoration locations. For biological data, this process was completed using the peer-reviewed literature to identify, for example, good oyster growth areas. For example, for the salinity layer, areas with a mean salinity between 5 and 25 were identified as suitable for oyster restoration (score of 1) while areas below or above that salinity were identified as unsuitable for oyster restoration. This allows for important layers to be used in creating suitability scenarios in the DS Tool. Details of the scoring of these layers are explained in the Table 28.

4.3.2. User Guide.

The Gulf of Mexico Restoration Decision Support User Guide is the product of the data collection and training event information (See Appendix C for complete User Guide)

Table 27. Louisiana spatial layers collected for Decision Support Tool

Group	Layer	Source
Restoration Projects	Coastal Restoration Project Infrastructure	
	Coastal Restoration Project	United States Geological Survey National Wetlands Research Center
Habitats	Historic Areas	Digitized historic reefs by The Nature Conservancy
	Historic Areas (1920)	Louisiana Department of Conservation
	Historic Area (1906 Vermillion Bay)	Digitized historic reefs by The Nature Conservancy
	Marsh (LDWF 2001)	Louisiana Department of Wildlife and Fisheries 2001
Bathymetry	Offshore bathymetry contours (2 m interval)	Texas Parks and Wildlife - National Oceanographic and Atmospheric Administration
	Bathymetry (Terrebonne/Timbalier Bays 1934-1935)	Louisiana State University
Salinity	High Tide Line	National Wetlands Inventory
	Low Salinity Season (ppt)	National Oceanographic and Atmospheric Administration National Coastal Data Development Center
	High Salinity Season (ppt)	National Oceanographic and Atmospheric Administration National Coastal Data Development Center
	Salinity	Louisiana Department of Wildlife and Fisheries
Coastal Hazards	Levee	U.S. Army Corps of Engineers
	Dispersant Pre-approved Area	Louisiana Oil Spill Coordinators Office
	FEMA flood zone	Federal Emergency Management Agency
	LA Observed cumulative oil (surface)	National Environmental Satellite, Data, and Information Service
	LA Observed cumulative oil (mid-surface)	National Environmental Satellite, Data, and Information Service
	USGS Coastal Vulnerability Index	United States Geological Survey

(Table 27 continued)

Social & economic	Population Center	2000 U.S. Census Bureau
	Persons living in poverty	2000 U.S. Census Bureau & National Oceanographic and Atmospheric Administration
	Percent employed in ag, fish, forestry	2000 U.S. Census Bureau & National Oceanographic and Atmospheric Administration
	Percent employed in construction	2000 U.S. Census Bureau & National Oceanographic and Atmospheric Administration
Coastal Management	Public seed ground area	Louisiana Department of Wildlife and Fisheries
	Cultch Plants	Louisiana Department of Wildlife and Fisheries
	Oyster leases	Louisiana Department of Wildlife and Fisheries
	Oyster production zones (Barataria-Terrebonne)	Barataria-Terrebonne National Estuary Program, Nicholls State University 1994
	Shellfish Water Quality	
	Marina	Louisiana Oil Spill Coordinator's Office, McNeese University, and Nichols State University
	Navigable Waterways	LSU Department of Geography and Anthropology (Brett Territo, Don Davis, Hampton Peele, Rob Cunningham)
	State claimed water bodies	Louisiana State Land Office
	State owned/leased land	Louisiana State Land Office
	Offshore boundary	Louisiana State Land Office
	Wildlife Management Area (LDWF)	Louisiana Department of Wildlife and Fisheries
	Managed Area	Mineral Management Service, Louisiana Department of Wildlife and Fisheries, Louisiana State University
Biological	ESI Waterfowl (LDWF 2001)	Louisiana Department of Wildlife and Fisheries 2001
	Rare and Endangered Species	Louisiana Natural Heritage Program

Table 28. Scoring for oyster reef restoration suitability layers.

Group	Data	Scoring
Ecological	**Historic Reef**	**Area's with reef = 1** **Areas without reef = 0**
	Depth Score	**Water depth<10 ft = 1** **Water depth >10 ft = 0**
	Salinity Score	**5-25 ppt = 1** **All other salinities =0**
	Distance to Marsh	**Areas < 50m from marsh = 1** **Areas > 50m from marsh = 0**
Socio-economic	**Natural Resource Job Dependency Score**	**Near shore areas within 2 km of a high natural resource job dependency = 1** **Adjacent to medium concentrations = .5** **All others = 0**
	Project Permit Feasibility Score	**Non-public or private leases= 1** **Public or private leases = 0**
	Erosion Score	**High erosion rate = 1** **Moderate erosion rate = .75** **Low erosion rate =.25** **No erosion rate = 0**

4.4 Conclusion

The Gulf of Mexico Restoration Decision Support Tool was created to assist decision makers across the northern Gulf of Mexico in their management decisions regarding coastal restoration, and in particular, oyster reef restoration. By focusing these efforts on the state of Louisiana, this ensures that appropriate and critical spatial information for this state is available to allow further progress with oyster reef restoration projects and plans in the area. The host of issues affecting coastal Louisiana, along with the immediacy of addressing coastal wetland loss and the funds available to do so, increases the need to have reliable, scientific information that aids oyster reef restoration project placement.

It is important to introduce this new interactive tool to those who will be most influential in spreading awareness of the DS Tool's usefulness and capabilities. By creating an easy to follow and informative user guide, introducing this tool to the public will be easier and more effective. Teaching the individuals at TNC Louisiana the basic concept of and navigation of the site enabled constructive feedback. This tool may be useful when a specific project is planned, and would allow users to look further into a location's attributes; leading to specific outreach efforts. The tool may also be used to engage and influence future donors such as government officials, organizations, or other conservationists. This tool will enable decision makers to share information and ideas about potential projects and issue areas, which may ultimately lead to fundraising efforts for specific locations or issues, as well as promoting new partnerships. The Gulf of Mexico Decision Support Tool will not only aid in appropriate placement of restoration projects in the Gulf coast, but provide for a scientific basis from which these decisions are made.

CHAPTER 5: CONCLUSION

Worldwide, over 85% of oyster reefs have been decimated due to a variety of natural and anthropogenic factors. The northern Gulf of Mexico remains one of the last regions in the United States where these oyster reefs continue to thrive (Beck et al., 2011), though they are exposed to significant pressure from commercial harvest and a degrading environment. Protecting and restoring oyster reefs is of utmost interest to a number of agencies along the coast, as the oyster reefs ecological and economic benefits are important to coastal communities, our state, and our nation. Until recently, oyster reef restoration plans and projects have been site-specific efforts, enabling restoration and benefits for localized areas. To address the significant loss of ecosystem services that historic reefs once provided, such as water quality improvement, fisheries habitat, and shoreline protection, region-wide plans are now being proposed.

To create a Gulf-wide oyster reef restoration plan, and conduct successful restoration projects across this large region, it is critical to possess a thorough understanding of factors affecting the success of these projects, and the obstacles that may be encountered. First, each Gulf State has different laws and requirements for conducting oyster reef restoration in its respective waters, making region-wide permitting complicated. Two efforts that would alleviate this issue and greatly assist future oyster reef restoration in the Gulf are 1) a common oyster reef restoration permitting procedure and 2) a streamlining of the permitting processes to better accommodate restoration. Next, entities currently conducting oyster reef restoration in the Gulf States differ in their goals, ideas and expectations for oyster reef restoration. There is division in the goals of project leader goals, with state managers restoring oyster reef primarily for commercial harvest and non-profit organizations restoring reefs primarily for ecological service

benefits. This division creates potential conflict with location and permitting requirements of oyster reef restorations. A unified northern Gulf of Mexico oyster restoration plan could foster understanding and support of these various efforts across states and entities and also serve as an important guide to expedite restoration efforts.

Stakeholder groups across the Gulf region share many beliefs about oyster reef benefits and services. Stakeholders support coastal as well as oyster reef restoration and believe it to be important. They also value ecological services and believe that oyster reefs have and can provide multiple, important service benefits. Stakeholders also agree that oyster reef health can be threatened by both natural (hurricane's) and man made (water resource alteration) events.

Stakeholder perception of oyster reef restoration is highly affected by values, as well as dependence on and familiarity with oyster reefs. Oyster harvesters and shrimp trawlers, those who rely directly on natural resources for their income, do not believe that fishing practices are a threat to oyster reef health, unlike other user groups. These stakeholders are also less likely to accept any management practices that restrict or limit their access to the reef resources such as changes in sack limits (increase or decrease), daily time restrictions, permanent reef closure, and restriction of commercial or recreational fishing on restored reefs. These changes should be avoided in harvest areas order to prevent conflict with these groups. On the other hand, oyster harvesters and shrimpers are willing to accept less invasive management practices such as the rotation of reef closures, restriction of harvest gear or restriction of seasons on restored reefs, as well as incentives for private restoration. These management tools may useful for future reef restoration and conservation efforts. Oyster harvesters, along with regulatory agency employees, believe restoration should be conducted primarily for commercial purposes, while environmental organization members and scientific researchers support restoration primarily for its ecological

benefits. Though there is divide in these preferences, outreach can help both groups understand that there is potential to achieve both objectives with oyster reef restoration in the northern Gulf of Mexico.

Stakeholder involvement and public outreach and education can be improved, and outreach is critical to successful reef restoration. Outreach and education can be done through e-mail to regulatory agency employees and scientific researchers, and U.S. mail to oyster harvesters and shrimp trawlers. Shrimp trawlers and environmental organization members are less familiar with oyster reef restoration and oyster resources, but incorporating their views may be important to gaining their support for oyster reef restoration. Funding sources are preferred to be a government responsibility, with most of the responsibility identified with the federal government. Education and outreach about the benefits of oysters to stakeholders Gulf-wide may not only increase stakeholder support for restoration but also increase its recognition by the federal government as a national priority, enabling funding for Gulf-wide restoration. Monitoring and planning should be left to universities and oyster advisory boards, tapping their expertise and interest in these ecosystems. Construction and maintenance of reefs can be conducted by the state or user groups, as has been done.

Appropriate placement of restored oyster reefs is key to restoration success, and spatial information should be used to guide these efforts. A Gulf of Mexico Restoration Decision Support Tool was created to provide important socio-economic and biological information that can be easily viewed spatially and used by restoration decision makers along the Gulf coast. This tool serves spatially plan where oyster reef restoration projects may be successful, and determine how these restoration efforts may affect or be affected by the socio-economics and politics of coastal communities. By introducing this tool to the public, decision making can

incorporate reliable and accurate scientific data, and visual data can be shared among planners and partners.

Collectively, the information gained from targeted interviews, a stakeholder survey, and spatial planning is helping to set the stage for guiding future Gulf-wide oyster restoration planning and planners to ensure that oyster reef restoration is successful. These identified potential constraints and opportunities can be used as a blueprint for what is currently achievable and provide insight into factors that need to be addressed to create a Gulf-wide oyster reef restoration plan. New policies incorporating this information could enable larger, more effective restoration projects in the northern Gulf of Mexico. The sustainability and success of Gulf-wide oyster reef restoration is highly dependent on these biological, socio-economic and geo-political factors; therefore accurate information about these factors is imperative for restoration managers.

Although this study provides important information about how various stakeholders groups perceive oyster reef restoration, efforts to reduce confounding factors such as age, education, ethnicity, state of residency and self-identified user groups would ensure that discovered beliefs are accurate for the designated user groups. In sampling a larger number of stakeholders, one may be able to divide user groups into those who only identify with one group (i.e. environmental organization member), compared to those who identify themselves with multiple groups (i.e. shrimper and oyster harvester). Also, incorporating identified recreational fisher persons would give another perspective of oyster reef resources.

User group differences in the perception of oyster reef restoration gives restoration planners an idea of where to begin with outreach and education efforts, but further understanding how perceptions vary by state, such as in the need for restoration of ecological services, and how

they vary by educational and age group should be a priority. This information will shed light on what differences there may be in various stakeholder groups across the Gulf of Mexico.

Another possible future research study would be to look at the extent of support for oyster reef restoration across stakeholders. Though overall support for restoration and recognition of its importance is apparent, stakeholder willingness to pay or willingness to give up may ultimately affect their level of support. This may provide restoration planners more insight into the depth of support and what future actions may be acceptable to promote oyster reef restoration as an effective method for coastal restoration.

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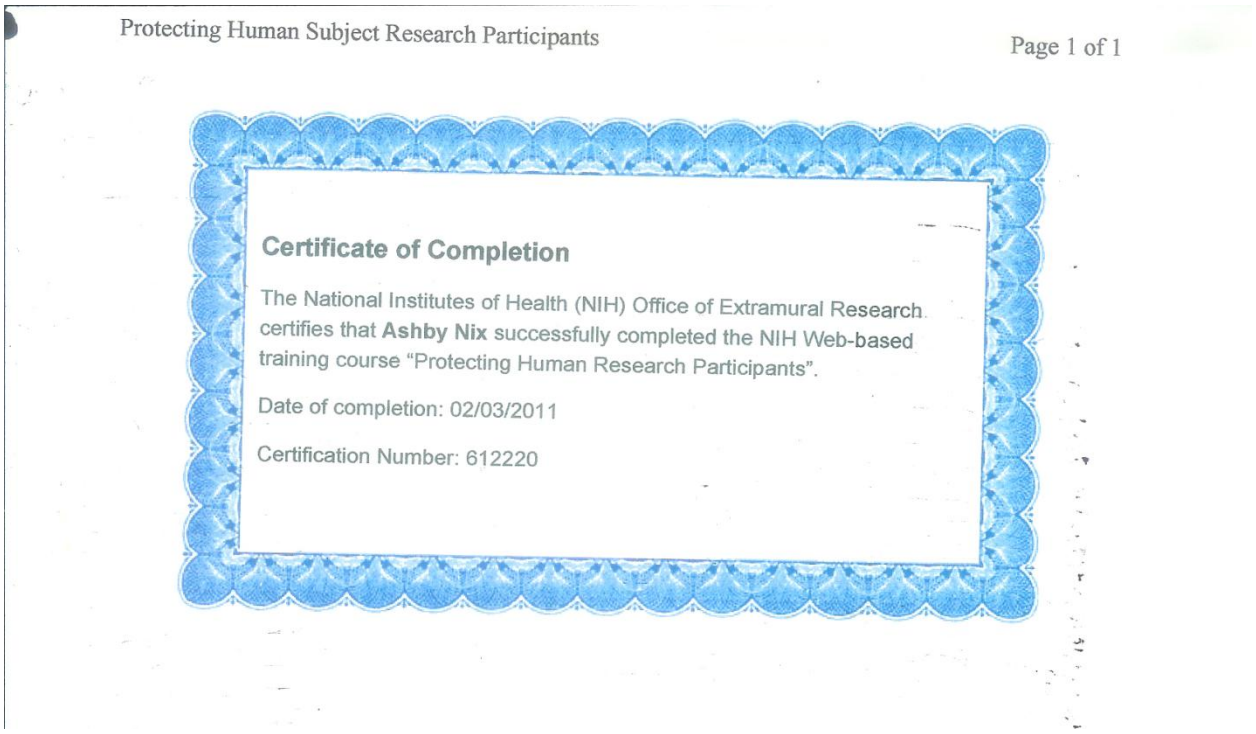
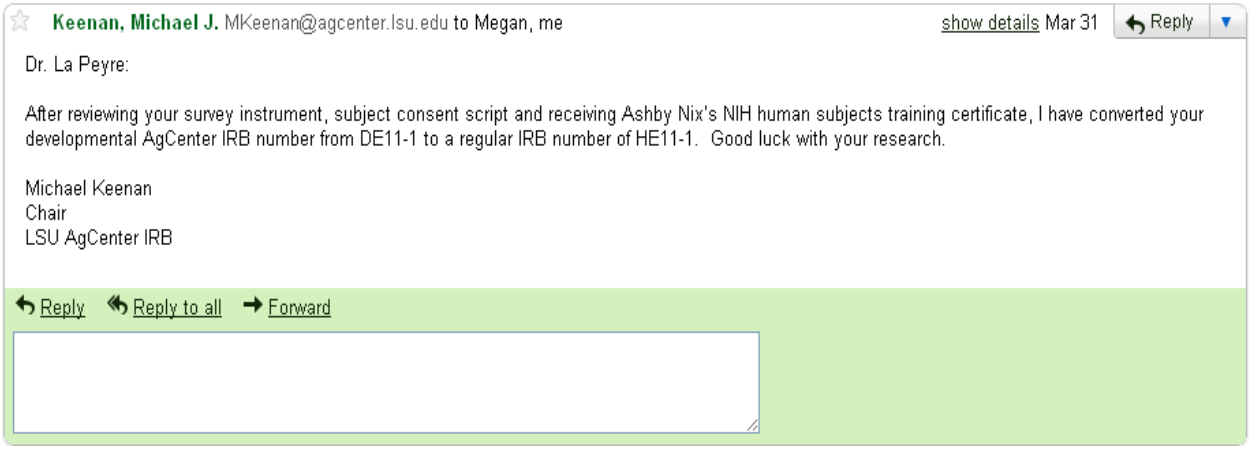
APPENDIX A: SURVEY MATERIALS



Appendix A – Figure 1. NIH human subjects training certification



Appendix A – Figure 2. IRB approval

«GreetingLine»

As a «Group» you have been randomly selected to participate in a survey regarding your perception of oyster reef restoration in the Gulf of Mexico. This is part of a graduate study conducted by Louisiana State University Agricultural Center with important stakeholders along the Gulf of Mexico.

By participating, you will provide to researchers important information about your knowledge of Gulf oyster resources and opinions about oyster reef restoration. **Oyster reef restoration refers to the process of creating or enhancing oyster reefs through "planting" oyster shell or other hard substrate to initiate settlement and growth of oysters for the benefit of the ecosystem.** Your input will aid scientists and resource managers in their evaluation of oyster reef restoration as a technique for restoring the Gulf coast. This survey should take no more than **10-15 minutes of your time** to complete.

Please note that you must be at least **18 years old** to participate. Your participation is voluntary. Your identity will remain anonymous and your answers will be kept strictly confidential. There are no known risks associated with completing this survey. Results of this survey will be released only in a summary form with no identification of an individual's answers. This summary of results is available to you upon request.

For your convenience, the survey can be completed in one of two ways.

1. **Online at the following web address** - http://www.rnr.lsu.edu/oystersurvey **Survey ID# «LoginID»**
2. **Paper Survey – this will be mailed to you in approximately two weeks time**

We *highly encourage* you to complete the survey online, but a paper copy of the survey will be provided for your convenience within the next couple of weeks. An identification number has been provided for you so your name can be deleted from our mailing list on receipt of your completed survey.

Your participation is critical to the future of oyster reef restoration in the Northern Gulf of Mexico. If you have specific questions, or would like to request a summary of this survey, please contact Ashby at 225-578-6428 or enix2@lsu.edu

Sincerely,

E. Ashby Nix
Graduate Research Assistant
School of Renewable Natural Resources
Louisiana State University Agricultural Center
Baton Rouge, LA 70803

Appendix A – Figure 3. Cover letter for first survey mailing

«GreetingLine»

As a «Group» you have been randomly selected to participate in a survey regarding your perception of oyster reef restoration in the Gulf of Mexico. This is part of a graduate study conducted by Louisiana State University Agricultural Center with important stakeholders along the Gulf of Mexico.

By participating, you will provide to researchers important information about your knowledge of Gulf oyster resources and opinions about oyster reef restoration. **Oyster reef restoration refers to the process of creating or enhancing oyster reefs through "planting" oyster shell or other hard substrate to initiate settlement and growth of oysters for the benefit of the ecosystem.** Your input will aid scientists and resource managers in their evaluation of oyster reef restoration as a technique for restoring the Gulf coast. This survey should take no more than **10-15 minutes of your time** to complete.

Please note that you must be at least **18 years old** to participate. Your participation is voluntary. Your identity will remain anonymous and your answers will be kept strictly confidential. There are no known risks associated with completing this survey. Results of this survey will be released only in a summary form with no identification of individual's answers. A summary of results is available to you upon request.

If you have already completed this survey, we thank you for your prompt response! If you have not yet completed the survey, we encourage you to in one of the following ways.

1. **Complete the survey online at** http://www.rnr.lsu.edu/oystersurvey **Survey ID # «LoginID»**
2. **Complete the paper copy provided for you in this packet**

We *highly encourage* you to complete the survey online, but a paper copy of this survey has been provided to you for your convenience. An identification number has been given to you so your name can be deleted from our mailing list on receipt of your completed survey.

Your participation is critical to the future of oyster reef restoration in the Northern Gulf of Mexico. If you have specific questions, or would like to request a summary of this survey, please to contact Ashby at 225-578-6428 or enix2@lsu.edu

Sincerely,

E. Ashby Nix
Graduate Research Assistant
School of Renewable Natural Resources
Louisiana State University Agricultural Center
Baton Rouge, LA 70803

Appendix A – Figure 4. Cover letter for second survey mailing

«GreetingLine»

A few weeks ago, you received a survey packet requesting your participation in a survey on oyster reef restoration. Your response will help researchers and managers make future decisions and plans regarding restoring oyster reefs in the Gulf of Mexico.

If you are receiving this post card, then we have not yet received your survey response by mail or online.

We *highly encourage* you to complete the survey, either online or the paper survey that was provided to you. A self addressed stamped envelope was provided so that this is of no cost to you. Once the survey is completed, your name and address will be deleted from any future mailings. **We would greatly appreciate your participation. Your response is very important to us!** If you have specific questions, please contact Ashby at 225-578-6428 or enix2@lsu.edu

Sincerely,
E. Ashby Nix
Graduate Research Assistant
School of Renewable Natural Resources
Louisiana State University Agricultural Center
Baton Rouge, LA 70803

Appendix A – Figure 5. Reminder postcard for survey third survey mailing

«GreetingLine»

As a «Group» you have been randomly selected to participate in a survey regarding your perception of oyster reef restoration in the Gulf of Mexico. This is part of a graduate study conducted by Louisiana State University Agricultural Center with important stakeholders along the Gulf of Mexico.

By participating, you will provide to researchers important information about your knowledge of Gulf oyster resources and opinions about oyster reef restoration. **Oyster reef restoration refers to the process of creating or enhancing oyster reefs through "planting" oyster shell or other hard substrate to initiate settlement and growth of oysters for the benefit of the ecosystem.** Your input will aid scientists and resource managers in their evaluation of oyster reef restoration as a technique for restoring the Gulf coast. This survey should take no more than **10-15 minutes of your time** to complete.

Please note that you must be at least **18 years old** to participate. Your participation is voluntary. Your identity will remain anonymous and your answers will be kept strictly confidential. There are no known risks associated with completing this survey. Results of this survey will be released only in a summary form with no identification of individual's answers. A summary of results is available to you upon request.

If you have already completed this survey, we thank you for your prompt response! If you have not yet completed the survey, we encourage you to in one of the following ways.

1. **Complete the survey online at** http://www.rnr.lsu.edu/oystersurvey **Survey ID # «LoginID»**
2. **Complete the paper copy provided for you in this packet**

We *highly encourage* you to complete the survey online, but a paper copy of this survey has been provided to you for your convenience. An identification number has been given to you so your name can be deleted from our mailing list on receipt of your completed survey.

Your participation is critical to the future of oyster reef restoration in the Northern Gulf of Mexico. If you have specific questions, or would like to request a summary of this survey, please to contact Ashby at 225-578-6428 or enix2@lsu.edu

Sincerely,

E. Ashby Nix
Graduate Research Assistant
School of Renewable Natural Resources
Louisiana State University Agricultural Center
Baton Rouge, LA 70803

Appendix A – Figure 6. Cover letter for fourth survey mailing

Stakeholder Perception of Oyster Reef Restoration «LoginID»

SECTION 1 – *Knowledge of Ecological Services*

Q1.1 Please indicate your view of the level of importance and need for restoration of ecological services in your state. (Mark two responses- one response for "Importance" and one response for "Need for Restoration".)

	Importance				Need for Restoration			
	Not important	Mildly Important	Very Important	Not sure/Don't know	No restoration required	Minor restoration required	Intensive restoration required	Not sure/Don't know
Oyster production for harvest	❍	❍	❍	❍	❍	❍	❍	❍
Oyster production for ecosystem health	❍	❍	❍	❍	❍	❍	❍	❍
Water quality	❍	❍	❍	❍	❍	❍	❍	❍
Marine habitat	❍	❍	❍	❍	❍	❍	❍	❍
Shoreline stabilization	❍	❍	❍	❍	❍	❍	❍	❍
Biodiversity (or variety of species) in coastal landscapes & ecosystems	❍	❍	❍	❍	❍	❍	❍	❍
Fish production for commercial fisheries (shrimp, crab, fin-fish)	❍	❍	❍	❍	❍	❍	❍	❍
Fish production for recreational fisheries	❍	❍	❍	❍	❍	❍	❍	❍
Scientific research on coastal ecosystems	❍	❍	❍	❍	❍	❍	❍	❍
Coastal heritage and culture	❍	❍	❍	❍	❍	❍	❍	❍
Coastal economy	❍	❍	❍	❍	❍	❍	❍	❍
Coastal wetlands	❍	❍	❍	❍	❍	❍	❍	❍
General environmental education	❍	❍	❍	❍	❍	❍	❍	❍

Appendix A – Figure 7. Stakeholder Survey (a)

Q1.2 Please indicate your level of agreement. (Mark one response for each statement.)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/ Don't know
Oyster reefs improve the water quality	❍	❍	❍	❍	❍	❍
Oyster reefs provide shoreline protection	❍	❍	❍	❍	❍	❍
Oyster reefs provide good marine habitat	❍	❍	❍	❍	❍	❍
Oyster reefs support the sustainability of oysters	❍	❍	❍	❍	❍	❍
Oyster reefs promote biodiversity in the landscape and ecosystems	❍	❍	❍	❍	❍	❍
Oyster reefs are an important buffer to climate change	❍	❍	❍	❍	❍	❍
Oyster reefs increase fish production	❍	❍	❍	❍	❍	❍
Oyster reefs impede navigation	❍	❍	❍	❍	❍	❍
Oyster reefs are an indicator of a healthy coast	❍	❍	❍	❍	❍	❍

Q1.3 How much of a threat are the following to the health of oyster reefs in your state today?

	Not a threat	Low threat	Moderate threat	High Threat	Not sure/Don't know
Commercial fishing (crabs, fin-fish, shrimp)	❍	❍	❍	❍	❍
Recreational fishing	❍	❍	❍	❍	❍
Hurricanes	❍	❍	❍	❍	❍
Oyster harvest practices (shell dredging, tonging, etc)	❍	❍	❍	❍	❍
Disease & natural predation	❍	❍	❍	❍	❍
Coastal development & land use	❍	❍	❍	❍	❍
Freshwater diversions	❍	❍	❍	❍	❍
Sea Level Rise	❍	❍	❍	❍	❍
Disruption of water supply (dams, canals, irrigation, etc)	❍	❍	❍	❍	❍

Appendix A – Figure 7. Stakeholder Survey (b)

SECTION 2 – *Views of Oyster Reef Restoration*

Q2.1 Please indicate your level of agreement with the following statements about oyster reef restoration. (Mark one response for each statement.)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/Don't know
Coastal restoration is important to me	❍	❍	❍	❍	❍	❍
Oyster reef restoration is important to maintaining a healthy oyster population	❍	❍	❍	❍	❍	❍
Oyster reef restoration would benefit the local commercial fishermen (crab, fin-fish, shrimp)	❍	❍	❍	❍	❍	❍
Oyster reef restoration would benefit the local oyster harvesters	❍	❍	❍	❍	❍	❍
Oyster reef restoration would benefit the local recreational fishermen	❍	❍	❍	❍	❍	❍
Oyster reef restoration would help the coastal community	❍	❍	❍	❍	❍	❍
Oyster reef restoration would help the recovery of local fisheries from natural disasters such as hurricanes	❍	❍	❍	❍	❍	❍
Oyster reef restoration would help the local fisheries recover from the Deep Water Horizon oil spill	❍	❍	❍	❍	❍	❍
Oyster reef restoration is necessary for sustainable commercial oyster harvest.	❍	❍	❍	❍	❍	❍
My awareness of the importance of oyster reefs has increased since the Deep Water Horizon oil spill.	❍	❍	❍	❍	❍	❍
I am personally familiar with the location of restored oyster reefs	❍	❍	❍	❍	❍	❍
I use restored oyster reefs for recreation and/or commercial purposes	❍	❍	❍	❍	❍	❍
Oyster reefs should primarily be restored for ecological services	❍	❍	❍	❍	❍	❍
Oyster reefs should primarily be restored for commercial harvest	❍	❍	❍	❍	❍	❍

Appendix A – Figure 7. Stakeholder Survey (c)

Q2.2 Please indicate your level of agreement with the following statements regarding support for oyster reef restoration. (Mark one response for each statement)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/ Don't Know
There is strong community support for oyster reef restoration	❍	❍	❍	❍	❍	❍
There is strong governmental support for oyster reef restoration	❍	❍	❍	❍	❍	❍
There is strong fishing industry support for oyster reef restoration	❍	❍	❍	❍	❍	❍
There is strong oyster industry support for oyster reef restoration	❍	❍	❍	❍	❍	❍
I personally support oyster reef restoration	❍	❍	❍	❍	❍	❍

SECTION 3 – *Implementation of Oyster Reef Restoration*

Q3.1 Please help us prioritize locations for oyster reef restoration. (Mark one response for each statement.)

	Not a priority	Low priority	Medium priority	High priority	Not sure/ Don't Know
Areas without freshwater diversions	❍	❍	❍	❍	❍
Areas without heavy shoreline development	❍	❍	❍	❍	❍
Areas that are resistant to change (stable wetlands, salinity, etc)	❍	❍	❍	❍	❍
Areas of most depleted oyster reefs	❍	❍	❍	❍	❍
Areas of easy public access	❍	❍	❍	❍	❍
Areas in need of shoreline stabilization	❍	❍	❍	❍	❍
Areas near existing oyster leases (public and private)	❍	❍	❍	❍	❍
Areas near existing fishing grounds	❍	❍	❍	❍	❍
Areas near current structures (bridges, piers, etc)	❍	❍	❍	❍	❍
Areas where oyster reefs were historically located (reef footprints)	❍	❍	❍	❍	❍
Areas where oyster reefs are currently present	❍	❍	❍	❍	❍
Areas where no oyster reefs exist but the environment is suitable	❍	❍	❍	❍	❍
Areas in need of water quality improvement	❍	❍	❍	❍	❍

Appendix A – Figure 7. Stakeholder Survey (d)

Q3.2 If you have a suggestion for a specific body of water in the Northern Gulf of Mexico that would benefit from oyster reef restoration, please identify the state and location here. (Please choose only one.)

❍ Texas _____ ❍ Louisiana _____ ❍ Mississippi _____
❍ Alabama _____ ❍ Florida _____

SECTION 4 – *Administration of Oyster Reef Restoration*

Q4.1 Please choose which outcomes you would be willing to accept in order to support oyster reef restoration. (Mark one response for each statement.)

	Not acceptable	Sometimes acceptable	Acceptable	Fully acceptable	Not sure/Don't know
Oyster sack limit maintained at current levels	❍	❍	❍	❍	❍
Oyster sack limit reduced from current levels	❍	❍	❍	❍	❍
Oyster sack limit increased from current levels	❍	❍	❍	❍	❍
Incentives for private restoration (oyster harvesters)	❍	❍	❍	❍	❍
Restriction of commercial fishing on restored oyster reefs	❍	❍	❍	❍	❍
Restriction of recreational fishing on restored oyster reefs	❍	❍	❍	❍	❍
Daily time restrictions of restored oyster reefs	❍	❍	❍	❍	❍
Restricted seasons on restored oyster reefs	❍	❍	❍	❍	❍
Rotating annual reef closure to allow stocks to rebuild	❍	❍	❍	❍	❍
Permanent reef closure for production of seed	❍	❍	❍	❍	❍
Restriction of gear used on restored oyster reefs	❍	❍	❍	❍	❍

Appendix A – Figure 7. Stakeholder Survey (e)

Q4.2 What issues must be addressed to ensure the success of oyster reef restoration. (Mark one response for each statement.)

	Importance of Issue				
	Not important	Slightly important	Important	Very Important	Not sure/Don't Know
Public support	❍	❍	❍	❍	❍
Enforcement & protection	❍	❍	❍	❍	❍
Permits (state and federal)	❍	❍	❍	❍	❍
Appropriate location	❍	❍	❍	❍	❍
Property rights	❍	❍	❍	❍	❍
Scientific knowledge	❍	❍	❍	❍	❍
Public communications	❍	❍	❍	❍	❍
Adequate funding	❍	❍	❍	❍	❍
Oyster reef design	❍	❍	❍	❍	❍

Q4.3 What should be improved with the current management practices for oyster reef restoration? (Please mark one response for each statement.)

	Needs no improvement	Needs some improvement	Needs significant improvement	Not sure/Don't know
Number of restored oyster reefs	❍	❍	❍	❍
Enforcement and protection of restored oyster reefs	❍	❍	❍	❍
Stakeholder input & involvement	❍	❍	❍	❍
Research to understand the role of oyster reefs on the coast	❍	❍	❍	❍
Education and outreach to the public about restored oyster reefs	❍	❍	❍	❍
Maintenance and monitoring of restored oyster reefs	❍	❍	❍	❍
Research on methods of oyster reef restoration	❍	❍	❍	❍

Appendix A – Figure 7. Stakeholder Survey (f)

Q4.4 Who should be primarily responsible for specific phases of oyster reef restoration? (Please mark all that apply.)

	Phases				
	Planning	Funding	Construction	Maintenance	Monitoring
Local government	❑	❑	❑	❑	❑
State government	❑	❑	❑	❑	❑
Federal government	❑	❑	❑	❑	❑
Conservation organizations	❑	❑	❑	❑	❑
Industry associations	❑	❑	❑	❑	❑
Individual users	❑	❑	❑	❑	❑
Corporate users	❑	❑	❑	❑	❑
Universities	❑	❑	❑	❑	❑
Oyster advisory board	❑	❑	❑	❑	❑

Q4.5 Please specify which are the best ways to communicate to you about restored oyster reefs. (Mark all that apply)

- ❑ Association meetings
- ❑ Social media (facebook, twitter, etc)
- ❑ U.S. mail (letters, newsletters, etc)
- ❑ Local newspapers
- ❑ Websites
- ❑ Dockside bulletin boards
- ❑ Local/community meetings
- ❑ Fishing magazines
- ❑ Email (letters, newsletters, etc)
- ❑ Phone
- ❑ I do not want to be informed about restored oyster reefs

Appendix A – Figure 7. Stakeholder Survey (g)

SECTION 5 – *Demographics*

Q5.1 In which state do you reside?

❍ Texas ❍ Louisiana ❍ Mississippi ❍ Alabama ❍ Florida ❍ Other

Q5.2 What is your age group?

❍ 18 - 30 years old ❍ 31-55 years old ❍ Older than 56 years

Q5.3 What is your highest education level obtained?

❍ High School/GED or less ❍ Bachelor's Degree ❍ Graduate Degree

Q5.4 Which of the following ethnicities, if any, do you identify yourself with?

❍ Cajun/Creole ❍ Vietnamese/SE Asian ❍ Eastern European ❍ American Indian
❍ Hispanic/Latino ❍ African American ❍ Caucasian ❍ Other

Q5.5 With which group do you most closely identify?

❍ Shrimp Trawler ❍ Oyster harvester ❍ Recreational fisher person
❍ Regulatory Agency ❍ Scientific Researcher ❍ Other commercial fisheries
❍ Environmental or conservation organization member ❍ Other

THANK YOU for completing this survey! Please fold and place survey in the reply envelope provided, then deposit in the mail.

Appendix A – Figure 7. Stakeholder Survey (h)

APPENDIX B: SURVEY SUMMARY RESULTS

Appendix B – Table 1. (Q1.11) Number of responses and to "Please indicate your view of the level of importance of ecological services in your state"

Question	Not important	Mildly Important	Very Important	Not sure/Don't know	Responses
Oyster production for harvest	5	41	352	19	417
Oyster production for ecosystem health	3	32	349	30	414
Water quality	1	27	379	15	422
Marine habitat	6	23	375	14	418
Shoreline stabilization	9	79	297	33	418
Biodiversity (or variety of species) in coastal landscapes & ecosystems	5	61	305	47	418
Fish production for commercial fisheries (shrimp, crab, fin-fish)	4	44	355	20	423
Fish production for recreational fisheries	28	111	255	25	419
Scientific research on coastal ecosystems	8	75	300	33	416
Coastal heritage and culture	13	110	277	21	421
Coastal economy	4	41	355	17	417
Coastal wetlands	6	41	351	19	417
General environmental education	10	88	295	24	417

Appendix B – Table 2. (Q1.11) Percent of responses and to "Please indicate your view of the level of importance of ecological services in your state"

Question	Not important	Mildly Important	Very Important	Not sure/Don't
Oyster production for harvest	1%	10%	84%	5%
Oyster production for ecosystem health	1%	8%	84%	7%
Water quality	0%	6%	90%	4%
Marine habitat	1%	6%	90%	3%
Shoreline stabilization	2%	19%	71%	8%
Biodiversity (or variety of species) in coastal landscapes & ecosystems	1%	15%	73%	11%

Fish production for commercial fisheries (shrimp, crab, fin-fish)	1%	10%	84%	5%
Fish production for recreational fisheries	7%	26%	61%	6%
Scientific research on coastal ecosystems	2%	18%	72%	8%
Coastal heritage and culture	3%	26%	66%	5%
Coastal economy	1%	10%	85%	4%
Coastal wetlands	1%	10%	84%	5%
General environmental education	2%	21%	71%	6%

Appendix B – Table 3. (Q1.12) Number of responses to the question "Please indicate your view of the need for restoration of ecological services in your state".

Question	No restoration needed	Minor restoration needed	Major restoration needed	Not sure/Don't know	Responses
Oyster production for harvest	4	63	270	59	396
Oyster production for ecosystem health	5	66	251	71	393
Water quality	9	85	229	68	391
Marine habitat	8	88	231	60	387
Shoreline stabilization	13	90	220	69	392
Biodiversity (or variety of species) in coastal landscapes & ecosystems	20	102	177	91	390
Fish production for commercial fisheries (shrimp, crab, fin-fish)	21	108	204	58	391
Fish production for recreational fisheries	48	119	152	69	388
Scientific research on coastal ecosystems	27	83	195	79	384
Coastal heritage and culture	52	112	164	61	389
Coastal economy	11	88	246	44	389
Coastal wetlands	11	70	263	46	390
General environmental education	35	90	200	65	390

Appendix B – Table 4. (Q1.12) Percent of responses to the question "Please indicate your view of the need for restoration of ecological services in your state".

Question	No restoration needed	Minor restoration needed	Major restoration needed	Not sure/Don't know
Oyster production for harvest	1%	16%	68%	15%
Oyster production for ecosystem health	1%	17%	64%	18%
Water quality	2%	22%	59%	17%
Marine habitat	2%	23%	60%	16%
Shoreline stabilization	3%	23%	56%	18%
Biodiversity (or variety of species) in coastal landscapes & ecosystems	5%	26%	45%	23%
Fish production for commercial fisheries (shrimp, crab, fin-fish)	5%	28%	52%	15%
Fish production for recreational fisheries	12%	31%	39%	18%
Scientific research on coastal ecosystems	7%	22%	51%	21%
Coastal heritage and culture	13%	29%	42%	16%
Coastal economy	3%	23%	63%	11%
Coastal wetlands	3%	18%	67%	12%
General environmental education	9%	23%	51%	17%

Appendix B – Table 5. (Q1.2) Number of responses to " Please indicate your level of agreement. (Mark one response for each statement.)"

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/ Don't know	Responses
Oyster reefs improve the water quality	4	2	27	121	221	47	422
Oyster reefs provide shoreline protection	5	10	24	147	187	48	421
Oyster reefs provide good marine habitat	5	0	7	122	260	26	420
Oyster reefs support the sustainability of oysters	6	0	7	113	268	24	418
Oyster reefs promote biodiversity in the landscape	3	6	24	118	200	64	415

and ecosystems							
Oyster reefs are an important buffer to climate change	16	31	69	63	88	155	422
Oyster reefs increase fish production	2	8	32	127	190	59	418
Oyster reefs impede navigation	61	131	79	57	23	70	421
Oyster reefs are an indicator of a healthy coast	4	6	23	110	239	36	418

Appendix B – Table 6. (Q1.2) Percent of responses to " Please indicate your level of agreement. (Mark one response for each statement.)"

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/ Don't know
Oyster reefs improve the water quality	1%	0%	6%	29%	52%	11%
Oyster reefs provide shoreline protection	1%	2%	6%	35%	44%	11%
Oyster reefs provide good marine habitat	1%	0%	2%	29%	62%	6%
Oyster reefs support the sustainability of oysters	1%	0%	2%	27%	64%	6%
Oyster reefs promote biodiversity in the landscape and ecosystems	1%	1%	6%	28%	48%	15%
Oyster reefs are an important buffer to climate change	4%	7%	16%	15%	21%	37%
Oyster reefs increase fish production	0%	2%	8%	30%	45%	14%
Oyster reefs impede navigation	14%	31%	19%	14%	5%	17%
Oyster reefs are an indicator of a healthy coast	1%	1%	6%	26%	57%	9%

Appendix B – Table 7. (Q1.3) Number of responses to "How much of a threat are the following to the health of oyster reefs in your state today?"

Question	Not a threat	Low threat	Moderate threat	High Threat	Not sure/Don't know	Responses
Commercial fishing (crabs, fin-fish, shrimp)	152	96	72	29	71	420
Recreational fishing	173	112	46	24	65	420
Hurricanes	12	32	107	229	38	418
Oyster harvest practices (shell dredging, tonging, etc)	72	101	90	78	76	417
Disease & natural predation	11	74	136	114	87	422
Coastal development & land use	18	53	92	197	60	420
Freshwater diversions	19	40	90	202	68	419
Sea Level Rise	71	82	89	69	107	418
Disruption of water supply (dams, canals, irrigation, etc)	27	49	97	175	70	418

Appendix B – Table 8. (Q1.3) Percent of responses to "How much of a threat are the following to the health of oyster reefs in your state today?"

Question	Not a threat	Low threat	Moderate threat	High Threat	Not sure/Don't know
Commercial fishing (crabs, fin-fish, shrimp)	36%	23%	17%	7%	17%
Recreational fishing	41%	27%	11%	6%	15%
Hurricanes	3%	8%	26%	55%	9%
Oyster harvest practices (shell dredging, tonging, etc)	17%	24%	22%	19%	18%
Disease & natural predation	3%	18%	32%	27%	21%
Coastal development & land use	4%	13%	22%	47%	14%
Freshwater diversions	5%	10%	21%	48%	16%
Sea Level Rise	17%	20%	21%	17%	26%
Disruption of water supply (dams, canals, irrigation, etc)	6%	12%	23%	42%	17%

Appendix B – Table 9. (Q2.1) Number of responses to the "Please indicate your level of agreement with the following statements about oyster reef restoration. (Mark one response for each statement.)"

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/Don't know	Responses
Coastal restoration is important to me	3	1	16	119	266	17	422
Oyster reef restoration is important to maintaining a healthy oyster population	2	3	14	114	269	20	422
Oyster reef restoration would benefit the local commercial fishermen (crab, fin-fish, shrimp)	2	9	25	125	220	42	423
Oyster reef restoration would benefit the local oyster harvesters	2	4	10	109	279	16	420
Oyster reef restoration would benefit the local recreational fishermen	7	10	31	134	189	50	421
Oyster reef restoration would help the coastal community	1	7	15	132	240	28	423
Oyster reef restoration would help the recovery of local fisheries from natural disasters such as hurricanes	3	9	32	121	206	51	422
Oyster reef restoration would help the local fisheries recover from the Deepwater Horizon oil spill	8	26	27	88	194	79	422
Oyster reef restoration is necessary for sustainable commercial oyster harvest.	5	11	25	108	238	32	419
My awareness of the importance of oyster reefs has increased since the Deepwater Horizon oil spill.	37	67	67	108	112	31	422

I am personally familiar with the location of restored oyster reefs	20	47	29	122	124	76	418
I use restored oyster reefs for recreation and/or commercial purposes	58	75	64	78	91	53	419
Oyster reefs should primarily be restored for ecological services	20	44	79	101	119	58	421
Oyster reefs should primarily be restored for commercial harvest	15	50	70	107	150	29	421

Appendix B – Table 10. (Q2.1) Percent of responses to the "Please indicate your level of agreement with the following statements about oyster reef restoration. (Mark one response for each statement.)"

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/Don't know
Coastal restoration is important to me	1%	0%	4%	28%	63%	4%
Oyster reef restoration is important to maintaining a healthy oyster population	0%	1%	3%	27%	64%	5%
Oyster reef restoration would benefit the local commercial fishermen (crab, fin-fish, shrimp)	0%	2%	6%	30%	52%	10%
Oyster reef restoration would benefit the local oyster harvesters	0%	1%	2%	26%	66%	4%
Oyster reef restoration would benefit the local recreational fishermen	2%	2%	7%	32%	45%	12%
Oyster reef restoration would help the coastal community	0%	2%	4%	31%	57%	7%
Oyster reef restoration would help the recovery of local fisheries from natural disasters such as hurricanes	1%	2%	8%	29%	49%	12%
Oyster reef restoration	2%	6%	6%	21%	46%	19%

would help the local fisheries recover from the Deepwater Horizon oil spill						
Oyster reef restoration is necessary for sustainable commercial oyster harvest.	1%	3%	6%	26%	57%	8%
My awareness of the importance of oyster reefs has increased since the Deepwater Horizon oil spill.	9%	16%	16%	26%	27%	7%
I am personally familiar with the location of restored oyster reefs	5%	11%	7%	29%	30%	18%
I use restored oyster reefs for recreation and/or commercial purposes	14%	18%	15%	19%	22%	13%
Oyster reefs should primarily be restored for ecological services	5%	10%	19%	24%	28%	14%
Oyster reefs should primarily be restored for commercial harvest	4%	12%	17%	25%	36%	7%

Appendix B – Table 11. (Q2.2) Number of responses to " Please indicate your level of agreement with the following statements regarding support for oyster reef restoration. (Mark one response for each statement)"

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/Don't Know	Responses
There is strong community support for oyster reef restoration	8	31	44	150	105	80	418
There is strong governmental support for oyster reef restoration	13	85	69	92	37	121	417
There is strong fishing industry support for oyster reef restoration	6	33	57	131	90	102	419

There is strong oyster industry support for oyster reef restoration	5	14	29	125	170	72	415
I personally support oyster reef restoration	6	1	21	105	267	18	418

Appendix B – Table 12. (Q2.2) Percent of responses to " Please indicate your level of agreement with the following statements regarding support for oyster reef restoration. (Mark one response for each statement)"

Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not sure/Don't Know
There is strong community support for oyster reef restoration	2%	7%	11%	36%	25%	19%
There is strong governmental support for oyster reef restoration	3%	20%	17%	22%	9%	29%
There is strong fishing industry support for oyster reef restoration	1%	8%	14%	31%	21%	24%
There is strong oyster industry support for oyster reef restoration	1%	3%	7%	30%	41%	17%
I personally support oyster reef restoration	1%	0%	5%	25%	64%	4%

Appendix B – Table 13 (Q3.1) Number of responses to " Please help us prioritize locations for oyster reef restoration. (Mark one response for each statement.)"

Question	Not a priority	Low priority	Medium priority	High priority	Not sure/Don't Know	Responses
Areas without freshwater diversions	17	41	87	142	124	411
Areas without heavy shoreline development	23	51	88	167	86	415
Areas that are resistant to change (stable wetlands, consistent salinity, etc)	11	44	84	192	84	415
Areas of most depleted oyster reefs	6	12	51	283	60	412

Areas of easy public access	61	106	95	74	76	412
Areas in need of shoreline stabilization	20	44	110	168	72	414
Areas near existing oyster leases (public and private)	25	41	110	165	75	416
Areas near existing fishing grounds	24	53	127	125	85	414
Areas near current structures (bridges, piers, etc)	55	85	96	71	107	414
Areas where oyster reefs were historically located (reef footprints)	4	16	58	286	51	415
Areas where oyster reefs are currently present	9	19	84	255	48	415
Areas where no oyster reefs exist but the environment is suitable	14	43	123	173	63	416
Areas in need of water quality improvement	25	41	107	158	84	415

Appendix B – Table 14 (Q3.1) Percent of responses to " Please help us prioritize locations for oyster reef restoration. (Mark one response for each statement.)"

Question	Not a priority	Low priority	Medium priority	High priority	Not sure/Don't Know
Areas without freshwater diversions	4%	10%	21%	35%	30%
Areas without heavy shoreline development	6%	12%	21%	40%	21%
Areas that are resistant to change (stable wetlands, consistent salinity, etc)	3%	11%	20%	46%	20%
Areas of most depleted oyster reefs	1%	3%	12%	69%	15%
Areas of easy public access	15%	26%	23%	18%	18%
Areas in need of shoreline stabilization	5%	11%	27%	41%	17%
Areas near existing oyster leases (public and private)	6%	10%	26%	40%	18%
Areas near existing fishing grounds	6%	13%	31%	30%	21%
Areas near current structures (bridges, piers, etc)	13%	21%	23%	17%	26%
Areas where oyster reefs were historically located (reef footprints)	1%	4%	14%	69%	12%

Areas where oyster reefs are currently present	2%	5%	20%	61%	12%
Areas where no oyster reefs exist but the environment is suitable	3%	10%	30%	42%	15%
Areas in need of water quality improvement	6%	10%	26%	38%	20%

Appendix B – Table 15. (Q3.2) Number and percent of responses to "If you have a suggestion for a specific body of water in the Northern Gulf of Mexico that would benefit from oyster reef restoration, please identify the state and location here. (Please choose only one.)"

Answer		Response	%
Texas		43	14%
Mississippi		44	15%
Florida		59	19%
Alabama		65	21%
Louisiana		92	30%
Total		303	100%

Appendix B – Table 16. (Q3.2) Bodies of water suggested

Texas	Louisiana	Mississippi	Alabama	Florida
Galveston Bay		biloxi/ocean springs	Mobile Bay/Dauphin Island	East Bay
Galveston Bay	coastal Plaquemines Parish	Mississippi Sound	MOBILE/GR.BAY BAYS	upper choctawhachee bay
Galveston Bay	Catfish Bay Area	Mississippi Sound, Bay of St. Louis	Portersville Bay	Pensacola
Galveston Bay	Nickel Reef south of Marsh Island	south of deer island	public reef Cut Off / Cedar Point	Pensacola bay
Galveston Bay	Barataria Bay	Hancock Co marshes	Grand Bay	Pensacola Bay
lower Laguna Madre	All coastal water	Bay St. Louis	south mobile county	Panhandle - Santa Rosa County to Franklin County
Corpus Christi Bay	Plaquemines Parish	Pass Christian	Mississippi Sound	Apalachicola
Matagorda Bay	black bay	Pascagoula	Mobile Bay	Choctawhatchee bay, Entrance to

				Joes Bayou, Marler Bayou, Indian Bayou, Areas on north side of bay east of Mid Bay Bridge
Galveston	Vermilion/Barataria/Terrebonne	Ms Sound	Portersville Bay	Apalachicola Bay
Corpus Christi	State Public Seed Grounds	Henderson Point	Perdido Bay	Apalachicola bay
Lavaca Bay	Grand Isle, Dulac, Venice	GraveLine Bayou, and between east and West Pasagoula, singing river island and west to west river	Mobile Bay	Bayou Chico and Bayou Texar
Aransas & Copano	barataria bay	Bayou Cunbest, Bayou Heron	Mobile Bay	Apalachicola
San Antonio Bay	Barataria-Terrebonne Estuary	Pass Christian Reef system	Mississippi Sound, Daulphin Island	Choctawhatchee Bay
Galveston Bay	grand isle	Jackson Co	Portsville bay, Heron Bay, Lower end of reef Dauphin Island Bay	Franklin Co
Galv-East-Trinity	Biloxi Marshes	Pass Christian Reefs - All	Mobile Bay	Apalachicola Bay
Galveston West Bay	Barataria Estuary	Henderson Point	Mobile Bay, Miss Sound	Apalachicola Bay
Galveston Bay	sister & machne lakes	Telegraph Key	South & Eastern Bay	Franklin Co
Matagorda bay	Lake Pelto	Bayou Cumbest	Mobile Bay	Apalachicola
Galveston	East & West Timbalier Bay	Bayou Heron East Miss	Bayou la Batre	Choctawhatchee Bay
Matagorda	St. Mary Parish	Southwest	Grand Bay or Porterville Bay	Apalachicola Bay System
Corpus	Calcasieu lake	Pass	Dauphin Island	Charlotte Harbor

Christi Bay		Christian		
Bay Galveston	Lake Boerne	Western Sound, Bangs Lake	Grand Bay	Gulf Breeze
Galveston Bay	Plaquemines Parish	Pass Christian	Bon Secour Bay	Pensacola
Matagorda Bay	East side of Miss River	Alabama state line to biloxi	Mobile Bay	Escambia Bay, East Bay
Galveston Bay	Big Lake	Between Ocean Springs and Pascagoula	Mobile	Pensacola Bay Area
	Timbalier	Sound - All Mississippi oyster reef	Mobile Bay	Choctawhatchee
	Grand Isle	ms sounds	Mississippi Sound	Choctawhatchee Bay
	East of Miss. River	Bayou Heron, East Jackson County	Bayou La Batre	Perdido Bay
	St. Bernard Parish	Use the oyster shells instead of limestone	Mobile Bay	Apalachicola
	Terrebonne Parish	Pass Christian	Mobile Bay	Apalachicola
	American & Black Bay	Pass Christian	Mobile Bay	Pensacola to Apalachicola
	There is an untouched reef in Calcasieu Lake - Protect it!	Pascagoula Sound	Cedar Point Reef	Panama City East Bay
	East Side of Miss River delta	Biloxi	South Mobile Bay, Northside of Ft. Morgan	Apalachicola
	Calcasieu Lake		Alabama Port	Apalachicola
	Lake Bare		Mississippi Sound/Mobile Bay	Apalachicola Bay
	pollution		Mobile Bay	Choctawhatchee Bay primarily East end
	Britton Sound		Mississippi Sound/Mobile Bay	Wahulla Co

	South of Houma		Mobile Bay	East Point
	Lake Borne		Bayou la Batre	Apalachicola, FL
	Grand Bank, Lake Borne		Bon Secour Reef in Bon Secour Bay	Apalachicola
	Black Bay Ar 6-7		Bayou la batre	
	Calcasieu		Mobile Bay	
	Barataria Bay			
	Big Lake - West Cove			
	Lake Calcasieu			
	Big Lake			
	Lake Fortuna/Drum Bay			
	Cameron, LA			
	Area 3-15-16			
	Black Bay Area			
	Calcasieu Lake			
	Baretaria or Thimbalier Bays			
	Grand Isle			
	Cocodrie			

Appendix B – Table 17. (Q4.1) Number of responses to " Please choose which outcomes you would be willing to accept in order to support oyster reef restoration. (Mark one response for each statement.)"

Question	Not acceptable	Sometimes acceptable	Acceptable	Fully acceptable	Not sure/Don't know	Responses
Oyster sack limit maintained at current levels	23	57	145	58	117	400
Oyster sack limit reduced from current levels	88	97	52	39	121	397
Oyster sack limit increased from current levels	87	92	59	36	125	399
Incentives for private restoration (oyster harvesters)	35	38	117	135	72	397
Restriction of commercial fishing on restored oyster reefs	75	83	102	81	63	404
Restriction of recreational fishing on restored oyster reefs	81	87	104	75	57	404
Daily time restrictions of restored oyster reefs	48	75	111	81	88	403
Restricted seasons on restored oyster reefs	25	71	127	119	62	404
Rotating annual reef closure to allow stocks to rebuild	12	40	143	162	46	403
Permanent reef closure for production of seed	81	75	92	81	75	404
Restriction of gear used on restored oyster reefs	47	55	115	116	70	403

Appendix B – Table 18. (Q4.1) Percent of responses to " Please choose which outcomes you would be willing to accept in order to support oyster reef restoration. (Mark one response for each statement.)"

Question	Not acceptable	Sometimes acceptable	Acceptable	Fully acceptable	Not sure/Don't know
Oyster sack limit maintained at current levels	6%	14%	36%	15%	29%
Oyster sack limit reduced from current levels	22%	24%	13%	10%	30%
Oyster sack limit increased from current levels	22%	23%	15%	9%	31%
Incentives for private restoration (oyster harvesters)	9%	10%	29%	34%	18%
Restriction of commercial fishing on restored oyster reefs	19%	21%	25%	20%	16%
Restriction of recreational fishing on restored oyster reefs	20%	22%	26%	19%	14%
Daily time restrictions of restored oyster reefs	12%	19%	28%	20%	22%
Restricted seasons on restored oyster reefs	6%	18%	31%	29%	15%
Rotating annual reef closure to allow stocks to rebuild	3%	10%	35%	40%	11%
Permanent reef closure for production of seed	20%	19%	23%	20%	19%
Restriction of gear used on restored oyster reefs	12%	14%	29%	29%	17%

Appendix B – Table 19. (Q4.2) Number of responses to the question "What issues must be addressed to ensure the success of oyster reef restoration"

Question	Not important	Slightly important	Important	Very Important	Not sure/Don't Know	Responses
Public support	6	24	131	212	27	400
Enforcement & protection	12	12	104	250	24	402
Permits (state and federal)	21	25	142	170	43	401
Appropriate location	2	7	112	253	28	402
Property rights	26	63	119	127	61	396
Scientific knowledge	5	21	96	240	34	396
Public communications	4	33	145	189	31	402
Adequate funding	3	8	76	284	30	401
Oyster reef design	8	28	106	208	49	399

Appendix B – Table 20. (Q4.2) Percent of responses to the question "What issues must be addressed to ensure the success of oyster reef restoration"

Question	Not important	Slightly important	Important	Very Important	Not sure/Don't Know
Public support	2%	6%	33%	53%	7%
Enforcement & protection	3%	3%	26%	62%	6%
Permits (state and federal)	5%	6%	35%	42%	11%
Appropriate location	0%	2%	28%	63%	7%
Property rights	7%	16%	30%	32%	15%
Scientific knowledge	1%	5%	24%	61%	9%
Public communications	1%	8%	36%	47%	8%
Adequate funding	1%	2%	19%	71%	7%
Oyster reef design	2%	7%	27%	52%	12%

Appendix B – Table 21. (Q4.3) Number of responses to "What should be improved with the current management practices for oyster reef restoration? (Please mark one response for each statement.)"

Question	Needs no improvement	Needs some improvement	Needs significant improvement	Not sure/Don't know	Responses
Number of restored oyster reefs	5	95	206	94	400
Enforcement and protection of restored oyster reefs	47	102	156	94	399
Stakeholder input & involvement	22	116	136	124	398
Research to understand the role of oyster reefs on the coast	34	117	161	85	397
Education and outreach to the public about restored oyster reefs	25	123	189	61	398
Maintenance and monitoring of restored oyster reefs	18	116	183	81	398
Research on methods of oyster reef restoration	19	105	175	95	394

Appendix B – Table 22. (Q4.3) Number of responses to "What should be improved with the current management practices for oyster reef restoration? (Please mark one response for each statement.)"

Question	Needs no improvement	Needs some improvement	Needs significant improvement	Not sure/Don't know
Number of restored oyster reefs	1%	24%	52%	24%
Enforcement and protection of restored oyster reefs	12%	26%	39%	24%
Stakeholder input & involvement	6%	29%	34%	31%
Research to understand the role of oyster reefs on the coast	9%	29%	41%	21%
Education and outreach to the public about restored oyster reefs	6%	31%	47%	15%
Maintenance and monitoring of restored oyster reefs	5%	29%	46%	20%
Research on methods of oyster reef restoration	5%	27%	44%	24%

Appendix B – Table 23. (Q4.4) Number of responses to "Who should be primarily responsible for specific phases of oyster reef restoration?"

Question	Planning	Funding	Construction	Maintenance	Monitoring	Responses
Local government	207	164	138	161	196	866
State government	194	296	200	199	219	1,108
Federal government	105	288	95	81	128	697
Conservation organizations	196	126	118	120	211	771
Industry associations	175	141	128	130	128	702
Individual users	159	93	99	152	131	634
Corporate users	116	176	103	121	90	606
Universities	229	37	79	79	244	668
Oyster advisory board	263	80	110	131	233	817

Appendix B – Table 24. (Q4.4) Percent of responses to "Who should be primarily responsible for specific phases of oyster reef restoration?"

#	Question	Planning	Funding	Construction	Maintenance	Monitoring
1	Local government	24%	19%	16%	19%	23%
2	State government	18%	27%	18%	18%	20%
3	Federal government	15%	41%	14%	12%	18%
4	Conservation organizations	25%	16%	15%	16%	27%
5	Industry associations	25%	20%	18%	19%	18%
6	Individual users	25%	15%	16%	24%	21%
7	Corporate users	19%	29%	17%	20%	15%
8	Universities	34%	6%	12%	12%	37%
9	Oyster advisory board	32%	10%	13%	16%	29%

Appendix B – Table 25. (Q4.5) Number and percent of responses to "Please specify which are the best ways to communicate to you about restored oyster reefs. (Mark all that apply)"

Answer		Response	%
I do not want to be informed about restored oyster reefs		37	9%
Association meetings		129	33%
Social media (facebook, twitter, etc)		65	16%
U.S. mail (letters, newsletters, etc)		222	56%
Local newspapers		202	51%
Websites		144	36%
Dockside bulletin boards		90	23%
Local/community meetings		126	32%
Fishing magazines		83	21%
E-mail (letters, newsletters, etc)		154	39%
Phone		76	19%

Appendix B – Table 26. (Q 5.1) Number and percent of responses to "In which state do you reside?"

Answer		Response	%
Texas		58	14%
Louisiana		115	28%
Mississippi		57	14%
Alabama		81	20%
Florida		100	24%
Other		2	0%

Appendix B – Table 27. (Q 5.2) Number and percent of responses to "What is your age group?"

Answer		Response	%
18 - 30 years old		16	4%
31-55 years old		178	43%
older than 56 years		218	53%
Total		412	100%

Appendix B – Table 28. (Q 5.3) Number and percent responses to "What is your highest education level obtained?"

Answer		Response	%
High School/GED or less		193	48%
Bachelor's Degree		82	20%
Graduate Degree		131	32%
Total		406	100%

Appendix B – Table 29. (Q5.4) Number and percent response to "Which of the following ethnicity's, if any, do you identify yourself with?"

Answer		Response	%
Cajun/Creole		26	6.4%
Vietnamese/SE Asian		30	7.4%
Eastern European		5	1.2%
American Indian		12	2.9%
Hispanic/Latino		9	2.2%
African American		8	2.0%
Caucasian		308	75.5%
Other		10	2.5%
Total		408	100.0%

Appendix B – Table 30 (Q 5.5) Number and percent response to "With which group do you most closely identify? (Mark up to 3 that apply)"

Answer		Response	%
Shrimp Trawler		181	44%
Oyster harvester		155	38%
Recreational fisher person		116	28%
Environmental or conservation organization member		127	31%
Regulatory Agency		15	4%
Scientific Researcher		37	9%
Other commercial fisheries		82	20%
Other		49	12%

Appendix B – Table 31. Number of respondents from *a priori* user groups

Value	Total
Environmental Organization Member	157
Oyster Harvester	109
Shrimp Trawler	128
Scientific Researcher	21
Regulatory Agency employee	11

Appendix B – Table 32. Number of respondents from *a priori* state of residence

Value	Total
Louisiana	126
Alabama	74
Florida	101
Mississippi	62
Texas	63

APPENDIX C: GULF OF MEXICO RESTORATION DECISION SUPPORT USER GUIDE

GULF OF MEXICO RESTORATION DECISION SUPPORT USER GUIDE:

In the wake of the Deepwater Horizon Oil Spill, the Presidential Executive Order on Gulf Restoration, and the Natural Resources Damage Assessment, The Nature Conservancy (TNC) Global Marine Team established the Gulf of Mexico Restoration Decision Support System (DSS). The DSS is an interactive web-based mapping tool that displays important coastal information relating to the resilience and restoration of the region's natural coastal habitats (The Nature Conservancy, 2011a). Like other interactive decision-support tools, the DSS promotes stakeholder engagement and transparency by providing centralized data and user-friendly scenario analysis. These features allow stakeholders to explore the ecological, social and economic tradeoffs of various conservation and restoration scenarios, thus promoting informed decision making. Ultimately the goal of informed decision making is to maximize benefits, by achieving the greatest return on investment of restoration funds (The Nature Conservancy, 2011a).

Oyster reefs are imperiled habitat, as a history of harvesting along with coastal land-use changes have forced them to the brink of extinction (Beck et al., 2011). The northern Gulf of Mexico is a region where oyster reefs remain in fair condition, compared to a majority of the U.S. where they are either of poor condition or functionally extinct (Beck et al., 2011), offering a high potential opportunity for reef restoration. Restoring oyster reefs at a large scale requires an oyster reef restoration 'blueprint' to establish goals and guide reef location and funding. For this reason, the DSS contains important and appropriate scientific information (environmental, biological, social, and economic) related to oysters and oyster reef restoration. The DSS also contains an "Oyster Restoration Dashboard," a multi-factor decision support tool that assimilates both the scientific information and factor weighting into an oyster reef restoration suitability score for specific areas of the U.S. Gulf Coast. By knowing which areas of the coast are potentially most suitable, both biologically (i.e., promoting optimal oyster growth and ecological functions), and socio-economically (i.e., complimenting human uses of the region), oyster reef projects can begin to be implemented in these areas where probability of project success and long-term sustainability is greatest.

The DSS is already guiding current TNC efforts in coastal Alabama to restore approximately 100 miles of oyster reef in Mobile Bay. In Louisiana, the DSS will also guide large-scale oyster reef restoration. The coastal region of Louisiana is an important and complex place for restoring oyster reefs, because it has high coastal loss rates, altered freshwater flows, human and natural disturbances and multiuse coastal zone factors, including a thriving oyster industry that is providing on average 56% of the total oyster landings in the northern Gulf of Mexico (Turner, 2006). This complex arrangement of biological, political and socio-economic

factors make coastal Louisiana an ideal place to test the ability of the DSS and the Oyster Restoration Dashboard to optimize placement of oyster restoration projects.

The goal of this introductory guide is to provide instruction on how to use the DSS and Oyster Restoration Dashboard to make decisions regarding oyster reef restoration in Louisiana and throughout the northern Gulf of Mexico region. Our objective is to train individuals who have established relationships to many of the future potential users of the DSS, facilitating effective communication of this information to the ultimate customers – the planners and decision makers for oyster reef restoration. To do this, we 1) introduce the purpose and goal of the DSS; 2) demonstrate how to navigate the site; 3) practice using site features; and 4) create audio and video simulations.

1. Introduction to Decision Support System

The Gulf of Mexico Restoration Decision Support System project can be found at www.coastalresilience.org/gulfmex. From here you can obtain information on the project and access the decision support system. You can also go directly to the DSS at www.gulfrestorationds.org. The DSS itself is best viewed through Firefox and Google Chrome web browsers, but also works in Internet Explorer.

When initially entering the DSS website, one notices that the map is focused on the northern Gulf of Mexico region (Figure 1), a major area of interest. Notice in the lower right hand corner the links to The Nature Conservancy website (www.nature.org), the Coastal Resilience website (www.coastalresilience.org) and the legal disclosure. These sites provide background information on The Nature Conservancy and partners that have built the DSS, why it was created, and its importance. The TNC legal disclosure and terms of use for using this tool are also included, and should be understood when using this tool. In the upper right hand corner, three logos can be found, which represent the organizations responsible for project development: The Nature Conservancy, University of Southern Mississippi, and NOAA.

The appearance and application of this web-based mapping system are much like other Google Maps applications and behave much the same way.

The user may use the F5 button to refresh the map at anytime

Figure 1: Gulf of Mexico Restoration Decision Support Website

2. Basic navigation and functionality

Panning across the map can be done by left clicking and dragging the mouse. In the lower left hand corner, a Google scale is provided for reference, as well as a latitude and longitude reference for the pointer location. The basic navigation tools in the upper right hand corner (Figure 2) include:

1) Zoom to full extent –allows the user to zoom out to the full North American continent view

2) Zoom IN –allows the user to zoom the map closer one level to view a smaller area in more detail

3) Zoom Out –allows the user to zoom the map further one level to view a larger area in less detail

4) Zoom Previous –allows the user to zoom to the previous extent

5) Zoom Rectangle - allows the user to draw a rectangle around the area or location of interest to view a smaller area in greater detail

6) Identify Tool –allows the user to identify all active layers on the map at a specific location, and will display attribute data from these layers

7) Google Location Search –allows the user to search for a specific location of interest, and displays the latitude and longitude of the search location. By double clicking on the location of choice, the map automatically centers on this area. A red dot is displayed on the searched location.

8) Measure Tool (not yet implemented) – allows the user to create line (distance) or polygon features (area), and displays this using various units (meters, feet, miles, kilometers). Double clicking allows the feature to be complete, and will be shown in the list of record. This tool will provide the user with information about type, area, length and perimeter, of the feature, as well as allow the new feature to be labeled.

9) Help – provides the user with general information about the site, as well as a guide to navigate through data layers in the Map Layers panel on the left hand side of the map (not yet fully implemented)
    a. About (Figure 3)
        i. About–provides basic information and FAQ's about the Coastal Resilience program (from the coastal resilience website)
        ii. Tools – provides an explanation of the functionality of each navigational tool (not yet complete).
        iii. Resources – provides an explanation about the uses and limitations of the site (User Guides and Training modules)
    b. Guide - allows the user to be guided to locations, categories and spatial layers of interest.

10) Background - allows the user to change the background to various Google, ESRI and Open Street base maps. The default is Google Maps (physical terrain).

11) Bookmark Link – provides a link and a "tiny url" website for capturing the current layers that are active and geographic location. This is helpful for sending a specific map scene to colleagues and partners.

Other features

1) Single/Split View- allows the user to compare to map images side by side. Navigation tools and spatial layers can be altered by clicking on the appropriate map side (Left Map or Right Map), then using these features. The legend reflects spatial layers in the selected map. Selecting Single View returns the view to the Left Map only

2) Layer Sorter and Display–allows the user to drag and drop categories of layers, placing them either further up or down the list in the Map Layers window. This changes the order of the layers on the map, with the layer at the top of the list on top and the layer at the bottom of the list on bottom. This is also reflected in the Legend. Right clicking on the category allows the user to change the transparency of that set of layers.

3) Restoration Dashboard –allows the user to create a suitability scenario for oyster reef restoration by weighting the importance of select layers. The scale beneath each ranges from 0 to 10, with the '0' representing "not important", and the '10' representing "important". This alters the suitability based on the chosen scenario. The scoring for each of these layers is displayed under the Map Layers Oyster Reef Restoration Data files and can be accessed by right clicking on these layers and going to Properties.

4) Hide/Show Windows –allows the user to minimize windows displayed on the screen, enabling a more unobstructed view of map images

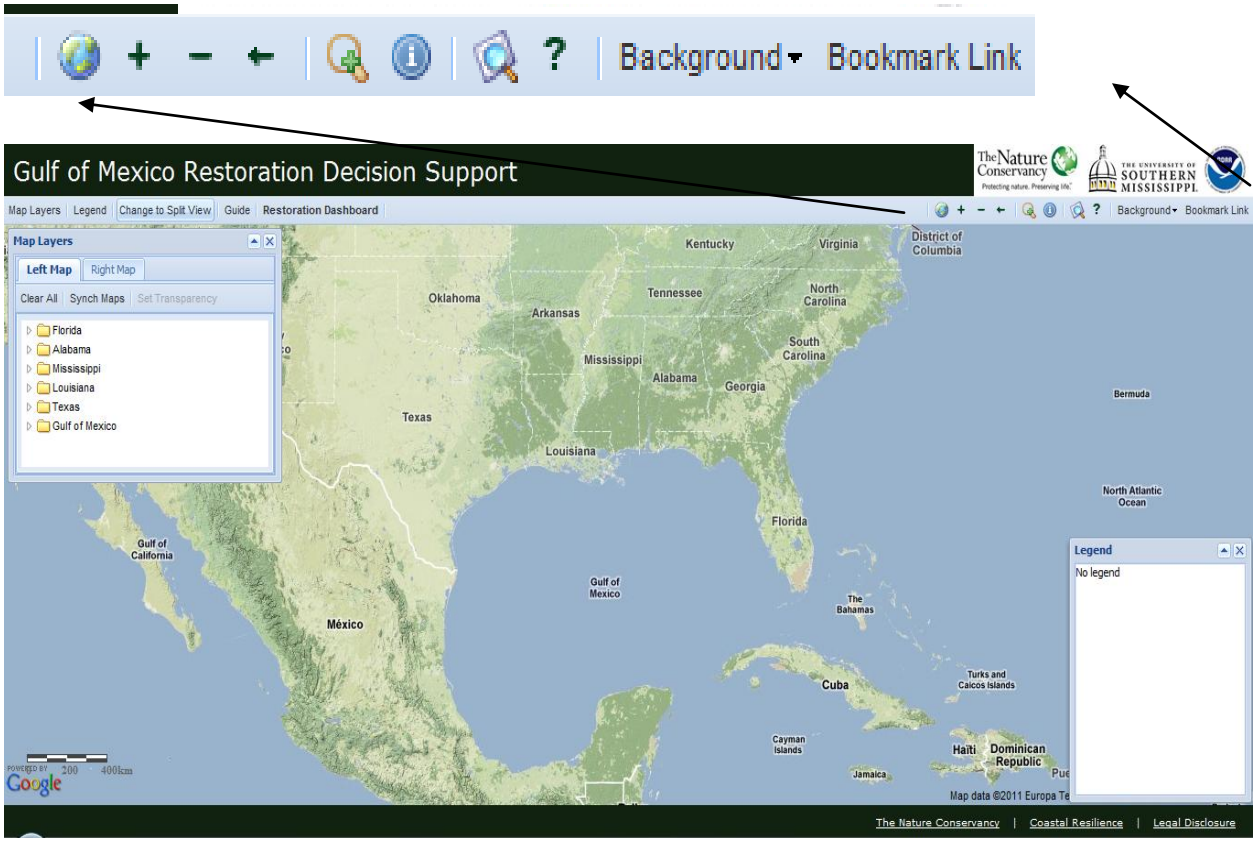


Figure 2: Upper Right Hand Corner Tool Bar

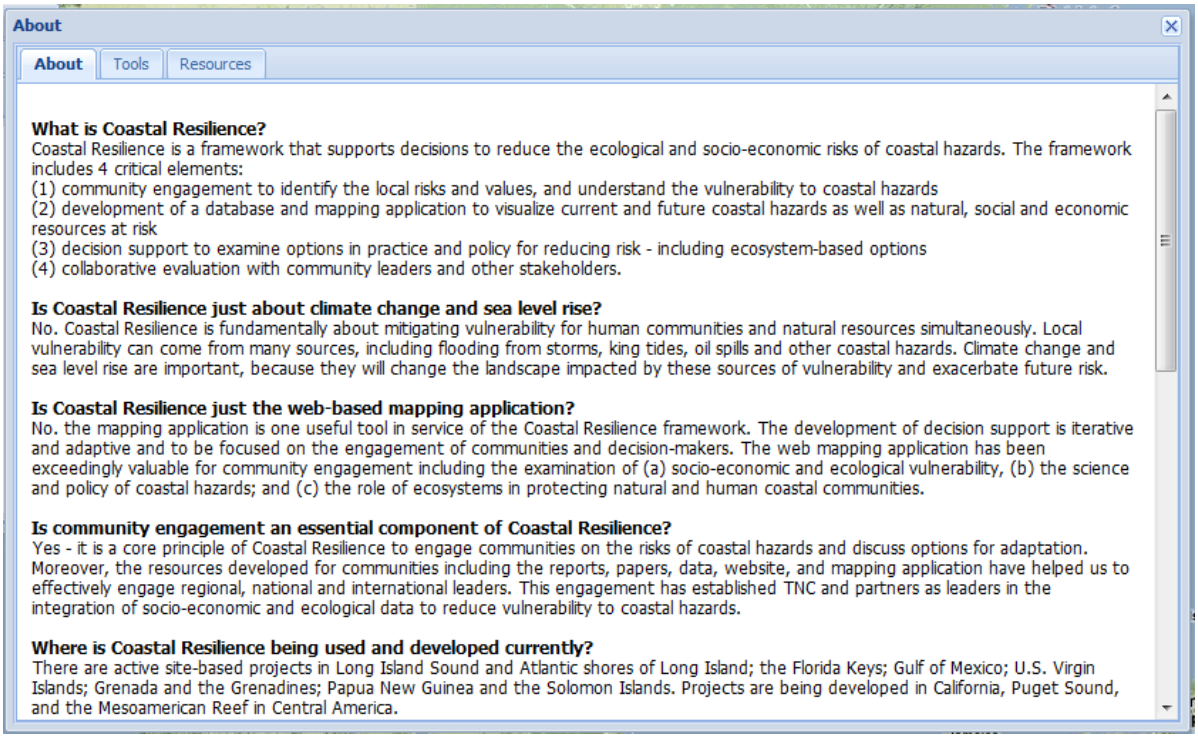


Figure 3: About Button Feature

3. Map Layers

There are several buttons located in the upper left hand corner of the page. These will bring up various windows such as the Map Layers and Legend windows already displayed on the screen. The Map Layers window (Figure 4) displays the bulk of the spatial data layers that have been assembled for the northern Gulf of Mexico.

Spatial data

Map layers are organized into state folders and a Gulf of Mexico folder houses layers that cross state boundaries. In each of these folders, spatial layers are also organized by category, such as salinity, biological, social, economic data. The project team has compiled and made available pertinent ecological, social and economic layers that should be considered when looking at state-scale restoration planning scenarios.

The user may click on any and all of the layers of interest to display spatial information for a specific state or region. Another way to do this is by using the Guide option (Figure 4) (combined with the Help menu in the upper right hand tool bar), which guides the user to the area and spatial layer of interest. When clicking on the Guide tab, a window pops up asking the user to choose the state of interest, then the topic of interest, then the data layer of interest. This continues in sequence until the user is done choosing all the layers they would like to view. The

layers chosen are shown in the legend in the lower right hand corner, with the first layer chosen displayed on top, and the last layer displayed on the bottom, the same way in which it is projected on the map. The order in which these layers are displayed can be changed by clicking on the category you wish to move, and dragging/dropping it to a higher or lower location in the Map Layers folder. The user may also change the transparency of these layers by right clicking on the category, clicking Properties, and altering the Transparency scale. A Clear All button allows the user to clear all selected layers and start fresh. Care must be taken not to choose too many spatial layers, as the program may become overwhelmed and not load properly. The Map Layers, Legend and Guide windows on the maps can be deleted from the map itself and brought back using these tool bar buttons.

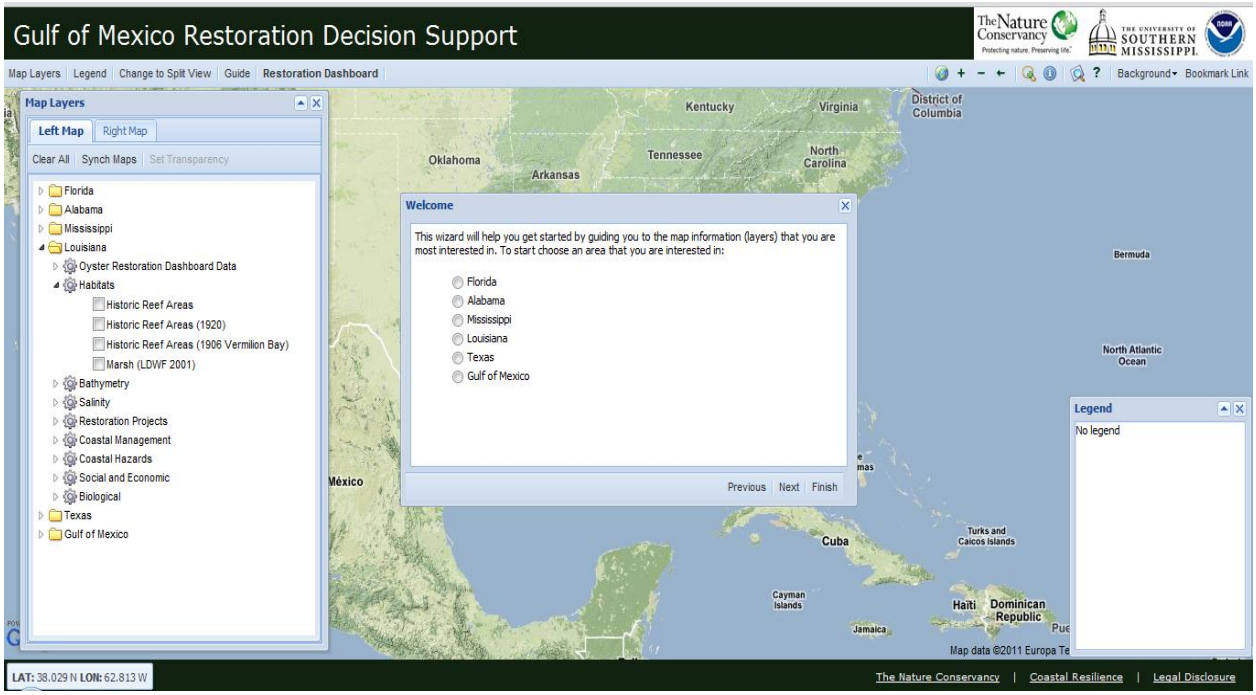


Figure 4: Maps Layers Window, Guide Window, and Legend Window

Layer-specific functionality

The Map Layers for Louisiana were collated specifically because they relate to or may be important to oyster reef restoration, and to some extent salt marshes. The source of these data can be seen by right clicking the layer and choosing Properties. This may also give a link to the metadata page for this layer, which has additional information about the source and an explanation of the data, or may provide a link directly to the site from which the data was obtained. A Zoom To option is also available with the right click of the layer. This allows the user to zoom directly to the extent of that layer.

4. Split view

If the user would like to compare two map screens, this can be done by clicking on the button Change to Split View (Figure 5). This creates two map screens which can each be altered separately by using the Left Map tab and the Right Map tab in the Map Layers window. When the Left Map tab is selected, a location and layers can be chosen for the left map. When the Right Map tab is selected, a separate location and layers can be chosen for that map if desired. Navigation tools can be used to alter the selected map. This allows the user to compare the same layers across two different regions, different layers across the same region, or any combination of the two. By clicking the Synch Maps button on the Map Layers window, the two maps align on to the same location, based on the selected map (Left or Right Map tabs). The legend also reflects the information on the map that is currently chosen. One can revert back to single map view by clicking on the button labeled Change to Single View, which shows the left map as the single view map.

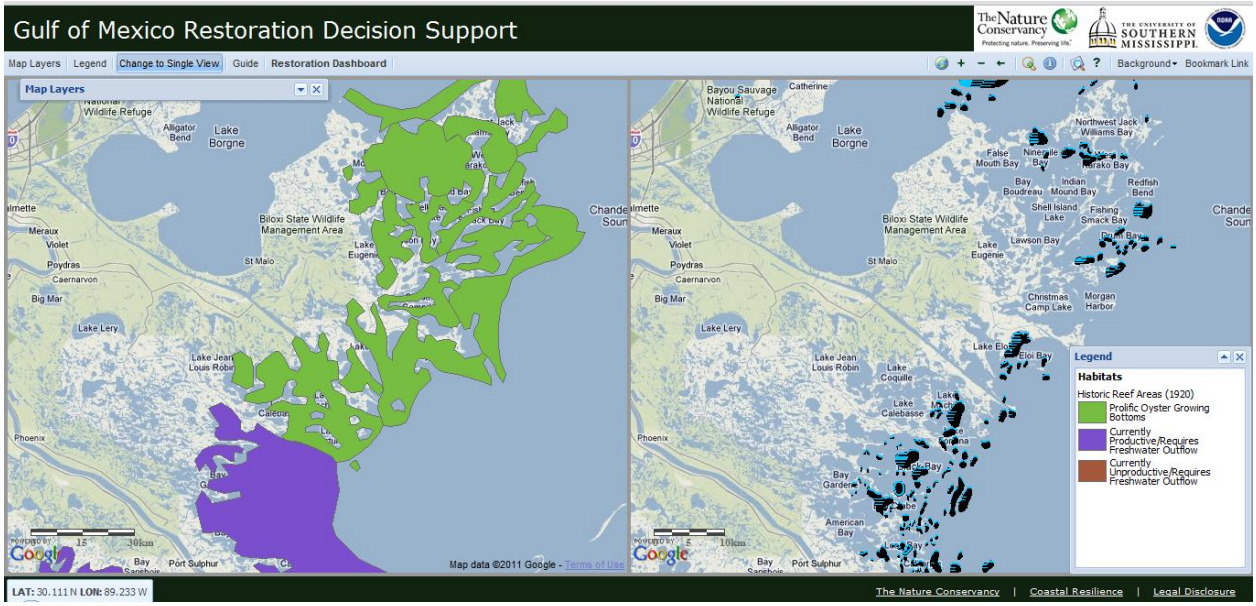


Figure 5: Synched Split View Screen of Southeast Louisiana. Left Map (selected) displaying Historic Reef Map of 1920 (from Louisiana Department of Conservation), and Right Map also displaying Historic Reef Areas (digitized by TNC). Legend reflects information from the selected Map

5. Restoration Dashboard

a) What is a dashboard and how can it be used

A unique feature that reflects a primary objective of the Decision Support project is the Restoration Dashboard, which considers ecological, social and economic factors together when planning coastal restoration scenarios. By clicking on this button a window appears requesting the user to choose an area. When a state is chosen, a list of ecological and socioeconomic variables along with a sliding scale for each is displayed. The sliding scale allows the user to define the importance of each layer depending on its importance for a particular oyster reef restoration scenario. Each scale ranges from zero (not important) to ten (very important). For example, if erosion control is of importance for a project, but project permit feasibility is not important, then the former can be placed at high importance (9 or 10), and the later can be placed at low or no importance (0 or 1). The scale's default setting is 5 for each of the layers (Figure 6). As each of these layers is adjusted, the map is altered to reflect the currently chosen scenario and the suitability for oyster reef restoration. The legend displays the various colors and their associated suitability for oyster reef restoration.

NOTE

The Gulf Restoration Decision Support Tool operates at regional and state scales. Therefore site selection suitability for oyster reef restoration across ecological, social and economic variables is constrained to the level of detail provided by the input data. This Dashboard was not designed for site planning, but scenario planning across a particular state. The Oyster Reef Restoration Dashboard should be used with this in mind.

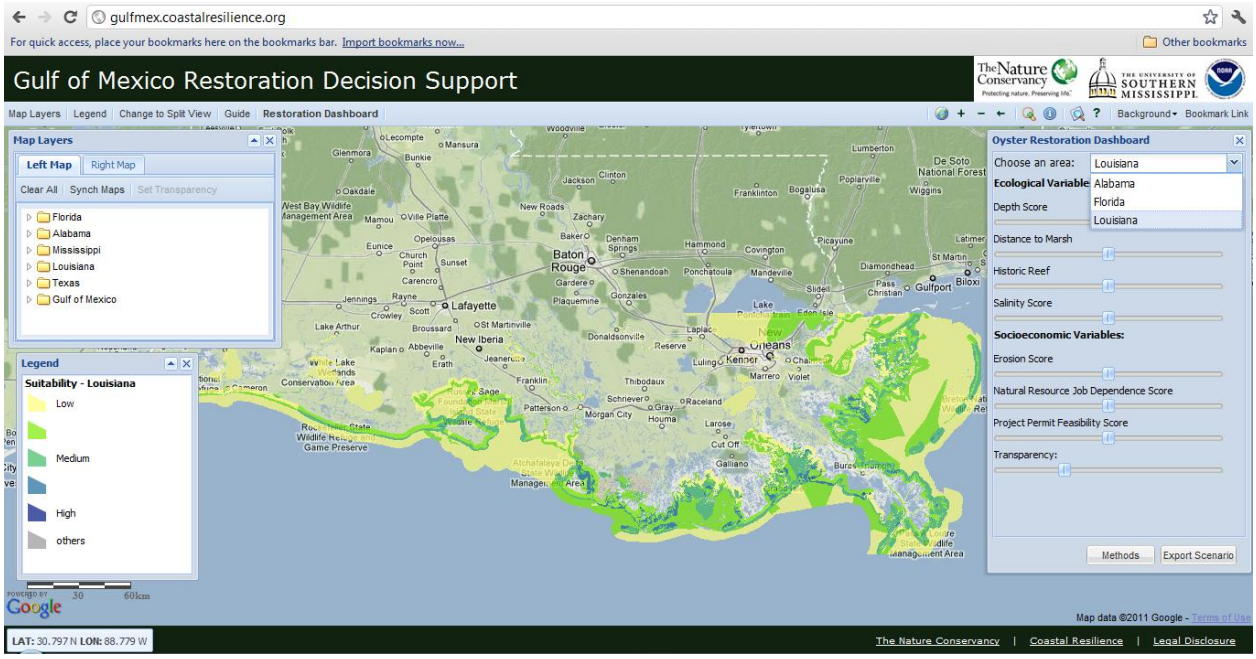


Figure 6: Louisiana Oyster Restoration Dashboard with default setting of 5 for each layer

Each of these dashboard layers is derived from data in the Map Layers window for a given state, under the category Oyster Restoration Dashboard Data. These layers were created by taking a spatial layer important to oyster reef restoration and giving suitability scores of either 1 (suitable) or 0 (not suitable) to the attributes of the layer (as seen in the Methods button for each state) (Table 1). For instance, oyster reefs successfully grow in salinities between 5-25 ppt. Therefore, for the salinity dashboard data, a score of 1 (suitable) is given to these salinity regimes, and a score of zero (not suitable) is given to all other salinities. This creates a layer that has areas delineated as suitable (1) or not suitable (0). The dashboard layer scoring is described in the table below. Each of these dashboard layers are displayed in the Map Layers window under Oyster Restoration Dashboard Data and customized for importance in the Restoration Dashboard when using the slider bars. Choosing each layer in the Map Layers window shows suitable regions on the map and legend based on the scoring, and the methods for scoring each layer can be seen by right clicking on the layer name and clicking Properties (Figure 7). There is also a Transparency function on the Dashboard that allows the user to determine how transparent the created scenario is compared to the background and other layers chosen. Note that if you use Split View you need to select the Restoration Dashboard button twice, once for the Left Map and once for the Right Map.

Table 1: Scoring for each layer in the Restoration Dashboard

Group	Data	Scoring
Ecological	**Historic Reef**	**Area's with reef = 1, Areas without reef =0**
	Depth Score	**Water depth<10ft =1 Water depth >10ft=0**
	Salinity Score	**5-25ppt = 1 All other salinities=0**
	Distance to Marsh	**Areas <50m from marsh= 1 Areas >50m from marsh =0**
Socio-economic	**Natural Resource Job Dependency Score**	**Nearshore areas within 2km of a high natural resource job dependency = 1 Adjacent to medium concentrations = .5 All others = 0**
	Project Permit Feasibility Score	**Non-public or private leases= 1 Public or private leases = 0**
	Erosion Score	**High erosion rate = 1 Moderate erosion rate = .75 Low erosion rate =.25 No erosion rate = 0**

More detailed information about the scoring of layers

1) Identifying ecological criteria that define where restoration can be successful

Historic Reefs:

Oysters are likely to be successful in areas where they historically have been productive. However, it is important to note that conditions may have changed in the given time span such that restoration may not be suitable in all of the areas identified by this layer. To identify areas where oysters have been or are currently found, multiple current and historic oyster reef data sets were collated and merged. Areas with reef were scored 1 and all remaining areas were scored a 0. The scored polygons were converted to a 100m, 100m grid. Original data source: TNC digitization (Vermilion Bay), 1920s Coast Line and Oyster Bottoms of Louisiana Historic Map digitization (TNC). Resolution: varies from 1:24,000 to 1:200,000.

Depth:

Oysters are able to thrive at a variety of depths, however, for the objectives of this project, the depth of placement was restricted to a maximum of 10 feet. All areas 10ft deep or less were scored 1 with remaining areas scored 0. The scored raster was resampled to a 100, 100m grid. Original data source: NOAA Bathymetry of Texas-Louisiana Continental Shelf and Coastal Regions (Digital Vector Data) compiled by Texas Parks and Wildlife Dept. (1930-2005).

Salinity:

Optimal salinity zones (5-25ppt) were scored as most suitable for oyster restoration while areas of extreme low and high salinities were scored as least suitable. Polygons representing optimal salinities between 5-25 ppt were scored 1 with remaining areas scored 0. The scored polygons were converted to a 100m, 100m grid. Original data source: Salinity Zones in Estuaries along the Gulf of Mexico- NOAA/NCDDC (polygon), Resolution: 1:24,000.

Distance to Marsh:

Oyster reefs placed next to marshes help mitigate shoreline erosion in vulnerable areas along the coast. A polygon layer identifying all wetland areas in Louisiana was used to identify suitable areas 50 meters or less from marshes. Suitable areas were scored a 1 and all remaining areas were scored 0. Scored polygons were converted to a 100m, 100m grid. Original data source: USFWS National Wetland Inventory data (polygon).

2) Identifying socio-economic criteria that determine when restoration is most feasible and beneficial

Natural Resource Job Dependence:

Oyster restoration projects can provide social and economic benefits to those communities whose livelihoods depend most upon the health of coastal natural resources. To identify coastal communities with high levels of natural resource job dependence, we used census data to map the percentage of the workforce employed in agriculture, forestry, and fishing per census block group. Need one sentence on classification method. Nearshore areas (within 2km of shore) adjacent to block groups with high concentrations of workers employed in natural resource dependent sectors were scored 1 while areas adjacent to medium concentrations received a score of .5. All remaining areas were scored 0. Scored polygons were converted to a 100m, 100m grid. Original data source: 2000 US Census (polygon), Resolution: 1:100,000.

Project Permit Feasibility:

Placement of reefs in areas where public and private oyster leases for harvesting are not present were considered most beneficial. All areas indicating public or private oyster leases were deemed unsuitable and scored a 0 while all other areas without leases were deemed suitable and

scored a 1. Scored polygon data were converted to a 100m, 100m grid. Original data source: Louisiana Dept. of Wildlife and Fisheries (LDWF) 2001, LDWF 2006 (polygon).

Erosion:

Oyster reefs can be placed adjacent to eroding shorelines to help attenuate waves and stabilize shorelines. To identify portions of the shoreline that are currently vulnerable to erosion, we used a portion of the USGS Coastal Vulnerability Index. We extracted shoreline erosion rates for Alabama and reclassified the values into quartiles with scores of .25, .5, .75, and 1. A score of 1 indicates areas with the highest erosion rates and a score of .25 indicates areas of low erosion or accretion. The scores were then allocated to the nearshore areas (within 2km of shore) adjacent to the shoreline. All remaining areas were scored 0. Scored polygons were converted to a 100m, 100m grid. Original data source: USGS Coastal Vulnerability Index (Used erosion raw values, polyline), Resolution: 3 arc-minute grid cell.

Figure 7: Salinity layer selected from the Louisiana Oyster Reef Restoration Dashboard Data, and Property information displayed to explain Salinity scoring.

b) Examples using Restoration Dashboard

To fully understand the capabilities and utilities of the Gulf Restoration Decision Support Tool and its many facets, a few example scenarios were created. If the user is interested in addressing Louisiana shoreline erosion, but wants a location that has reasonable public access

and is on or near state-owned land, then one way this can be done is by using the Guide button. This will prompt the user to specify which state and which layers are of interest. We choose Louisiana as the state of interest, and Marina's and State Owned/Leased Land as our layers of interest. The spatial areas are highlighted and an explanation is provided in the legend. Under the Oyster Restoration Dashboard Layers in Map Layers, clicking on the Shoreline Erosion layer will project areas that are appropriate for shoreline erosion control (1 is high erosion rate, .75 is moderate erosion rate, .25 is low erosion rate, and 0 is no erosion rate). This combination will enable the user to view areas of Louisiana that need shoreline erosion control and are in close proximity to state lands and marinas (Figure 8).

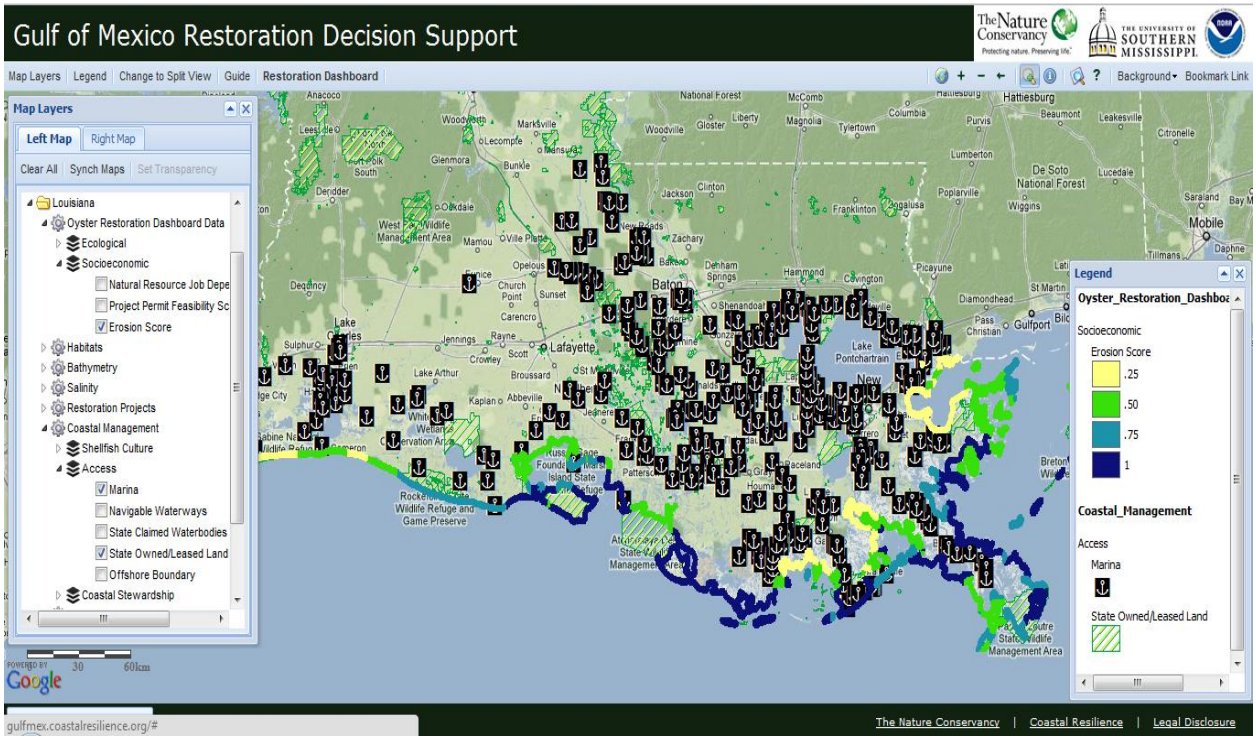


Figure 8: Example Scenario 1. Location of high erosion rate sites in proximity to marina's and state owned/leased land

As an example of how the Dashboard can be used to determine suitable oyster reef restoration based on different ecological and socioeconomic considerations, a split view using different Dashboard scenarios gives the user an idea of how these layers can change the suitability of a location. Let's say that we are interested in the Atchafalaya/Vermillion Bay area for oyster reef restoration and we are curious whether the water depth (and our ability to use certain equipment or methods) may be a significant inhibitor in this area. We can use Location Search to find Atchafalaya Bay. Then, when we are on the location of interest, we choose

Change to Split View. Launch the Restoration Dashboard and while on the Left Map, alter the depth score to 0 (not important). Then click on the Right Map choose the Restoration Dashboard and Atchafalaya Bay again. Alter the depth score to 10 (very important). Use Synch Maps on the Map Layers window so they are both on the same location and same scale. The depth score is based on the assumption that the most suitable areas for oyster reef restoration are less than 10 ft of depth. Therefore, on the Left Map, the depth layer has little influence, and areas shown as suitable may have depths of greater than 10 ft. On the Right Map, with depth being of high importance, only areas that meet the depth criteria (10 ft or less) are shown as suitable. This changes large expanses of areas in the West Cote Blanche Bay, Vermillion Bay and Atchafalaya Bay to more suitable because of appropriate water depth (Figure 9).

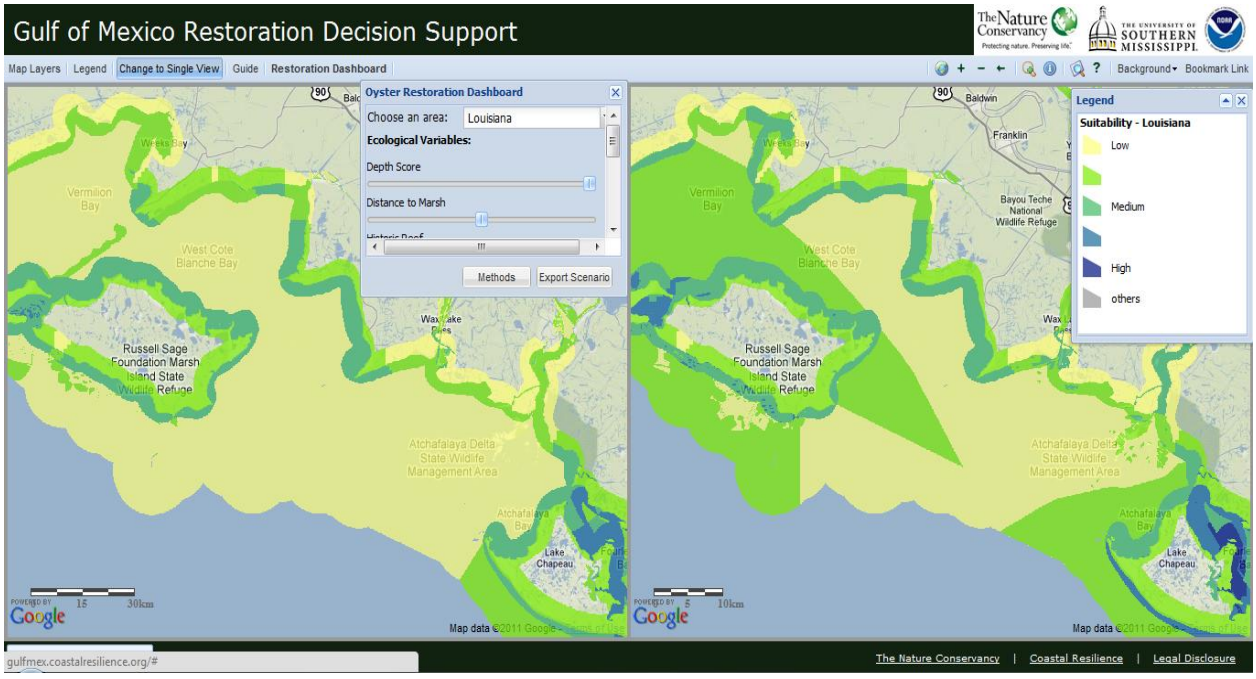


Figure 9: Depth Score differences between Left and Right Map (Selected

Another way the tool can be used is to compare two different locations using the same dashboard scenario criteria. For instance, let's say that an organization is interested in doing oyster reef restoration in an area where it can provide economic assistance to the local community. They are interested in restoration on either the left side of the Mississippi River or the right side, depending on the area with the greatest potential economic benefit. To start, a Zoom Rectangle was placed around the Mississippi River area. Change to Split View was chosen. The left side of the river was selected for the Left Map and the Right Map focused on the right side of the river. They also wanted a different background, so they changed it to ESRI World Topo for both maps. The Restoration Dashboard button was selected, and Louisiana was

chosen. The Natural Resource Job Dependency was changed to ten for both maps to display which areas could truly benefit economically. This shows which areas are most suitable based on a high importance for Natural Resource Job Dependency and average importance for the other factors. This score is obtained by ranking adjacent nearshore areas within 2km of a high natural resource job dependency with a score of 1, those areas adjacent nearshore areas within 2 km to medium natural resource job dependency with a score of .5 and all others with a zero 0. If the user is concerned that current restoration projects around the Mississippi River could be a potential conflict, then we can also click on these layers under Map Layers window to display them in both the Left and Right Maps. We can also choose the Identify button and click on the various restoration projects to learn more about them. This allows us to view what regions would be good to restore for economic improvement (Figure 10).

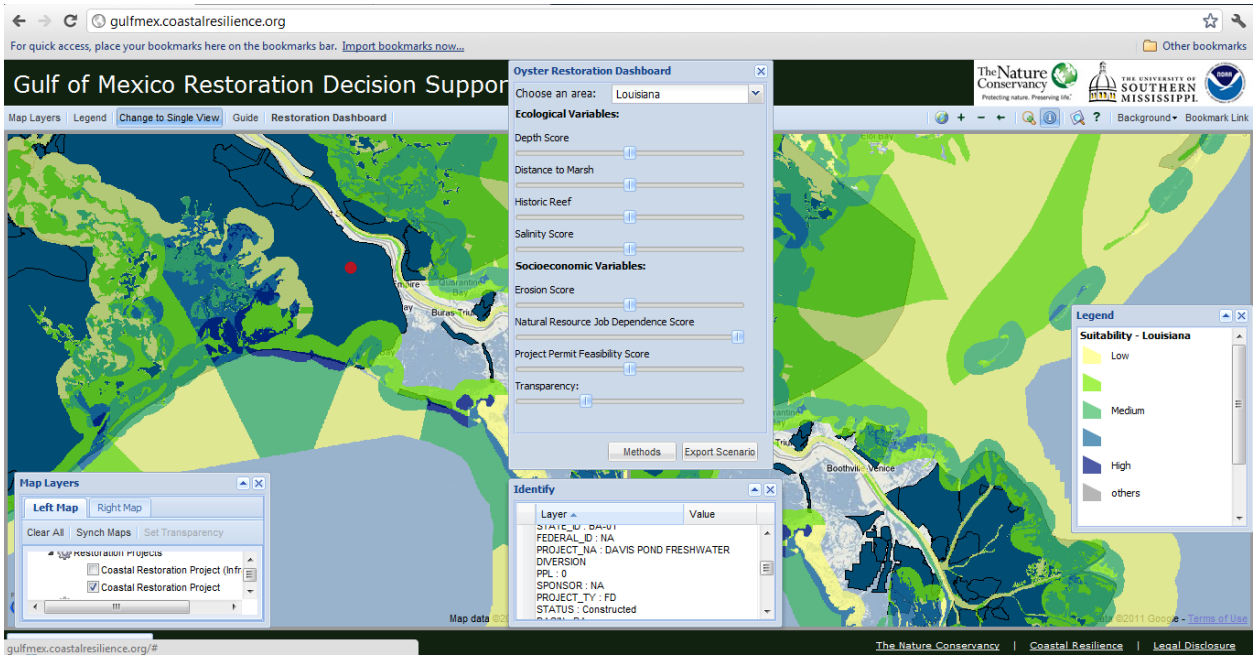


Figure 10: Suitable on Eastern and Western side of the Mississippi River with Natural Resource Job Dependency ranked very important (10) on both maps. Coastal restoration sites layer also displayed, as well a restoration project identified with red dot.

6. Exporting Maps

The created scenario can be exported by clicking on the Export button which provides a downloadable export file that contains an ESRI shapefile, an ArcGIS 10 layer file and a kmz (Google Earth) file. Note that settings chosen from the sliding scale will be reflected in the attribute table of the exported GIS and Google files. Scenarios may also be exported by clicking

on bookmark and copy and pasting the link. Note that if you use Bookmark Link it will capture only those geographic features from the selected Left or Right Maps (Figure 11).

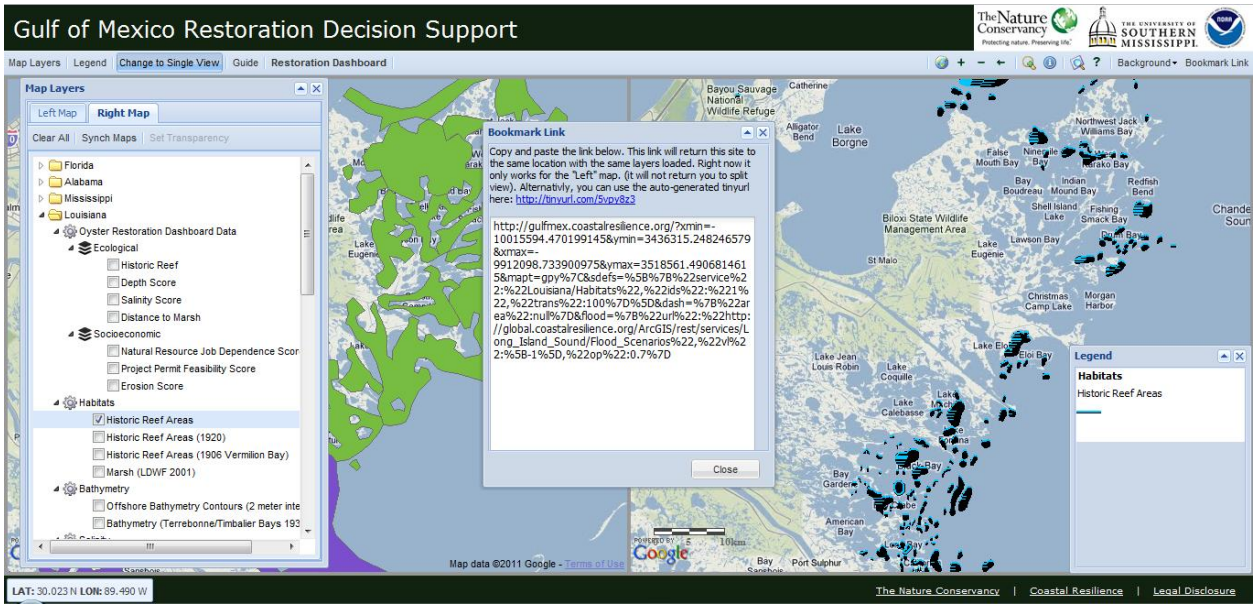


Figure 11: Showcasing Bookmark Link for Scenario, and Right Map Selected

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USER GUIDE END

VITA

Born in 1983 and raised in the foothills of North Georgia, Ashby Nix grew up enjoying the nature that surrounds her hometown of Canton. After attending Sequoyah High School where she participated in many extracurricular sports and clubs, she ventured to Georgia's coast to attend college. There she found her passion for the coastal wetlands and marine environment, and she carried this with her as she attended Mercer University in Macon, Georgia, where she majored in environmental science and biology. Graduating *Cum Laude* in 2006, Ashby went to work for The University of Georgia Marine Extension Service conducting coastal water quality analysis and oyster reef restoration. Two years later, Ashby took her passion for the water and environment up to Nova Scotia where she gardened and ran a kayak rental business during the summer of 2008. She returned to coastal Georgia later that year to work on a project identifying vegetative ecotypes in the coastal Georgia region. In the fall of 2009, Ashby accepted a graduate assistantship position at Louisiana State University, where she would spend the following two years gaining knowledge of wetland ecosystems that will help guide her future career endeavors. Ashby looks forward to her future of studying, conserving and enjoying the beautiful wetlands of the Southeast.