ECOLOGICAL RESTORATION ON THE HALF SHELL:
THE CULTURAL ECOLOGY OF OYSTER MANAGEMENT AND RESTORATION IN
NORTH CAROLINA

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ABSTRACT
Linda Marie D’Anna
Ecological Restoration on the Half Shell:
The Cultural Ecology of Oyster Management and Restoration in North Carolina
(Under the direction of Seth R. Reice)

Efforts to rebuild populations of eastern oysters (*Crassostrea virginica*) are evolving from single-species approaches focused on maximizing fishery exploitation to efforts centered on sustaining ecological processes. Long a productive and economically valuable commercial fishery, oyster harvest reached historic lows in the mid-1990s. Restoration efforts have been spurred by the recognition of long-underestimated benefits related to water quality and biodiversity, which arise from the direct and indirect ecosystem services that oyster reefs provide as they filter-feed and accumulate three-dimensional structure. The interconnectedness at the center of process-based restoration efforts must encompass geographical, ecological, and physical factors while also addressing the cultural and social contexts of ecological systems. I explored how cultural and social considerations can influence our understanding of restoring oysters to North Carolina’s estuarine systems.

I studied how stakeholders conceptualize oyster restoration by combining cultural modeling approaches with participatory mapping methods using semi-structured interviews. I investigated how views of oysters and oyster restoration differ among stakeholders by identifying the explicit and implicit cultural-ecological knowledge, values, and beliefs that stakeholders possess in order to assess whether the degree of difference in perceptions and perspectives suggests shared or distinct underlying cultural-ecological models.

Each stakeholder group’s cultural model of restoring oysters is unique in certain propositions, but important perspectives, though conceptualized differently among groups,
are shared across all models. All models include a proposition regarding the value of ecosystem-based approaches to address the effects of large-scale environmental changes, such as increased runoff from changing land use patterns, for efforts to restore oysters. Groups differed in their conceptualizations of the use of dredges for oyster harvest and its relationship to sustaining oyster populations. Stakeholders consider oyster restoration a success when it encompasses economic, ecological, and heritage values. Successful restoration is about what stakeholders want the world to look like, not what makes sense economically. The complexity of both individual and group values and knowledge about specific places, processes, and resources suggests that there may not be right answers to restoration questions, but rather cultural plurality, which informs notions of right and wrong behavior towards nature.
To my grandmothers, Rose Stabile D’Anna and Martha Molzon Hayward, for lifting me up and letting me stand on your shoulders.
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Most critically, this work would not have been possible without the participation of the men and women who talked with me about oyster management and restoration. It was my distinct pleasure to meet and talk with each and every one of you. If you had not shared so generously of your time, insights, experiences, and knowledge, the following pages would be blank. I have done my best to present your stories and perspectives fully and accurately; any errors are, of course, only my own. Thank you for inviting me into your homes and offices for some wonderful conversations. Thank you for being my teachers.

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And to my family, finally, a better answer to the question of what I have been doing here in North Carolina. Thank you to all of the D’Annas, Delaneys, Haywards, and Stapletons for always letting me be exactly who I am. Especially to my grandma, Martha Hayward, and my nonna, Rose D’Anna, for showing me what it means to work hard and take care of those around us. Nonna would always ask me how much longer. Nonna, it’s done.

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And finally, to my parents, Joseph and Karen D’Anna, I do not know how to express the gratitude that I feel. Even though you have been farther away during this process, your presence has been no less immediate. You are always with me, reminding me to do the right thing and strive to be a good citizen of the planet. Your unconditional love and financial support has made all the difference in this endeavor and throughout my life. Thank you for always encouraging me to just do my best and for believing in its merit.
PREFACE

Why oysters?

It was in early 2005, after my first semester teaching at UNC’s Albemarle Ecological Field Site, that I noticed the growing attention focusing on oysters. Suddenly, it seemed, this gray, rough-shelled, not stereotypically attractive or charismatic critter was everywhere. And it was getting a good amount of press, too. Headlines read: “Aw Shucks? State Recycles Oyster Shells to Boost Births”; “Oysters at Core of State Project”; “Learning from the Past: Old Maps Help Build a New Future for the Eastern Oyster.” There was even a short-lived, and ill-advised, petition to list the eastern oyster as an endangered species.

At the time, the North Carolina Division of Marine Fisheries was continuing to create and enhance oyster settlement sites as it had for decades, but it was also implementing new projects such as oyster shell recycling and under-dock oyster gardening, along with participating in coordinated planning for coastal habitat protection. It was expanding oyster sanctuaries in partnership with researchers and nonprofit organizations, which were conducting volunteer events and educational programs to increase public awareness about oysters. The North Carolina General Assembly was funding key oyster-related initiatives; chief amongst these was planning for the development of oyster hatcheries at the state’s three aquariums. A year later, our field site would become a partner in the hatchery program.

While the hatchery plans would eventually change to building one research hatchery at UNC-Wilmington, likely much of this attention and the intensification of restoration efforts in the state were reactions to what was happening at the time just to our north in Chesapeake Bay. Due to the remarkable declines in their oyster populations, the States of
Maryland and Virginia had proposed introducing a non-native species of oyster into the bay. Such an introduction would surely have ecological and economic impacts in North Carolina, where commitment to restoring the native species remained. Was native oyster species restoration a failure in need of abandonment for introduction of a non-native species? Instead of the efforts failing, success had been defined too narrowly, only including criteria related to the oyster fishery. Beyond harvest value, long-underestimated ecological and societal benefits related to water quality, biodiversity, and shoreline stabilization flow from the direct and indirect ecosystem services that oyster reefs provide as they filter-feed and accumulate three-dimensional hard structure in otherwise sediment-dominated estuarine systems. In mid-2009, after six years of study and nearly $17 million, officials in Chesapeake Bay chose to focus on improving the efficacy of restoring the native species.

There were many fronts in the debate over introducing a non-native oyster to Chesapeake Bay. The most compelling, for me, centered on questions of value: How do oysters matter? I believe questions of value like this one drive all efforts to restore and manage, not just marine or fishery species, but all natural resources. Questions of value are at the core of our relationship with nature, and they are made manifest in ecological restoration, the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. This process does not encompass merely biological and physical components, but has ends that are cultural, social, economic, political, and moral, ends shaped by the beliefs, values, and knowledge that inform our answers to questions of value. What are our goals? What is important?

Ecological restoration is at once a methodology, concept, process, way of thinking, and philosophy. It is interdisciplinary. Interdisciplinarity ranges from instances of disciplines borrowing tools from each other to the integration of concepts and methods from multiple disciplines that result in fundamental shifts in thinking. Ecological restoration, along with
other endeavors to deal with complexity, solve real-world problems, or answer questions of unique scale, cannot be accomplished satisfactorily with a single method or approach. It demands an interdisciplinary approach. An interdisciplinary approach is like a series of transparent overlays in which the scope and content of each discipline are superimposed on a common phenomenon to selectively integrate ideas and concepts.

The increased prominence of oyster restoration in 2005 presented an opportunity to think about interdisciplinarity in ecological restoration. Oyster restoration does not occur within a landscape from which humans have been removed. In addition to being part of an ecological system, oysters are part of an economic system: the multi-million dollar fishing industry of North Carolina, and a cultural system: the coastal heritage of North Carolina. All of these systems are changing rapidly. Restoring oysters, restoring nature, must be more than the application of ecological science to a problem. Ecological restoration requires superimposing a series of place-based examinations of culture, value, meaning, and perception onto a complex, real-world, nonhierarchical problem by considering the kind of world we want to inhabit.

And so it was in the midst of the oyster’s newfound popularity that I began to formulate my work and think about interdisciplinarity. I am hopeful that my work amongst stakeholders in oyster restoration in North Carolina might contribute to the expansion of our thinking about what it means to successfully restore natural resources. I am hopeful that the oyster’s popularity will be enduring.

“What I tell people is that I’m not very optimistic about the future, but I’m still hopeful. You know, so, up here in my head, I’m really not that optimistic, you know, that as a species we’re going to be able to solve these problems, but I’m still very, very hopeful in my heart.” -- Conservation practitioner
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<th>Full Form</th>
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<tbody>
<tr>
<td>BRACO</td>
<td>Blue Ribbon Advisory Council on Oysters</td>
</tr>
<tr>
<td>CHPP</td>
<td>Coastal Habitat Protection Plan</td>
</tr>
<tr>
<td>CRC</td>
<td>Coastal Resources Commission</td>
</tr>
<tr>
<td>EBM</td>
<td>Ecosystem-based management</td>
</tr>
<tr>
<td>EMC</td>
<td>Environmental Management Commission</td>
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<tr>
<td>FRA</td>
<td>Fisheries Reform Act</td>
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<tr>
<td>FMP</td>
<td>Fishery management plan</td>
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<tr>
<td>MFC</td>
<td>Marine Fisheries Commission</td>
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<tr>
<td>NCDMF</td>
<td>North Carolina Division of Marine Fisheries</td>
</tr>
<tr>
<td>PBER</td>
<td>Process-based ecological restoration</td>
</tr>
<tr>
<td>PEK</td>
<td>Practical experience knowledge</td>
</tr>
<tr>
<td>ppt</td>
<td>Parts per thousand</td>
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<tr>
<td>US</td>
<td>United States</td>
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<tr>
<td>WRC</td>
<td>Wildlife Resources Commission</td>
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Chapter 1

INTRODUCTION TO CULTURAL CONTRIBUTIONS TO UNDERSTANDING COASTAL AND ESTUARINE SYSTEMS

The world’s coasts and estuaries have undergone fundamental ecological changes including loss of large consumers, reduction of ecological-engineering species, and eutrophication, because of both natural changes and anthropogenic influences such as hydrological alterations, land use patterns, and fisheries exploitation (Jackson 2001). These changes have modified ecological function and shifted patterns of primary and secondary productivity resulting in diminished provisioning of ecosystem services (MEA 2005). Ecosystem services produced by intact estuarine habitats encompass a multitude of important processes that benefit human society (Daily 1997). Even though the North Carolina coastline has not suffered the major industrial pollution of other coastal regions, it has still undergone important changes. One important change that has occurred in our coastal rivers and sounds is a reduction in the once extensive area of oyster reef habitat (Rothschild et al. 1994). Intact oyster reef habitat can provide services and benefits like habitat provision, water filtration, fisheries production, and shoreline stabilization (Grabowski and Peterson 2007). Yet, using oyster fishery landings as a proxy for population size, today, only a small percentage of the historical oyster population remains in North Carolina (NCDMF 2008).

To address changes and challenges like the loss of oyster reefs, management of coastal and estuarine fisheries recognizes the need to evolve from a single-species
approach to an ecosystem-based approach centered on sustainability (Christensen et al. 2096). The goal of this approach is to conserve ecological structure, function, and process by focusing on the interconnectedness of ecosystems. (McLeod et al. 2005). Restoration of ecological processes has become an integral component of these approaches to managing coastal and estuarine systems. The interconnectedness and context-dependency at the center of ecosystem-based management and process-based ecological restoration approaches encompasses not only geographical, ecological, and physical factors and contexts, but cultural and social ones as well. In fisheries management and restoration, great strides have been made incorporating the roles of biological and physical interconnections into our understanding of coastal and estuarine systems, but more limited progress has been made integrating social and cultural considerations into that understanding. This contradiction prompted the general questions that have guided my work. These questions are: Can cultural and social considerations contribute to our understanding of coastal and estuarine systems and our efforts to manage and restore them? If so, what can they tell us?

To think about this question, we must consider the context-dependency of ecological restoration. Restoration is context-dependent because it takes place across a multitude of sites within a range of landscapes. This context-dependency complicates the task of developing a predictable restoration practice while simultaneously highlighting the need for unifying theories (Palmer et al. 2006). Restoration based solely on biological-physical place and theory risks ignoring the range of social, political, moral, and aesthetic qualities that vary from place to place. Places are more than natural or physical entities; they are constructs defined by social convention and cultural expression (Higgs 2003). Culture is collective subjectivity, a worldview, theory, model, or outlook on the world adopted by a community or group in given place that organizes everyday life, products, values, and ideas and gives
meaning to behaviors and practices (Alasuutari 1995). The cultural construction of a place describes how people endow it with meaning (Escobar 2001) and describes the terrain of ideas that have grown up about how to live there (Berg and Dasmann 1977). It is an expression of the worldview shared by the inhabitants of a place about how they want the world they live in to look and function.

Because restoration projects exist in a cultural context, to be sustainable, they must be supported by the surrounding human population and produce culturally acceptable conditions (Hull and Gobster 2000). This requires understanding the place-based knowledge, beliefs, values, and perceptions that local people have about their environment. Cultural perspectives and attitudes toward resource use, ecological restoration, and conservation in a given place are shaped by the environment and local history of that place. Those perspectives shape individual and community decision-making about how places should look, act, and be managed. The resulting decisions influence local history and forge changes in the environment.

As perceptions and knowledge vary from place to place, they give meaning to actions (Medin et al. 2006). Meanings are not simply labels for certain objects, but the interpretations of what objects mean and the rules of interpretation by which people conduct themselves and understand reality (Alasuutari 1995). Meanings matter for natural resource management, conservation, and restoration because environmental decision-making is driven by the symbolism people attach to objects or activities and the interpretations they make about their relationship with the rest of nature and the world (Alasuutari 1995, Medin et al. 2006). People cannot absorb all of the world’s complexity, so they construct cultural models to solve problems or interpret situations (Paolisso 2002). Cultural models are simplified frameworks that are widely shared, though not exclusively, by members of a group or society for understanding the surrounding world and their behavior in it (Paolisso 2002).
These models contribute to public perceptions of restoration success, landscape health, and resource robustness.

Applying a cultural model approach to studying and resolving natural resource management and ecological restoration conflicts is useful because the approach can illustrate unarticulated reasoning that connects statements and positions made by one group in opposition to another group (Paolisso 2002). Such conflicts can be viewed as clashes of competing knowledge systems and cultural constructs (Rikoon 2006). Settlements of conflicts like these are not a measure of whose construct is better, but who is more powerful, often with implications for the protection of local communities, livelihoods, and culture. A shift in management and restoration approaches to resource conflicts is necessary such that local knowledge and perspectives are considered along with scientific data and models in restoration projects. To avoid tension, restoration strategies must incorporate an understanding of specific cultural views and contexts, i.e. understanding why stakeholders believe as they do and how their beliefs about could inform policy. Qualitative data reveal the norms and values that underpin observable attitudes, behaviors, and practices among stakeholders (Honneland 1999). These data are more than descriptive; they need to be integrated with stakeholders’ economic and ecological knowledge within decision-making processes (Paolisso et al. 2006).

Stakeholders in North Carolina’s populations of eastern oysters utilize cultural models to give meaning to this once abundant species as well as the evolving efforts to manage and restore it. By focusing on meanings, a cultural model contextualizes specific management and restoration issues within a holistic framework of cultural beliefs and values. Failure to explicitly consider the cultural and social context of in which oyster restoration initiatives are taking place might prevent efforts to sustain oyster fishery from achieving their goals.
This dissertation begins with a pair of literature reviews. In the first of these two chapters, I introduce the species at the center of my research, the eastern oyster, *Crassostrea virginica*, describing its biology, ecology, and population decline. I also offer detailed background on the oyster industry and management in North Carolina from its inception until the middle of the 20th century. The impacts of these early management practices live on today, both in terms of attempts to sustaining oyster fishery production and efforts to conserve oysters for their important roles in the estuarine system. In the subsequent review in Chapter 3, I explore the shift in oyster management, and natural resource management at large, to address ecological functions and processes within a regime that maintains chiefly utilitarian focus. I discuss how a combined ecosystem-based approach to management and ecological process-based approach to restoration, with an explicit cultural analysis component, is critical for successfully stabilizing and enhancing North Carolina’s oyster populations.

The subsequent research chapters document how stakeholders conceptualize oyster restoration in North Carolina. Chapter 4 explores how stakeholders perceive the factors, concerns, problems, and pressures that currently threaten the state’s oyster population. I utilized a participatory mapping methodology to ask stakeholders about their concerns and calculated incidence, severity, and overall importance indices for each concern. Differences in perceptions of environmental pressures can arise from differences in knowledge, experiences, familiarity, and economic ties to activities and ecosystems, and lead to adversarial relations among stakeholders. These tensions can impede management processes and diminish the effectiveness of restoration policies.

In Chapter 5, I investigate how stakeholder perceptions of oysters and oyster restoration efforts in North Carolina differ among stakeholder groups, asking whether the degree of difference in these perceptions suggests shared or disparate underlying cultural-
ecological models. My objectives are to identify the explicit and implicit cultural-ecological knowledge that different stakeholder groups have about oysters and that they use, in combination with beliefs and values, to form perspectives and perceptions of oyster management and restoration. To do so, I utilized a cultural modeling approach. Documenting shared cultural models among stakeholders could have important regulatory and policy implications. Identification of the knowledge, values, and beliefs that structure these models will improve our understanding of how stakeholders will respond to management and restoration decisions and of the impacts of those decisions.
References


2.1. Introduction

Oysters once supported subsistence fishing and local use among Native Americans (Phelps 1984) and other early residents of coastal North Carolina prior to the Civil War (Carter 2000), and subsequently a major commercial fishing industry in the late 1800s (Taylor 1992). Descriptions of the natural history of the state from the late 1700s depict great numbers of oysters in every salt water creek, even growing attached to tree limbs that bent low enough to reach under the water at high tide (Brickell 1973). The earliest colonists described oysters growing in configurations large and tall enough to be navigational hazards (Wharton 1957). Today, the oyster fishery is are only a small percentage of the historical production (Frankenberg 1995). Responses to the population decline have resulted in the implementation of variable management measures over the last century, but only recently do oyster landings seem to exhibit signs of modest recovery (NCDMF 2008b). Oysters are no longer viewed as merely a fishery resource. There is widespread recognition of their critical roles in estuarine ecosystem functioning and the impact of their decline on the ongoing environmental crises in estuaries up and down the US Atlantic coast.

In this chapter, I provide an introduction to various elements of oyster biology and ecology, including the ecosystem services they provide. I also discuss their important economic and social roles in coastal North Carolina and describe the history of the oyster fishery in the state. Problems in the oyster fishery led to the development of the first fishery
management programs in North Carolina. I describe the history and pattern of oyster management efforts through the 1950s and offer an analysis of how those decisions still influence the current status of the state’s estuarine waters and its oyster populations.

2.2. Introduction to Oyster Biology and Natural History

2.2.1. Range and Habitat Preference

The eastern oyster, *Crassostrea virginica* (Gmelin), is native to the western Atlantic coast from the Gulf of St. Laurence to the Gulf of Mexico and the Caribbean and even further south to the coasts of Brazil and Argentina (Carriker and Gaffney 1996). Along the North Carolina coast, oysters occur from Roanoke Island, at the very southern end of Albemarle Sound, to the border with South Carolina (NCDMF 2008b). Surrounding more than 8,000 miles of estuarine shoreline, North Carolina’s extensive coastal landscape is ecologically complex with great local and regional variation in habitat and associated fish species determined by climate, geology, hydrology, land use, human population, and both point and nonpoint sources of pollution (Mallin et al. 2000). Within the state’s coastal landscape, oysters are found at varying distances up the estuaries, sounds, rivers, and creeks of the state, depending on salinity, substrate, and flow.

The Albemarle and Pamlico Sounds at the northern end of the coast, enclosed by a barrier island chain that forms an eastern boundary, are primarily wind-driven such that astronomical tidal influence is largely confined to areas near the inlets while the majority of the broad and shallow system experiences wind-driven tides (Pilkey 1998). The majority of oyster reefs in the Pamlico Sound are subtidal and concentrated in the lower portions of the Pamlico and Neuse Rivers, along the western shore of the sound especially in the Swan Quarter area, and between Long Shoal and Roanoke Island (E. Ballance, pers. comm.).
South of Cape Lookout, subtidal reefs occur in the New, Newport, and White Oak rivers. Due to an abundance of inlets and few small Coastal Plain rivers emptying into the coastal zone, most of the southern province experiences highly regular astronomical tides (Pilkey 1998). These estuaries, creeks, and rivers have extensive intertidal oyster beds (Street et al. 2004).

Oysters grow well on hard mud or shell bottom. Soft mud and shifting sand are not good substrates for oyster growth because oysters tend to sink and get sedimented over on these bottoms (Galstoff 1964). Oysters are ecosystem engineers (Jones et al. 1994), creating and maintaining habitat composed of a mixture of shells from dead and living oysters, and variously-sized sediment. Oysters can grow as single oysters or in small clumps, but commonly grow in large aggregations variously called reefs, beds, or rocks. Many fishermen refer these formations as lumps. I will use these terms interchangeably throughout this document.

*C. virginica* is a quintessentially estuarine species with a broad tolerance for variation in environmental conditions. The two most important environmental conditions determining growth and survival are temperature and salinity. Oysters can tolerate a wide range of temperature, from -2 to 36°C, but rapid fluctuations in temperature can be fatal (Shumway 1996). They can survive in water with 5 – 40 ppt salinity (Shumway 1996), but grow optimally in 14 – 30 ppt (Street et al. 2004). Recruitment is generally greater at higher salinity sites, such as eastern Pamlico Sound, than at sites in the western portion of the sound where salinity varies from 10 to 30 ppt (Ortega and Sutherland 1992). Mortality results after extended periods of low salinity (Galstoff 1964). Individuals from different locations may not physically resemble one another very closely since shell morphology can vary widely due to a variety of environmental factors, including bottom type, salinity, temperature, current velocity, and turbidity (Carriker 1996).
2.2.2. Reproduction and Development

The eastern oyster has an annual reproductive cycle that culminates in the warmer months with spawning and external fertilization. Fecundity varies among locations and from year to year within a single location (Thompson et al. 1996). *C. virginica* is a protandric species; individuals generally mature as males and undergo sex reversal as they grow larger. Once they are large females, oysters allocate more energy to egg production than somatic growth (Thompson et al. 1996). Together, these factors highlight the population-level contributions larger oysters make and underscore the important implications of maintaining large individuals in a population.

Oysters spawn by releasing their gametes into the water column, where fertilization takes place. Spawning is stimulated primarily by two environmental cues: increase in temperature and food availability (Thompson et al. 1996). In North Carolina, the first pulse of spawning occurs as water temperatures near 20°C in June, with a peak in spawning at 25°C towards the end of summer (Thompson et al. 1996). Once spawning has been initiated, the presence of gametes in the water column stimulates surrounding oysters to spawn, resulting in synchronized mass spawning (Thompson et al. 1996). Dense aggregations of oysters on reefs maximize spawning efficiency (Mann 2000). Spawning synchronization by aggregations of oysters produces millions of fertilized eggs, but only a small percentage of these will survive living in the plankton to the settlement stage, and only a limited proportion of spat, young oysters that have attached to hard substrate, will survive to reach adult size (Thompson et al. 1996, Kennedy 1996).

Oyster larvae grow and develop in the plankton for about three weeks, dispersing largely with the patterns of water movement and retention, grazing on microalgae, detritus, and bacteria (Kennedy 1996). The length of the larval phase depends on temperature and food supply (Kennedy 1996). When they reach the “eyed” or benthic settling stage, larvae
selectively settle onto hard surfaces according to cues associated with the substrate, cement themselves to hard substrate especially natural shell, but other objects like rocks and pilings as well, and undergo metamorphosis to the adult form (Street et al. 2004). Oyster management programs typically add substrate for oyster settlement to the water. This substrate is referred to as cultch material. Oyster shells are most often used, but limestone, marl, concrete, and shells from other bivalves are suitable alternatives used in many oyster growing and restoration efforts (Brumbaugh and Coen 2009). However, oyster larvae will attach to almost any hard surface, from pilings to crab pots to bricks. Most settle gregariously, stimulated to settle near adults and newly settled oysters or spat occupying existing reefs (Kennedy 1996).

2.2.3. Feeding

Oysters are active suspension feeders, consuming primarily phytoplankton and detritus ranging in size from 1 to 30 µ (Newell and Langdon 1996). Cilia on the gills beat rhythmically to generate a current that captures particles out of suspension (Newell and Langdon 1996). Captured particles are sorted and the less nutritious and abiotic ones are rejected before ingestion as pseudofeces (Newell and Langdon 1996). Oysters maintain high clearance rates even when the volume of seston captured on their gills exceeds their gut capacity by rejecting the excess as pseudofeces (Newell et al. 2005). Voiding excess and rejected particles as pseudofeces is the main mechanism by which oysters regulate the amount of material ingested (Newell and Langdon 1996). This ability allows them to maximize their ingestion of nutritious particles, but also results in their great influence on benthic-pelagic coupling (see below) (Newell et al. 2005).
2.3. Ecological, Economic and Cultural Contexts of Eastern Oysters

Oysters have long been an important food and valuable fishery. As a result, historically, the focus of human attention on oysters has been on means and maximization of exploitation. However, long-underestimated ecological and societal benefits, including amelioration of environmental conditions and habitat provision, which flow from the direct and indirect ecosystem services that oysters provide, delineated through research, have garnered new attention from fisheries management agencies and environmental groups in recent years.

2.3.1. Oysters in the Water

2.3.1.1. Environmental Amelioration

One of the fundamental ecosystem services that oyster reefs provide is alteration and improvement of environmental conditions through the ways in which oysters alter local physical conditions and the roles that they play in energy production and processing cycles. Oysters engineer their environment, in ways that affect the biological functioning of oysters and other reef-associated species, both by altering the pattern and speed of water flow with their physical structure (autogenic engineering) and by transforming materials from one physical state to another (allogenic engineering) through their filter-feeding mechanism (Jones et al. 1994). Water flow speed increases as it moves over reefs with increasing reef height, with concomitant increases in oyster growth rate and condition index at higher reef elevations due to increased food delivery, reduced sedimentation, enhanced renewal of oxygen, and greater removal of wastes (Lenihan 1999, Lenihan et al. 1999). Lower water flow speed at reef bases increases sedimentation rates, which can negatively impact oysters located there but also improves water clarity (Meyer and Townsend 2000, Cressman et al. 2003).
Changes in flow affect both reef residents and adjacent habitats. The modification of water flow caused by oyster reefs enhances aggregation of naked goby larvae such that recruitment rates are 10-100 times higher than rates reported for coral reef fish or other temperate reef fish species (Breitburg et al. 1995). Oyster reefs oriented along salt marsh shorelines serve as a natural breakwater, reducing erosion and stabilizing sediment on adjacent shorelines subject to wave energy (Meyer et al. 1997, Piazza et al. 2005).

As filter-feeders, oysters have important direct and indirect effects on the conditions in estuaries through their roles as nutrient recyclers, nutrient retainers, and carbon sinks (Dame et al. 1984, Dame et al. 1992, Dame and Libes 1993, Newell et al. 2002). Allogenic engineering occurs as oysters and other suspension feeders associated with oyster reefs suppress concentrations of organic matter and turbidity in the water column by consuming phytoplankton and other organic particulate matter (Coen et al. 1999). Concentrations of seston/chlorophyll a are reduced downstream of oyster reefs compared to upstream through a combination of physical mechanisms and selective oyster filtration (Dame et al. 1984, Cressman et al. 2003, Grizzle et al. 2006). Oysters can improve conditions for seagrass growth, primarily through nutrient enrichment and improved light penetration (Peterson and Heck 2001a, 2001b, Jackson et al. 2001, Newell et al. 2002, Newell and Koch 2004, Wall et al. 2008). The ability of oysters to continue filtering and eliminating rejected particles as pseudofeces even at high particulate concentrations means that large oyster populations have the capacity to buffer periodic influxes of suspended materials after storms or excessive phytoplankton blooms (Jackson et al. 2001). Oysters in aquaculture installations also contribute to water filtration, nutrient and carbon transfer to the sediments, and biogeochemical cycling, though the extent of the contributions depends on the stocking density and estuarine flushing rates (NRC 2009).
The ability of filter-feeding oysters to reduce eutrophication and rehabilitate estuarine systems with overabundant phytoplankton production is under continued debate. Based on mismatched spatial and temporal scales, Pomeroy et al. (2006, 2007) have critiqued suggestions (Newell 1988) that the ability of pre-1870 oyster populations to filter Chesapeake Bay in less than 3-6 days had been degraded by 1988 to 325 days and thereby so had their influence on the bay’s phytoplankton population. Pomeroy et al. (2006) charge that neither historical nor targeted oyster populations are large enough to exert top-down control of spring phytoplankton blooms or reduce summer hypoxia on a bay-wide scale because of spatial and temporal mismatches between the filtration capacity of oyster populations and phytoplankton abundance. Oysters are concentrated in the shoals and tributaries while phytoplankton production over the deeper water trenches of the bay settle to the bottom and contribute to anoxia (Cerco and Noel 2005). While the extent of the requisite restoration to achieve such goals on a bay-wide scale is beyond the scope of the current efforts, oysters and other benthic filter-feeders can have appreciable impacts on phytoplankton in shallow creeks and other localized areas (Officer 1982, Cerco and Noel 2007). While system-level effects of oyster filtration have not been quantified sufficiently, it is clear that the presence of functional oyster populations can have important local impacts on water quality, which, together with the other ecosystem services provided by oysters, provide strong reasoning for oyster restoration (Grabowski and Peterson 2007). Coen and co-authors (2007) decry attributing to oyster restoration a goal like large-scale water quality improvement and then describing that goal as impossible without emphasizing other real and measurable goals and benefits of restoring oysters, such as biodeposition, habitat for fishes and invertebrates, and stabilization of shoreline habitats.
2.3.1.2. *Benthic-Pelagic Coupling*

By joining the water column to the reef through filtration and accompanied biodeposition, oysters connect the pelagic and benthic realms of an estuary in the cycling of carbon, nitrogen, and other materials (Newell 2004). As oysters ingest seston from the water column, they excrete inorganic nitrogenous waste, enhancing downstream levels of ammonium (Dame et al. 1984, Nelson et al. 2004). Ammonium stimulates phytoplankton production, so often high levels of primary production are found around oyster reefs (Newell et al. 2002). However, at the ecosystem level, less nitrogen leaves a reef system than enters (Newell et al. 2005). When oyster biodeposits, feces and pseudofeces, sink to the bottom sediment, the particulate organic nitrogen they contain is transferred to the aerobic surface layer of sediment where it may be subjected to microbial degradation and transformed into ammonium ($\text{NH}_4^+$), which returns to the water column, or it may undergo nitrification to nitrite ($\text{NO}_2^-$) or nitrate ($\text{NO}_3^-$) if nitrifying bacteria are present (Newell 2004). Some of the $\text{NO}_2^-$ and $\text{NO}_3^-$ will return to the water column as dissolved inorganic nitrogen, while some will diffuse into an underlying anaerobic sediment layer, if it is present, where denitrifying bacteria will reduce the $\text{NO}_2^-$ and $\text{NO}_3^-$ to nitrogen gas ($\text{N}_2$) (Newell et al. 2002, Newell 2004). In this form nitrogen is unavailable to plankton as the nitrogen gas moves to the atmosphere effectively reducing ecosystem fertility. Without oysters, phytoplankton may be more likely to accumulate in the benthos where microbial respiration generates bottom-water anoxia and nitrogen can be regenerated as ammonium (Jackson et al. 2001, Newell et al. 2002, Kirby and Miller 2005).

2.3.1.3. *Oyster Reefs as Habitat*

Oysters provide vital habitat and enhance biodiversity and productivity by creating and maintaining hard substrate and three-dimensional habitat in typically sediment-
dominated systems like Pamlico Sound (Kennedy 1996, Lenihan and Peterson 1998, Coen et al. 1999). The main mechanisms suggested for the differences between the communities found in three-dimensional versus simple estuarine habitats include enhanced refugia from predation (Posey et al. 1999), high architectural heterogeneity (Harding and Mann 1999), and increased food availability (Harding and Mann 2001a). The irregular surface of an oyster reef produces a complex structure of interstitial spaces for refugia and numerous microhabitats and high surface area for colonization by a variety of organisms (Kennedy 1996, Tolley and Volety 2005, Shervette and Gelwick 2007). A highly diverse assemblage of species, including both juveniles and adults of commercial and recreational value, utilizes oyster reefs (Wells 1961, Meyer and Townsend 2000, Tolley and Volety 2005, Boudreaux et al. 2006). Wells (1961) found 303 species, including sponges, flatworms, mollusks, annelids, arthropods, echinoderms, and vertebrates, in North Carolina oyster beds. Calculations by Peterson et al. (2003) reveal that replacing unstructured estuarine bottom with a restored oyster reef can enhance production of fish and mobile crustaceans by 2.57 kilograms per year per square meter of restored reef.

Habitat engineered by restored oysters could enhance landscape-level biodiversity if it provides resources not otherwise available in the system and species can gain access to them (Gutierrez et al. 2003). The small number of inhabitants in common among oyster reefs, seagrass beds, and salt marshes suggests that oyster reefs make a unique and important contribution to estuarine diversity (Glancy et al. 2001).

Oyster reefs provide several different types of habitat: foraging, spawning, nursery, and refuge. Oyster drills, whelks, moon snails, blue crabs, and finfish, such as black drum, oyster toadfish, and sheepshead, feed on oysters as do cownose rays, raccoons, and ducks (Galstoff 1964). Recently, concerns have arisen about the effect of predation by surging
populations of cownose rays, a cascading effect of the loss of predatory sharks (Myers et al. 2007).

Most feeding relationships on oyster reefs involve species other than oysters (Tolley and Volety 2005). The hard substrate and complexity of oyster reefs attracts high abundances of macroalgae, macroinvertebrate prey, intermediate predators, and upper-level predators and fisheries species such as red drum, spotted seatrout, and bluefish (Summerson and Peterson 1984, Harding and Mann 2000, Harding and Mann 2001b, Lenihan et al. 2001, Harding and Mann 2003, Grabowski 2004, Grabowski and Powers 2004, Tolley and Volety 2005). Predation rates are high in oyster reefs because interference interactions between predators, which lead to behavior modifications and reduced foraging success in structurally simple habitats, are reduced by the complex structure of reefs (Grabowski and Powers 2004, Hughes and Grabowski 2006).

Other species use reefs as refuge habitat, especially during juvenile or spawning periods. While high habitat complexity can increase predation success by reducing interference, it can also decrease predation intensity because the microhabitats on the reef surface provide a variety of shelter sizes and disrupt predator-prey interactions (Grabowski 2004, Shervette et al. 2004, Soniat et al. 2004, Grabowski and Kimbro 2005, Tolley and Volety 2005). This structural habitat, combined with high benthic invertebrate production, enhances the use of oyster reefs by fish and crustaceans by providing protection from higher-order predators (Coen et al. 1999). Though long overlooked as such, oyster reefs are important nursery habitat with high rates of juvenile settlement and survival for a variety of crustaceans including stone crabs (Zimmerman et al. 1989) and blue crabs (Eggleston et al. 1998, Moksnes and Heck 2006), and fish like seabass, groupers, and snappers (Lehnert and Allen 2002). Young fish may actively select shell habitat because it provides protection and food (Szedlmayer and Howe 1997). Oyster reefs also contribute to recruitment by
providing spawning substrate. Several fish, including multiple species of blennies, spawn on oyster reefs, depositing their eggs inside oyster boxes – the empty valves of dead oysters (Crabtree and Middaugh 1982, Harding and Mann 2000, Tolley and Voley 2005).

2.3.2. Oysters out of the Water:

2.3.2.1. Local Identity and Life on the Coast

For all of the groups of humans who have inhabited the Pamlico Sound region throughout history, oysters have played a prominent role in daily life and special occasions. Because they were so abundant, oysters figured large in local diets, but they were also a good source of nutrition and vitamins, including protein, calcium, and vitamins B₂, B₃, and C, for the isolated native and colonial populations along the North Carolina coast (Hedeen 1986). Oysters were far and away the most numerous item found in a Native American shell midden at the south end of Roanoke Island (Phelps 1984). Sites like this one were established for seasonal access to surrounding oyster beds. Later, European Americans developed many recipes for oysters, and many meals featured oysters – steamed, pickled, scalloped, and stewed among others (Rutledge 1979, HIUMW 1987).

Oysters were important to poor coastal residents because they were an easily obtained, flexible commodity: they could be eaten, traded for other foodstuffs, and had several other uses in all seasons. Fishermen gathered oysters in the winter and early spring to trade for corn on the mainland (Carter 2000). Their value as lime made them useful for home construction, roads, kiln making, and fertilizer (Brickell 1793). As early as 1840 people established small shallow-water plots for cultivating oysters for home use (Grave 1904). Referred to as oyster gardens, these plots were permitted by the local counties, and as the name suggests, each was rather small in extent and production (Thorson 1982).
Oysters were instrumental in maintaining social networks as part of the roasts and festivals that marked the beginning of the typical winter fishing and oyster harvesting season. They featured prominently in Old Christmas in Rodanthe, celebrations that take place about twelve days after Christmas and can be traced back to 1752 and England’s adoption of the Gregorian calendar, which shortened the year by eleven days (DeBlieu 1987). The oyster shoot, which started as a test of skill among the surfmen of the lifesaving station, rewards the winner of a target-shooting contest with a half-bushel of oysters (DeBlieu 1987, NPS 2005). Bushels of oysters are roasted and shoveled onto tables for everyone to enjoy. Oysters play a central role in this annual tradition, though they are no longer collected locally, but are instead shipped in from the Gulf Coast (NPS 2005). Despite these and other changes and struggles, long-standing events like Old Christmas are expressions of local pride, history, and traditions, and oysters play a prominent role (DeBlieu 1987).

2.3.2.2. Current Fishery Production

In the 1800’s oyster catches represented 20% of all fishery landings in the state; today they comprise just 2.5% (NCDMF 2008b). Landings began to decline by the end of the 1800s, and the fishery never regained the prominence it held earlier that century (Fig. 2.1). The history of the fishery and reasons for the decline are discussed in the next section. Landings curtailed severely following a red tide outbreak in 1987 that closed the oyster hand harvest fishery in the southern part of the state. Overall oyster landings surged that year though, due to increased effort in the oyster dredge fishery in Pamlico Sound by fishermen displaced from the mechanical clam fishery by the red tide (NCDMF 2008b). 1987 and 1988 were the last big years for the oyster fishery in North Carolina (Table 2.1). The next twelve years were marked by widespread oyster mortality due to the oyster disease Dermo, caused
by the oyster parasite *Perkinsus marinus*, and consequent low landings (NCDMF 2008b). 2006 marked the fourth consecutive year that oyster harvest increased in the state. In 2007, commercial landings about held steady from the previous year at 84,585 bushels of oysters, valued at over $2.2 million, compared to 46,082 bushels in 2002 (NCDMF 2008a). Landings rose slightly in 2008 to 88,008 bushels valued at just over $2 million (NCDMF 2008a). The number of shellfish licenses issued by the state declined from 2,304 in the year 2002 to 1,529 in 2006, but has since increased by about 100 per year in 2007 and 2008 (NCDMF 2008a).

**Figure 2.1.** North Carolina commercial landings.


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<tr>
<th>YEAR</th>
<th>POUNDS (MEATS)</th>
<th>BUSHELS</th>
<th>VALUE ($)</th>
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<td>2008</td>
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According to the North Carolina Division of Marine Fisheries (NCDMF), the state agency responsible for the stewardship of the state’s marine and estuarine resources, the economic impact of oyster harvesting on the state’s economy indicate that it more than
doubled from 2000 to 2005 (NCDMF 2008b). In addition to dockside value, economic benefits flow from secondary products and services such as shucking and packing houses, transport, manufacturing of prepared oyster products (freezing and canning), retail sales, and boat sales and maintenance (King and McGraw 2004). In the past couple of years, harvesters have been getting 20% to 40% greater value than they did during the last peak in landings (NCDMF 2008b). Because the recent increase in production has not coincided with a price-per-bushel decrease, the market demand for oysters appears to be growing. Still, studies investigating the social and economic characteristics of commercial fisheries by interviewing fishermen and fish dealers reveal that 32% of respondents in Core Sound and 38% of respondents from south of Beaufort inlet to the South Carolina line target oysters, but oysters did not make the list of top targeted species amongst respondents from the Albemarle/Pamlico region (Cheuvront 2003, Crosson 2007a,b). In the region south of Beaufort Inlet to the South Carolina line, 12% respondents lost money fishing in 2001 and 19% of those had targeted crabs and/or oysters (Cheuvront 2003). Over the past seven years, no more than 35 people in the state have earned more than $10,000 in annual income from oyster harvesting (NCDMF 2008b). This is a marked change from the late 1800s and early 1900s when the oyster fishery, together with the shad fishery, drove the entire coastal economy in northeastern North Carolina (Taylor 1992).

2.4. Understanding Oyster Population Decline: The Scientific Narrative

The dramatic decline of North Carolina’s oyster populations is mirrored in locations throughout the east coast of the United States (Rothschild et al. 1994, Kirby 2004) and worldwide (Jackson et al. 2001, Lotze et al. 2006). As with other dramatic landscape changes, fisheries data do not address the true historical degradation of oyster reefs because there is no record of the undisturbed, fully functioning oyster reefs that once existed
in our estuaries (Pauly 1995, Jackson 2001). It is believed that oyster reefs were a dominant ecological factor in estuaries because of their large size and wide distribution, and as a consequence of the abundance of suspension feeders (Kirby 2004). How could these dominant ecological factors have been exhausted? As will be discussed at other points in this dissertation, there is some disagreement among stakeholders as to the causes of oyster population decline and the reasons for its continued suppression. Here, I present a narrative of the decline based on a review of the scientific literature.

Declines in the eastern oyster populations along the Atlantic coast of the U.S. were caused mainly by the confluence of overfishing, habitat destruction, and disease (Kennedy 1996). The change from harvesting oysters by hand for local use to using mechanical means to supply oysters for large markets drastically affected the sustainability of oyster reefs and led to the collapse of the fishery (Rothschild et al. 1994, Mann 2000). Mechanical harvesting with a dredge involves the removal and leveling of reef substrate, the substrate upon which young oysters attach and grow, resulting in less settlement and growth area and lower profile habitat for subsequent generations of oysters (Rothschild et al. 1994, Lenihan and Peterson 1998, Breitburg et al. 2000, Lenihan et al. 2001, Lenihan and Peterson 2004). In addition to habitat destruction, overexploitation can result from harvesting that reduces the spawning stock biomass (total weight of oysters that are old enough to spawn) and the lifetime reproductive yield of each oyster. Oyster overexploitation typically results from targeting the largest individuals, which tend to be females, thereby reducing egg production per unit of adult biomass (Rothschild et al. 1994).

After oyster populations had been vastly reduced by habitat destruction and overharvesting, other factors, such as declining water quality, resultant hypoxia and anoxia, and disease outbreaks, contributed to the further collapse of the oyster population and still impede recovery today (Jackson et al. 2001). Declines in estuarine filtration capacity through
the loss of oyster populations may have predisposed the estuaries to turbidity, hypoxia, algal blooms, parasitic diseases, and other degradation (Jackson et al. 2001, Kirby 2004). Runoff from land clearing and agricultural activities had long been entering estuaries, but after oyster populations were diminished, sedimentation, eutrophication, pollution, algal blooms, and hypoxia began to stress the weakened remaining population (Rothschild et al. 1994, Frankenberg 1995, Lenihan and Peterson 1998, Jackson et al. 2001). Modeling work done in the 1980s demonstrated that development, specifically permanent population growth, is positively correlated with closure of shellfish bottom, though the acreage of shellfish bottom does mitigate the impact of development (Tschetter and Maiolo 1984). Oysters could grow to maturity despite current levels of eutrophication and resulting deep water hypoxia/anoxia if they were living on reefs that were tall enough to reach higher up in the water column where they would experience faster water flow, improved delivery of food and oxygen, and less sedimentation (Galstoff 1964, Rothschild et al. 1994, Lenihan et al. 1999, Lenihan et al. 2001). The interaction between two disturbances, leveling of reef profiles by habitat-degrading fishing practices and bottom-water anoxia and sedimentation caused by runoff, dramatically affects oyster populations in areas where they co-occur (Lenihan and Peterson 1998).

The diminished physiological condition of oysters on short reefs leads to greater prevalence and intensity of disease (Lenihan et al. 1999). The first extensive assessment of oyster disease in North Carolina did not occur until 1988, well after the populations had drastically diminished (NCDMF 2008b). This assessment, prompted by large-scale mortalities, found two diseases, Dermo and MSX, but Dermo was much more prevalent and caused more mortality (NCDMF 2008b). Dermo and MSX are caused by waterborne parasites, *Perkinsus marinus* and *Haplosporidium nelsoni* respectively, acquired through feeding (Ford and Tripp 1996). The *H. nelsoni* parasite was most likely introduced to east
coast US oyster populations through human importation of *C. gigas*, an oyster species native to the Pacific Ocean (Burreson et al. 2000). Prevalence of the diseases may have increased at this time because habitat loss and eutrophication had compromised the condition of the oysters rendering them unable to ward off disease or because the large size of the historical oyster reef communities of suspension feeders had limited pathogen populations in the past (Jackson et al. 2001).

Each of the four major factors in the decline of the eastern oyster populations (destructive harvesting practices, overharvesting, water quality, and disease) in isolation would have had a dramatic effect on oyster abundance, but the application of all four factors, and the interrelations among them, proved disastrous.

2.5. History of the Oyster Industry and its Management in North Carolina

2.5.1. From the Beginning until the Boom

Demand for North Carolina oysters and a desire to meet the demand grew in the 1880s and 1890s. Prior to this period oystering was done for local use, and oyster harvest in North Carolina was limited by the inaccessibility of large markets and the abundance of oysters in Chesapeake Bay (Dunbar 1958, Stick 1958, Carter 1991). When landings in Chesapeake Bay declined, landings in North Carolina’s estuaries began to increase dramatically as oystermen from Maryland and Virginia journeyed south to harvest oysters and transport them to northern markets (Kirby 2004). North Carolina oysters sold in the Chesapeake Bay region, chiefly in Baltimore, were marketed as Chesapeake oysters (Grave 1904). Such marketing benefited the coastal region economically in the short-term, but had long-term impacts on the visibility and recognition of North Carolina oysters as their own product and brand that continue today.
As more and more oysters were harvested from North Carolina’s estuaries, tensions rose among stakeholders. Non-resident oystermen used dredges to harvest oysters. An oyster dredge drags a heavy metal bar with teeth and basket behind it over an oyster bed to collect material (Fig. 2.2). At the time, only hand tongs, a pair of rakes that can grab shells attached to the end of two poles, which are connected like a pair of scissors, could be used legally to harvest oysters on public beds in North Carolina (Fig. 2.3) (Stick 1958). This restriction was established in 1822 in the state’s first public law regarding oysters, which also made it unlawful to export large amounts of oysters from the state. This restriction was intended to encourage the establishment of oyster houses with North Carolina to improve local economies (Thorson 1982). However, non-residents were not covered under the law (Thorson 1982).

Figure 2.2. Oyster dredge for harvesting oysters (Source: NOAA National Marine Fisheries Service/Dept. of Commerce)
Figure 2.3. Oyster tongs for harvesting oysters
(Source: NOAA National Marine Fisheries Service/Dept. of Commerce)

Tongs can only be used in relatively shallow water. With dredges, heretofore untapped oyster beds in the deeper parts of Pamlico Sound could be targeted (Dunbar 1958). Divisions arose over what techniques for harvesting these “new” beds should be permissible. Civic leaders and those running the new canneries that had opened in the region favored dredging because it supported progress, industry, and employment while the
local small-scale oystermen saw dredgers as trespassers on tonging grounds they had used for decades (Thorson 1982, Carter 2000).

Laws were eventually passed prohibiting dredging in water less than 8-feet deep, but there was essentially no enforcement (Thorson 1982). The creation of new laws with no enforcement is a recurring theme in the history of oyster regulation in North Carolina. At the close of the 19th Century and beginning of the next, a series of laws with title beginning “An Act for the Protection of Oyster in…” were passed. Despite the goal of protection, as stated in their titles, these laws had no hope of protecting the oyster resources of the state because there was never appropriate funding or infrastructure for enforcement. The Commissions that oversaw the industry were intended to be self-sufficient, funding their activities through the taxes and license fees they raised. However, the laws seemed to hurt more than help the shellfish industry. When they were restrictive, production would drop, canneries would close and there would be fewer license and boat fees paid, meaning little revenue for the Commission to operate on and with which to fund enforcement patrols (Thorson 1982).

Thorson (1982) theorizes that the real reason why tongers wanted dredging outlawed was because dredging harvested so many more oysters more quickly than tonging and took all of the business supplying the canneries. All but three canneries in the state went out of business during the brief period when dredging was excluded from the state. Thorson also believes there was a connection between the dredge regulations and the drop in harvest that occurred during 1894-1896.

Coincident with this rising debate over gear, North Carolina funded a survey to define the public and private oyster bottom in the state and study the potential of the state’s waters for oyster culture. This survey, conducted in 1885, found the oyster industry of North Carolina “insignificant”: with 583,000 acres upon which oysters could probably be successfully cultured in the state, there were only about 8,000 acres of natural beds or less
than 1.5% of the possible bottom in production (Winslow 1889). In addition to the survey and sampling work, Winslow interviewed fishermen who reported better conditions on oyster beds in the past. This was attributed to “unrestricted working” of the beds, and Winslow (1886) cautioned that its continuance would mean that North Carolina’s beds would “share the universal fate” of oyster beds around the world - destruction. Winslow indicated in his report that the laws in place to prevent monopoly over the bottom were too restrictive and were preventing the expansion of the oyster industry. Instead of restricting the fishery, he counseled increasing the supply of beds through cultivation of currently unproductive areas. The creation of the state’s first Shellfish Commission to oversee the industry and other oyster laws enacted in 1887 were responses to Winslow’s report designed to encourage cultivation of private oyster beds by small-scale oystermen (Thorson 1982). With the new laws of 1887, a great many new applications were made for bottom franchises, but most entered into leases for speculative reasons and never actually used them (Thorson 1982). Over the years there would be many attempts to stimulate private cultivation of oysters as a means to promote the economy, but none would ever realize real expansion of private oyster production.

The new laws to prevent non-residents from dredging were not enforced; the efforts by northern harvesters led to a peak in oyster landings in North Carolina in 1890 of an estimated 2,700,000 bushels (Coker 1907). Continued tensions between residents and non-residents led to the creation of a more comprehensive oyster law in 1891. This law created a state residency requirement for oystering, outlawed all dredging on public bottom, established a licensing program for oystermen, and restricted the oystering season to October through May (Thorson 1982). The new restrictions kept harvest levels low for much of the 1890s.
With production low, tongers and dredgers blamed each other for the troubles in the industry. Tongers claimed illegal dredging going on that was compromising the resource, but the problems existed before dredging reappeared. There was actually an increase in tongers, who may have used the beds too heavily because there was money to be made in oystering (Thorson 1982). The number of licensed fishermen nearly doubled from 1887 to 1902. Dredgers may have unjustly been blamed for the oyster population troubles.

Beginning in 1894, believing that the beds had recovered, and hoping to stimulate growth in the industry, North Carolina instituted a series of new laws including a new dredge law allowing state residents to dredge in water greater than 10-feet deep (Thorson 1982, Carter 2000). Laws also created a rotation system in Pamlico Sound by splitting the sound in half and allowing a half to be dredged in alternate years. The oystering season was extended by two months in 1897. The outcome of the eased restrictions was a boom-time for oystering in North Carolina resulting in a second peak in landings listed by Coker (1907) at 2,450,000 bushels in 1898-1899 whereas modern-day statistics maintained by NCDMF show a peak at 806,561 bushels\(^1\) harvested in 1902 (Stick 1958, NCDMF 2008a).

### 2.5.2. After the Boom Through the Mid-Century

High production in North Carolina’s oyster industry did not last long. Harvest dropped quickly after the peak in 1898-1899, continued throughout the 20\(^{th}\) century, and bottomed out in 1994 at 197,904 pounds or 37,000 bushels (NCDMF 2008a). Debate raged over the reasons for the decline, and the state called for numerous studies to examine it. Natural phenomena such as shifting bottom and storms were cited, but much of the subsequent policy was based on overharvest as the cause.

\(^1\) 1.8 million bushels has long been cited as the 1902 catch, but a different conversion rate for bushels is now being employed for older data.
In the early 1900s studies sponsored by the state and subsequent changes in the law attempted to encourage an oyster culturing industry in North Carolina. The initial interest in cultivation sparked by the Winslow Report had waned by this time; there were claims that not a single bed being cultivated or yielding any income could be found in the entire state (Grave 1904). Cultivation of oysters was intended to enrich the individuals involved in it and raise revenue for the state through lease and franchise fees (Coker 1905, Marshall et al. 1999). However, cultivation never resulted in significant oyster production. As early as 1904 North Carolinians were disenchanted with oyster cultivation because it relies heavily on choosing an appropriate setting, requires a great deal of labor, does not realize profits immediately, and is not adequately protected under the law (Grave 1904). The state continued attempts to stimulate a private oyster industry until 1915, by which time it was clear that it would never catch on in North Carolina because of several inadequacies in the program including limited availability of seed oyster resources and inadequacy of legal protections for oyster growers (Pratt 1912, Marshall et al. 1999).

In 1903 the Shellfish Commission was given the power to purchase shells to add to natural oyster beds on public oyster grounds (Thorson 1982). This was the first attempt by the state to enhance production rather than hoping the private sector would do it. Naturally recruiting spat would grow to market-size and could be harvested 18 to 36 months after shell plantings (Munden 1981). In 1918 the state began planting shell on bottom where there were no natural beds in locations that were close enough to existing beds to catch spat (Thorson 1982). About 1.8 million bushels of cultch material and seed oysters were planted between 1915 and 1934, but a lack of continuity in the planting efforts led to limited population enhancement, and landings largely continued to decline during this period (Street et al. 2004). 1923 marked a major expansion in the shell planting program from 100,000 bushels of shell planted in 1921 to over 730,000 in 1923 (Thorson 1982). The Fish
Commissioner attributed the increase in landing in 1923/24 season to the shell planting program, but it was likely due to improved transportation which lead to increased demand, higher bushel prices, and more effort by North Carolina oystermen (Thorson 1982).

In 1915 the Shellfish Commission was combined with the Fish Commission into the Fisheries Commission Board, which had the power to make rules and regulations and had control over all marine resources in North Carolina. The laws promulgated in 1915-1917, specifically the shell planting and cull laws, were considered models of fisheries management legislation by other states (Thorson 1982). Interestingly, Thorson notes that the regulations usually resulted from fishermen agitating for protective laws when they believed that the resources were being overused as opposed to being based on traditional scientific information. A Research and Development section would not be added until 1965 (Thorson 1982). Some considered fishermen’s concerns to really be fears, jealousies, and rivalries. This contradiction is paralleled by another: the state wanted a large fishery industry to create jobs and collect taxes, but made the use of modern equipment, like steam power, which would have made the industry more efficient, illegal. This may have been because fishermen could not afford such equipment and allowing it would have been disadvantageous to them.

Renewal of the oyster canning industry in the state during the early 1940’s may have fostered enhanced interest in oyster management (Marshall et al. 1999). In 1947, this interest turned into an effort to revive the oyster industry when the Oyster Rehabilitation Program was established by the General Assembly as part of the Shellfish Division of the Department of Conservation and Development (Munden 1981). The objectives of the program were to: 1) bring as much shellfish bottomland into production each year as possible while maintaining traditional shellfish grounds in a productive and healthy state; 2) distribute large volumes of shell cultch and seed oysters over public shellfish bottom
annually; and 3) promote the orderly harvest of surpluses in a manner that will result in the greatest economic gains to shellfishermen and be of the greatest overall benefit to the citizens of North Carolina (Munden 1982). The program included a large-scale shell and seed oyster planting effort, a tax on oysters to support the program, a requirement that shucking houses recycle half of their shells back to the program, and a bushel tax on oysters shipped out of state (Marshall et al. 1999). Under this legislation, shells that had been used for lime, chicken feed, and roads were to be used as oyster cultch material (Marshall et al. 1999).

The program’s efforts seemed insufficient from the start: Maryland and Virginia were planting many times more shell and harvesting millions of bushels of oysters (Marshall et al. 1999). In addition to insufficient effort, landings may have been impacted by severe hurricane activity during the early 1950s (Munden 1981, Marshall et al. 1999). In 1954 the General Assembly approved an annual appropriation of $80,000 for the program, an amount that has continued to increase over the years (Munden 1981). Since 1970 the state has relied on cultch planting to maintain the oyster resource for harvest, with only limited transplantation of seed oysters (Marshall et al. 1999). Approximately 15 million bushels of shells were planted from 1915 to 1994 (Street et al. 2004). As supplies of oyster shell were outstripped by demands for cultch material, that state found that limestone marl was a suitable alternative (NCDMF 2008b, Soniat and Burton 2005).

2.6. Implications and Conclusions

Remapping efforts revealed that the oyster beds Winslow mapped in 1886 no longer contain many live oysters because of sedimentation, frequently from dredging and channelization, and related shifts in salinity (Ballance 2005). Early in the history of oyster fishery management, policymakers took a short-term view of the state’s oyster resources
rather than formulating a long-term comprehensive and sustainable strategy for managing oysters and the industry they underwrote. The increasing market value of oysters towards the end of the 1800s led to looser oyster fishery policy resulting in high landings followed by a drastic decline in harvest, which led to stricter regulation of the fishery. Changing the laws and regulations every couple of years demonstrated a lack of vision for the usage and management of the resource. Commissioners knew very little about the oyster resource and limited scientific information about it was available (Thorson 1982). Without a long-term view, policymakers were largely unable to maintain a healthy and sustainable oyster population and were instead forced to respond reactively to changing conditions both in the waterbodies and the surrounding watersheds. The Shellfish Commission (and later the Fisheries Commission) was created to be self-sufficient, operating from the taxes and license fees it collected, but neither ever achieved the kind of success in the oyster industry that was projected. While some of the measures enacted did help the industry, it may have been too difficult to regulate a resource that could be affected by so many variables.

This behavior is representative of the larger history of the rise of the industry in the post-Civil War South. Policymakers viewed resource extraction in the Pamlico Sound as a pathway to economic vitality for coastal North Carolina. Oysters were envisioned in ways akin to cotton and tobacco in the central part of the state: raw materials that could be cultivated for industrial and economic gain (Carter 2000). For a short time oysters did create large gains for out-of-state enterprises that set up operations in coastal towns like Elizabeth City, Washington, and New Bern, but did not do so for the small-scale rural oystermen. State policymakers generally responded to the interests of business rather than engaging oystermen in decision-making.

This pattern of leadership points to a reluctance that policymakers and managers had to take decisive action and offer real leadership on the issue of oyster management.
Instead they seemed to follow the paths of greatest expediency or succumb to political and economic influences. Time and again, the studies undertaken of the oyster resources in the state (e.g. Winslow in 1885, Grave in 1903, Coker in 1905) urged state policymakers to take immediate and decisive action, cautioning that timeliness was critical and opportunities would disappear. The impacts of the failures to heed these warnings live on today, both in terms of sustaining fishery production and conserving oysters for their important roles in the estuarine system. In the next chapter, I explore the shift in oyster management, and natural resource management at large, to address ecological functions and processes within a management regime that had previously maintained a chiefly utilitarian focus. I discuss how a combined ecosystem-based approach to management and process-based approach to ecological restoration, with an explicit cultural analysis component, is critical for successfully stabilizing and enhancing North Carolina’s oyster population.
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3.1. Introduction

As oyster landings in North Carolina have grown since 2001, after reaching all-time lows in the mid-1990s due to the effects of habitat loss and two parasitic diseases, they have done so in a new era in oyster management. In this era, management has a goal of sustaining the ecological roles of oysters and the ecosystem benefits they provide including water filtration, habitat provision, and carbon sequestration, in addition to maintaining high and sustainable production. Despite limited success in achieving these goals and the many sources of uncertainty that remain, management should not abandon the goal of simultaneously achieving sustainability in the harvest production and the habitat. However, management may need to approach the prospect of simultaneous fishery and ecological restoration in alternative ways. One approach in which cultural knowledge and perspectives are considered along with scientific data and models in planning and assessing restoration projects is described below. This chapter also provides a context for understanding the evolution in priorities and players in oyster restoration by examining the shift in the field of natural resource management generally to a more ecosystem-based approach as well as the sharper focus within ecological restoration to a process-based emphasis.

3.2. The Pattern of Historical Oyster Management and Harvest in North Carolina

The increase in market value for oysters at the end of the 1800s led to a loosening of
North Carolina’s oyster harvesting policies that resulted in greater harvest and record landings. The high was followed by a decline in harvest, which led to stricter regulation of the fishery. This pattern of regulating in response to swings in landings as opposed to attempting to forecast sustainable landings was indicative of the emphasis on production and exploitation of natural resources for economic gain at the turn of the century that continued into the post-war period. The term “conservation” had a strictly utilitarian context, referring to efforts to get the greatest production out of resources for human usage and to improve the stature of the state of North Carolina by using tools like engineering, regulation, and enforcement (Kelly and Baskerville 1941). These utilitarian efforts are exemplified in how public bottoms were administered and in the ongoing attempts to launch widespread cultivation of privately held bottom. Oysters were viewed as a tool for cultivating local economic stability and industry (Carter 2000).

The changes in the regulations also reflect a reactionary approach that is epidemic in natural resource management. With limited warning signals of impending crisis, and by ignoring the signals that there were, managers seem to lack the motivation to initiate protective measures such that strong environmental planning and natural resource management measures are more likely to be implemented after damage to or overexploitation of resources has occurred, when there may be little left to protect or manage (Brody 2003). Should resource levels rebound, it may become politically expedient to relax strong regulations. This damage control driven style of management is in stark contrast to an anticipation/prevention mode of management that proactively resolves resource conflicts and anticipates disturbances before they reach the crisis stage (Brody 2003). This pattern has been referred to as the land use management paradox, a label first applied to flood plain land use management. The paradox is that communities do not become concerned with flood plain land use management and do not adopt vigorous
management programs until after problems have arisen due to flood plain invasion. At that point, land use management may no longer be the appropriate approach since to be effective such measures must be implemented well before flood plain development has even begun (Burby and French 1981). The same paradox applies to the historical pattern of oyster management: measures to protect the resource were not implemented until landings had plummeted, and after they were implemented, they were not enforced and then they were relaxed when harvest improved.

3.3. The North Carolina Oyster Fishery in the 1970s and 1980s: Locating Shortcomings

In the midst of the environmental movement of the 1960s and 1970s, North Carolina Division of Marine Fisheries (NCDMF) (Early in this period NCDMF was called the Division of Commercial and Sports Fisheries) began to become more aware of its shortcomings. While the agency assigned a significant role to overfishing in the historical decline of the oyster fishery, it seemed to place some of the blame at its own feet (Godwin et al. 1971). In the early 1970s, the agency claimed that large amounts of research funding and effort had been expended and that there was likely sufficient knowledge available to manage the oyster fishery. Yet, in its report documenting problems, priorities, and research needs for all fisheries (Godwin et al. 1971), NCDMF admits to not making much progress towards solving the problems in the oyster fishery, which they define as one of the most important species in terms of annual commercial landings. The authors cite political, legal, and financial reasons for their failure to translate knowledge into appropriate management action (Godwin et al. 1971).

Ten years later NCDMF recognized the following four factors in the historical decline of oysters in the state: 1) harvesting virgin stocks that took hundreds of years to develop; 2)
poor management and few restrictions on harvest; 3) failure to utilize cultch to replenish beds or create new beds; and 4) a series of hurricanes in the 1950s directly after cultch planting efforts intensified in the late 1940s (Munden 1981). Most of these factors point to a failure to take appropriate management action. At the time, NCDMF viewed the current problems facing the oyster industry to be 1) degradation of water quality, especially freshwater drainage from farming and forestry operations into Pamlico Sound, and 2) a shortage of shell cultch material to meet expanding habitat rehabilitation efforts caused by failure to require oyster shell recycling (Munden 1981). Despite these issues, participation in the fishery and landings increased at the end of the 1970s and through the mid-1980s (NCDMF 2008b). Oysters from expansion of the rehabilitation program in the early 1970s began entering the fishery in the latter part of the same decade, and landings increased each year from 1978 through 1980 (Tschetter and Maiolo 1984). Enhanced participation was accompanied by high expectations in NCDMF reports of how the greater landings would support expanded opportunities in harvesting and shucking/processing industries (Munden 1981). These expectations have yet to be realized.

3.3.1. The Emergence of Disease

Landings continued to expand during the 1970s and 1980s until 1987 when a relative high of 225,000 bushels of oysters were harvested in the state (NCDMF 2008a). This peak in landings was the result of greater participation that year in the dredge oyster fishery in Pamlico Sound. That year, a red tide caused by a dinoflagellate bloom closed over 361,000 acres in the southern estuaries to shellfish harvest from November 1987 to May 1988 (NCDMF 2008b). Oyster harvesters, as well as participants in the mechanical clam harvest, in the affected region shifted their efforts during that winter to dredging for oysters in Pamlico Sound.
With less effort and unexplained mortalities during the following year, landings fell off to 138,000 bushels in 1988 and declined even further over the next six years (NCDMF 2008a). Testing revealed the presence of two parasitic diseases: MSX, caused by the *Haplosporidium nelsoni* parasite, and Dermo, caused by *Perkinsus marinus*. Infection intensities and mortalities remained high through 1992. Infection intensity dropped thereafter, but the prevalence of the parasite remained near 100% through 2006 (NCDMF 2008b). Impacts on the fishery varied by harvest gear, which itself varied with location within the state, leading to an interesting interplay of human and ecological factors. In the southern estuaries, where only hand harvest is allowed, higher salinity and greater flushing combined to promote higher survival rates and more limited declines in landings (NCDMF 2008b). Oysters in this region may also grow faster, reaching harvest-size quickly while minimizing both disease exposure and time for infection to cause mortality (Luckenbach et al. 1999). Mechanical harvest in Pamlico Sound fell off much more significantly. There were no landings by mechanical gear recorded during the winters of 1995/1996 and 1996/1997 due to the combination of Dermo and hurricane damage.

In this climate of disease mortality and greatly impoverished landings, the General Assembly convened the Blue Ribbon Advisory Council on Oysters (BRACO) in 1994 to study and make recommendations concerning the policies and management of the state’s oyster resources. The legislative bill creating BRACO emphasized concerns over production and marketing of oysters (NC S.1403, 1993). In addition to thoroughly examining these issues, the work of the Council brought North Carolina oyster management into a new era. The Council advised that oyster production could no longer be viewed as an oyster fisheries issue. Citing the filtration and habitat providing capacities of oysters, the Council determined that oysters play keystone roles in structuring the estuarine ecosystems of the state and providing goods and services in the coastal zone. The steps to recovery of the oyster are to
be considered representative of the efforts required to achieve ecosystem management in the coastal zone and sustain coastal ecosystem goods and services (Frankenberg 1995).

3.4. Ecosystem-based Management: Sustaining Ecosystem Services

As opposed to considering a single species or sector, ecosystem-based management (EBM) is an integrated approach to management that explicitly considers the interconnectedness of ecosystems, the interactions among ecosystem components, including humans, and the cumulative impacts of multiple activities (Christensen et al. 1996, McLeod et al. 2005, Leslie and McLeod 2007). EBM takes a landscape perspective on resource management. EBM for the oceans and coasts involves applying ecological principles to integrate the management of activities that affect the marine environment (Levin and Lubchenco 2008). Approaches to marine EBM focus on protecting ecosystem structure, function, and process to attain long-term sustainability of marine ecosystem health, production, and resilience, and the human communities that depend upon them (McLeod et al. 2005, Levin and Lubchenco 2008).

The interconnectedness within and among marine and coastal ecosystems created by both the physical and biological processes, including interactions among species, generates ecosystem services (McLeod et al. 2005). Ecosystem services, the conditions and processes of natural ecosystems, sustain and fulfill human life (Daily 1997). In addition to provisioning services, or the production of goods for harvest and trade such as fiber, freshwater, and seafood, ecosystem services encompass a multitude of important functions that benefit human societies that can be categorized as regulating (e.g. water purification, pollination, and climate regulation) cultural (e.g. inspiration, aesthetic values, and recreation), and supporting (soil formation, nutrient cycling, and photosynthesis) services (MEA 2005). There has been growing recognition of the linkages between coastal and
marine ecosystems and the human communities that depend on them for coastal development, tourism, and fishing as well as less noticeable, often undervalued ecosystem services like erosion protection (Leslie and McLeod 2007). The goods and services produced by coastal ecosystems are valued at $400,000 per square kilometer (Pitcher 2001).

Unfortunately, changes in ecosystems have degraded their capacity to provide these services. For ecosystem services to be sustained over time, ecosystems must be resilient. Resilience is the amount of change or disturbance required to change a system to an alternative stable state or different set of mutually reinforcing processes and structures, and it is an emergent property that relates to an ecosystem’s capacity to absorb stress and continue functioning (Levin and Lubchenco 2008). Resistance, recovery, and reversibility are all features of resilience, also referred to as robustness (Palumbi et al. 2008). It is appropriate to ask: Robustness of what? We must identify those aspects of ecosystems that are most important in terms of the values that humans apply to them and the services they provide. Coastal ecosystems can be affected by both direct and indirect impacts of natural and anthropogenic activities, and they can exhibit highly variable and unpredictable environmental conditions over short time scales. Fortunately, this means that coastal ecosystems, including estuaries, may be highly robust (Elliott et al. 2007). Another difficulty for management is that the ecological functions that underlie ecological services can vary in dynamic and non-linear ways or have threshold values, which can complicate defining relationships between functions and services and the process of service valuation (Koch et al. 2009). The challenge for coastal EBM is to consider holistically both the factors that affect the functionality of ecological systems and how to manage those factors in order to sustain service provisioning into the long-term future.
3.4.1. The Role of Ecological Restoration in Managing Ecosystem Services

Unfortunately, management regimes have not adequately sustained coastal and estuarine resources. Estuaries and coasts have undergone fundamental changes in freshwater inputs, pollution, exploitation by nearshore fisheries, and local landscape alterations that have limited their ecological function (Hawkins et al. 1999, Simenstad et al. 2006). Ecological restoration has become an integral component of managing these systems for the production of ecosystem services (Hawkins et al. 1999, Hobbs and Norton 1996, Hobbs and Harris 2001).

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2004). In its purest form, restoration connotes an attempt to recover a system’s normal or perfect condition as it existed in a historic state prior to major human modification. Seemingly in an effort to accommodate the multitude of activities undertaken in its name, the definition of ecological restoration has broadened from this pursuit of historical perfection, and the term is often used interchangeably with terms like recreation and enhancement (Elliott et al. 2007). Together, all of these terms connote a sense of improvement or making something poor, good enough through active intervention. They do not describe a return to a pristine state, which would not be realistic given the context of current land use and legacies of historical change (Hawkins et al. 1999).

Simenstad et al. (2006) considers restoration and rehabilitation two alternative ecosystem phases of ecosystem recovery where restoration requires reactivating ecosystem processes and reintroducing indigenous species while rehabilitation favors one group of species or ecosystem service by modifying management over the short term. The historical fishery-science management approach of managing single stocks as well as societal preferences for certain iconic species have resulted in a large number of rehabilitation
efforts, including much of the efforts on behalf of oysters in North Carolina. Rehabilitation projects remain common even where there is little evidence that the efforts have resulted in measurable improvements. Alternatively, restoration projects seek ecological integrity or the quality of ecosystems resulting from restoration by focusing on restoring processes (Higgs 2003). There is a need to shift away from estuarine restoration as structural interventions and toward efforts to restore hydrologic, geologic, and riparian processes (Palmer 2009). Restoration designs based on structural features are insufficient to restore ecosystem services: how a system looks is not the same as how a system functions (Palmer and Filoso 2009). Like EBM, Process-Based Ecological Restoration (PBER) focuses on interconnectedness: the processes that connect ecosystem functions and services (Bradshaw 1996, Ehrenfeld and Toth 1997). The principles of PBER have been applied to many terrestrial and riverine restoration efforts though challenges remain (Jentsch 2007). PBER has not been applied as widely in fisheries management and restoration (Pikitch et al. 2004).

3.5. EBM and PBER: Applications for Oysters

The widespread oyster mortality in the late 1980s and early 1990s prompted the creation of a Blue Ribbon Advisory Council on Oysters and marked a turning point for the oyster management in North Carolina. While harvests had long been far less than the highs recorded at the end of the 1800s and beginning of the 1900s, the unexpected emergence of widespread disease brought the fishery to its lowest levels ever. Faced with such severe losses, management was ill equipped to make effective decisions. No one had ever seen this before; no one knew what to do.

On the heels of BRACO, which called for ecosystem-based management approaches, the Fisheries Reform Act (FRA) of 1997 mandated the preparation of coastal
habitat protection plans (CHPPs) and coastal fisheries management plans (FMPs). The CHPPs provision seeks long-term enhancement of fisheries associated with coastal habitats by coordinately four rule-making commissions in the state – Marine Fisheries Commission (MFC), Environmental Management Commission (EMC), Coastal Resources Commission (CRC), and Wildlife Resources Commission (WRC) – to identity threats and recommend actions to protect and restore the habitats that are critical to North Carolina’s coastal fishery resources (Street et al. 2004). FMPs must include conservation measures for all commercially and recreationally significant species in North Carolina (NCDMF 2008b). Together, these two provisions of the FRA expand oyster restoration beyond merely oyster fishery stock enhancement.

One goal of the Oyster FMP is to attain sustainable harvest of the native oyster population. The Oyster FMP has a second goal that recognizes the importance of the ecological services provided by oysters: to maximize the oyster’s role in providing ecological benefits to North Carolina’s estuaries (NCDMF 2008b). This reflects a growing motivation to restore oysters for ecological reasons. This motivation is attributable to four reasons: 1) resource-based economics could not just justify the work; 2) aquaculture production was expanding and would take pressure off of wild stocks; 3) a growing recognition of the importance of ecosystem services provided by oysters in estuarine environments; and 4) oyster reefs were an option for required mitigation for shallow water disturbances (Coen and Luckenbach 2000). In North Carolina, reasons #1 and #3 resonated most. The BRACO recommendations and the FRA mandate legislatively underscore that intact oyster reefs perform do matter for the state’s overall estuarine ecosystem function and warrant explicit targeting by restoration efforts.
3.5.1. Challenges for Oyster EBM and PBER

The difficulty with restoring ecosystem services begins with defining specific targets, beyond more biodiversity or more finfish production or improved ecosystem services, and designing metrics for measuring the success of those efforts (Coen and Luckenbach 2000, Bernhardt et al. 2005). Setting oyster restoration goals based on actual ecosystem services would require defining most of the services provided by oyster habitat and summing their values in a common unit (Peterson and Lipcius 2003). This unit is typically dollars. As described in Chapter 2, oysters provide a variety of ecosystem goods and services that benefit North Carolina’s estuaries (Table 1). As with most other habitats and ecosystems, attempts to assess the economic value of the ecosystem services provided by oyster reefs have been limited. By calculating the commercial value of oysters per unit of reef area and comparing that value to estimates of the values of all other ecosystem services provided by oysters, Grabowski and Peterson (2007) reveal that all ecosystem services provided by intact oyster reefs probably far exceed the value derived from harvest. However this comparison is hindered by a lack of quantitative information regarding some of the services. These information gaps also limit the ecosystem-based approach that can be taken to manage these and other coastal resources.

While experimentation and previous restoration efforts have elucidated much about the value of oyster reefs, identification of design criteria integral to ecological function and ecological milestones for oyster reef restoration remains a work-in-progress (Coen and Luckenbach 2000). Breitburg et al. (2000) suggest measuring the ability of a unit area of reef to filter a given volume of water or support a certain biomass of target species as opposed to attempting to define the contribution of a single reef to the percent of the entire water mass filtered each day or biomass of a species in the entire estuary. Successful ecological restoration of habitat and requisite structural relief to counteract sedimentation and bottom-
hypoxia does require a viable, sustained oyster population, but does not require harvestable quantities of market-sized oysters (Coen and Luckenbach 2000, Powers et al. 2009). In North Carolina, where the minimum harvest size is three inches, oyster populations may be reproducing and sustainable without many market-size individuals. Not all of the ecological services of oyster reefs come to fruition only after the populations are long-established or contain harvestable oysters (Luckenbach et al. 2005). Instead, oyster abundance and size/age structure could provide quantitative measures of ecological restoration success (Luckenbach et al. 2005).

3.5.2. Sustaining Oyster Services: Addressing Recruitment and Mortality

The recognition of the importance of the ecological services provided by healthy oyster populations did not fix oyster management or result directly in the application of PBER approaches. To be successful in sustaining those services, oyster restoration must address the processes of recruitment, mortality and shell production, and shell loss (Mann and Powell 2007). Shell loss, other than through removal by harvest, is not well understood or controlled by human intervention; it results from burial, disarticulation, dissolution in sulfide-rich sediments, and activity of shell-boring organisms (Powell et al. 2006). Therefore, restoration efforts must focus on the other two factors: recruitment and mortality and how they maintain and accrete the shell resource.

Oyster population dynamics are tied to shell resource availability: live oysters store shell and provide it through mortality to sustain the habitat (Powell and Klinck 2007). A healthy oyster population requires both a lot of oysters and a lot of oysters that die. Unlike corals, which also make their own substrate, oysters do not protect their substrate, at least partially, with living tissue; thus their own deaths sustain future generations (Powell and Klinck 2007).
To rebuild and stabilize oyster populations, we must insure high enough recruitment, enhanced longevity of recruits, and low natural mortality. Small increases in recruitment rate can produce large changes in oyster abundance and shell resource that can outpace natural mortality or fishing (Powell and Klinck 2007). Enhanced recruitment rates promote the development of a multiple-year class structured population that maintains the availability of substrate because the longer-lived individuals on reefs provide a continual supply of new substrate at their growth edges (Mann and Powell 2007). Oysters are protandrous, beginning life as males and converting to females with age (Thompson et al. 1996). For this reason, and because their smaller size limits the number of gametes produced, younger oysters contribute less than older individuals to subsequent generations. However, large losses of small oysters, for example when young oysters are transplanted to stock other locations, reduce the spawning stock biomass (total weight of oysters that are old enough to spawn) and the lifetime reproductive yield of each oyster (Rothschild et al. 1994).

The age class structure of a population becomes truncated by mortality factors that are affect larger and older individuals more. The oyster disease Dermo has a greater impact on older year classes, and it can destroy a multi-year class population structure (Ford and Tripp 1996). The disease shortens the generation time of the population whereas increased generation time would increase the proportion of females in the population and their lifetime reproductive capacity (Mann and Powell 2007). Re-establishing a multi-year class population structure in an environment with disease through restoration seems predicated on increased disease tolerance. Disease tolerance, through lower infection prevalence and intensity and/or increased survival, among eastern oysters has a genetic component, but selective breeding efforts have thus far achieved limited success with Dermo resistance, although there appear to be some naturally occurring Dermo-resistant stocks (Encomio et al. 2005).
Fishing also preferentially targets larger individuals, but unlike disease, fishing increases the mortality of the population without leaving behind shell. In addition to impacts on abundance, fishing modifies the structure of oyster reefs and reduces the amount of shell available to support the demands of processes that break down shell material after oyster death and other forms of shell loss (Rothschild et al. 1994, Powell and Klinck 2007). The removal of market-size oysters from reefs may remove little superficial shell if the oysters going to market are culled of attached shell “in place” or while the fishing boast is still over the reef, but it does reduce the shell content of reefs because oysters that enter the fishery fail to die naturally and thereby do not add shell to the reef. If the fishing rate is much lower than the natural mortality rate, natural processes will dominate the fate of the shell resource. More typical fishing mortality rates impose a significant cost to the shell budget and enhance ongoing fossilization and depositional processes that are detrimental to oyster bed habitat (Powell and Klinck 2007). A productivity index analysis revealed a 6-year lifetime for reefs with exponentially declining productivity such that there was very limited production during the last 2 years (Dodge 1995).

The removal and leveling of reef substrate by harvest mechanisms results in less habitat and lower profile habitat for subsequent generations of oysters (Rothschild et al. 1994, Breitburg et al. 2000, Lenihan and Peterson 2004). Dredging tends to spread shell material away from reefs across the bottom and to leave behind cracked or broken open oysters, resulting in high incidental oyster mortality (Lenihan and Peterson 2004). When reef habitat is degraded by fishing that reduces reef height, reefs experience lower water flow rates, which results in diminished food delivery, a generally depressed physiological state for oysters, and higher susceptibility to disease (Lenihan et al. 1999). In this way, fishing and disease can act synergistically, combining to result in greater losses for oyster populations. Ultimately, to restore the ecological services we value will require: 1) more widespread
disease tolerance; 2) a multiple year-class structure to buffer recruitment variability; and 3) shell accretion through natural oyster deaths.

3.6. The Difficulty with Achieving Simultaneous Fishery and Ecological Restoration

Simultaneously achieving both fishery and ecological restoration is a challenge. Fishery restoration for oysters is concerned with providing a sustainable economic resource with the understanding that stocks are ephemeral and cannot supply long-term ecological services because they are essentially destroyed upon harvest (Mann and Powell 2007). The goal of ecological restoration for oysters is the provision of ecological services by a self-sustaining population through the re-establishment of a large-scale metapopulation with many sources and sinks (Mann and Powell 2007). In co-occurring fishery and ecological restoration of fishery species like oysters, rehabilitating nature-dominated systems where change is normal is pitted against ensuring reliable services in human-dominated systems where predictability is essential (Weinstein and Reed 2005). Like North Carolina’s Oyster FMP, the Chesapeake Bay Oyster Management Plan also envisions a restored oyster resource that performs important ecological roles and supports an oyster fishery, but it admits that in tandem these two objectives are often in opposition to one another. According to Schulte et al. (2009), who report unprecedented restoration success in the Great Wicomico River of Chesapeake Bay, attempting to restore the wild fishery and native populations in tandem allows destructive harvest practices to devastate the structural integrity of reefs and inhibit recovery.

Reporting the outcomes of restoration efforts in the Great Wicomico River of Chesapeake Bay, Schulte et al (2009) state that attempting to accomplish fishery and ecological restoration simultaneously has resulted in partial fishery recovery via put-and-take fisheries, but not real ecological restoration, as oyster populations remain compromised. The
shell resource is not maximized because it is only maximized when natural mortality is at pre-disease levels and the population is not fished (Powell and Klinck 2007). If disease has increased the natural mortality rate or fishing is permitted, then management must engage in the perpetual addition of shell to compensate for the loss to the shell resource (Powell and Klinck 2007). However, such shell repletion or shell planting programs have been ineffective in restoring habitat because such additions do not permanently increase recruitment (Mann and Powell 2007). Studies in Delaware Bay show that shell planting programs must overcome the relatively short half-lives of shell; shell added to a reef in a given year will is lost in two to ten years (Powell et al. 2006). According to Mann and Powell (2007), shell repletion programs should not have intentions other than maintaining the current extent of the shell resource and should be discontinued if costs cannot be sustained by a tax on the harvested product.

To manage for both fishery and ecological restoration Mann and Powell (2007) recommend: 1) limited fishing (less than 5% of the stock); 2) return the shell removed by the fishery at industry cost via a “shell tax”; and 3) investment in shell maintenance in the form of a tax to offset the effects of disease and encourage recruitment. The first two of these efforts remove fishing as a cause of habitat decline. Other research postulates that improving harvest will require restricting harvesting, at least temporarily. Models of the oyster population in the Maryland portion of the Chesapeake Bay show that, even without augmenting the long-term average recruitment rate, reducing the fishing mortality rate to about 60% of the average rate during the years 1986 through 2001 would result in economically significant short-term losses to the fishery that would be more than compensated in the long-term by sustained high landings (Jordan and Coakley 2004).
3.6.1. Achieving Simultaneous Fishery and Ecological Restoration Through Spatial Segregation

To be compatible, the goals of fishery and ecological restoration may need to be separated spatially by creating unharvested or sanctuary areas. Sanctuaries protect broodstock that can produce larvae that can grow to adulthood in surrounding areas that are open to harvesting (Roberts et al. 2001). The first oyster sanctuary in North Carolina was created in 1996, at the height of the Dermo epidemic for the dredge fishery in Pamlico Sound, in an attempt to manage for the disease. These sanctuaries are no-take, no-disturbance areas: oyster harvesting and use of bottom-disturbing gear for other fisheries are prohibited in order to enhance survivorship of large oysters (NCDMF 2008b). As no harvest zones, sanctuaries protect broodstock. Sanctuary oysters that are able to survive in the presence of disease remain undisturbed and have the opportunity to contribute their disease-resistant genes to subsequent generations. Large oysters are assumed to be disease-resistant, by virtue of the fact that they have survived to grow to their large size, with the potential to contribute such traits to the oyster population beyond the sanctuary borders through the transport and recruitment of larvae. The creation of sanctuaries to provide larvae to other areas open to harvest will require a larger total biomass of oysters to achieve simultaneous phytoplankton removal benefits if harvest protection does result in larger oysters (Fulford et al. 2007). Effective planning of restoration that involves partial harvest protection to provide a steady larval supply has been suggested as an effective strategy to accomplish both restoration objectives.

Designating bottom sanctuaries can remove fishing bottom from other fisheries while higher profile sanctuary reefs may cause navigation hazards and require constant marking (NCDMF 2008b). Despite these constraints, the sanctuary built in 2004 by the Army Corps of Engineers in the Great Wicomico contained high vertical profile reefs at a broad spatial
scale (Schulte et al. 2009). Prior to this project, typical sanctuaries encompassed only 1% or less of an estuary’s original oyster reef extent while this project encompassed 35.2 hectares or about 40% of the original footprint within a hydrodynamically restricted system (Schulte et al. 2009).

3.6.2. Site Selection for Sanctuaries: Assuring Recruitment

Of critical importance in the creation of these refuge areas is site selection: the location and placement of an oyster sanctuaries within the estuarine landscape (Southworth and Mann 1998, Breitburg et al. 2000, Mann and Evans 2004). It is not enough to create sanctuaries; they have to be created in the right locations. Important considerations include historical distribution, bottom conditions, salinity, flushing rate, sedimentation rate, current velocity, sources of pollution, and compatibility of ongoing fishing activities (TNC 2006).

Location affects the ecological benefits a reef can provide. In high-nutrient, high-phytoplankton waters filtration by restored reefs would have a higher impact on water quality (Nelson et al. 2004). Proximity to existing reefs or other structural habitat may promote habitat connectivity and increase the habitat value of restored reefs. Restored reefs isolated from other habitats and habitat corridors may provide greater refuge from mobile predators like blue crabs (Micheli and Peterson 1999). At the local scale, site selection must also consider substrate suitability, which generally favors restoring reefs on the footprints of historical reefs (Southworth and Mann 1998).

Site selection in process-based ecological restoration of oysters requires a landscape perspective of the oyster recruitment processes that underlie oyster population dynamics and population stability. Recruitment is a critical process in restoring exploited subpopulations of oysters to sustainable harvest within the metapopulation structure exhibited by oysters. Failure to site restorations appropriately can lead to recruitment failure.
The most critical aspect of site selection is the availability of recruits in the selected area (Coen and Luckenbach 2000). The ability of larvae to disperse from a broodstock sanctuary, either a man-made or natural concentration of adults, to nearby reefs or move between spatially distinct reefs depends on metapopulation relationships and physical circulation patterns among restored reefs, or restored and existing reefs (Whitlatch and Osman 1999, Breitburg et al. 2000, Peterson and Lipcius 2003).

Like many estuarine and marine species, oysters occupy source and sink habitats, which vary in their level of contributions to population-level dynamics. Modeling studies by Lipcius et al. (2008) of oyster reefs in a portion of the lower Chesapeake Bay have shown that few reefs in the metapopulation are sources, which self-replenish while also contributing larvae to most of the other populations in the metapopulation. These sites would be optimal for restocking broodstock because they will have the greatest impact on the overall metapopulation. Sink reefs, which produce larvae that are transported away from suitable habitat, would not be suitable for broodstock restoration, but enhanced populations at those sites could improve local water quality and enhance habitat for finfish and shellfish. Circulation models can be used to establish networks of reefs such that source reefs are linked to sink reefs through the movement of larvae. The models of the Chesapeake Bay oyster metapopulation showed that a large proportion of the reefs were “putative sources” such that they fluctuated between acting as sources and sinks with changing environmental conditions (Lipcius et al. 2008).

Oysters produce planktonic larvae that are distributed principally by water movements and respond to chemical factors released by adult oysters and biofilms on shell surfaces to settle onto clean hard surfaces, preferably oyster shells or live oysters (Galstoff 1964, Tamburri et al. 1992). Circulation patterns, mixing, and fronts combined with larval behaviors, including sinking and rising in the water column in response to waterborne cues,
make predicting larval transport in estuaries a complex undertaking (Turner et al. 1994, Kennedy 1996). Currents in the Pamlico Sound are predominantly wind-driven. Oyster larvae do not exhibit much horizontal free-swimming ability, and they are expected to follow the direction of winds, which are generally southwestwardly in the summer and fall when larvae are in the water column. However, modeling studies of Chesapeake Bay, in which circulation patterns are primarily driven by river inflow, show that vertical larval swimming behavior had a stronger influence on larval trajectory than inter-annual variability in environmental conditions, including flow and wind (North et al. 2008). In Pamlico Sound, work on the distribution of juvenile blue crabs in the sound revealed behavioral responses to hydrodynamic conditions such that transport of post-larval blue crabs does not simply occur in directions downstream of the prevailing winds (Reyns et al. 2006). The level of complexity of habitat and sub-population connectivity for oysters in the Pamlico estuary is unknown since patterns of oyster larval transport and distribution have not been fully documented. Other oyster larval transport studies in the Chesapeake Bay have shown that areas with low flushing rates, small tidal amplitudes, restricted entrances, or gyre-like circulation pattern tend to retain the larvae produced within them, a pattern that results in more successful oyster restoration efforts (Mann and Evens 1998, Southworth and Mann 1998, Schulte et al. 2009).

3.7. The Role of Social Systems in EBM and Process-based Restoration

The interconnectedness of ecosystems that is the bases of EBM and PBER arises from the heterogeneity that exists at multiple spatial and temporal scales within the systems. A basis in theoretical, conceptual, and empirical ecological knowledge must underlie PBER (Young et al. 2005, Palmer et al. 2006). Restoration efforts benefit from utilizing the results of ecological research regarding community development and structure (Palmer et al. 1997).
Moreover, the connection between theory and restoration is mutually beneficial: Ecological theory is advanced by the large-scale experimentation opportunities offered by restoration projects (Peterson and Lipcius 2003, Palmer et al. 2006).

The context-dependency of EBM and ecological restoration extends not only to geographical and ecological contexts, but to cultural and social contexts as well. Social systems, stakeholder groups, and communities contribute to the interconnectedness that EBM and PBER attempt to address (Leslie and McLeod 2007). Management and restoration as solely scientific endeavors based on biological-physical place and ecological theory risk ignoring the range of social, political, moral, and aesthetic qualities that create places. Places are more than natural or physical entities - they gather things, thoughts, and memories in particular configurations (Esobar 2001). Place exists as a construct defined by social convention and cultural expression (Higgs 2003). The cultural construction of a place describes how people endow it with meaning (Escobar 2001). Culture is collective subjectivity, a worldview, theory, model, or outlook on the world adopted by a community or group in a given place that organizes everyday life, products, values, and ideas and gives meaning to behaviors and practices (Alasuutari 1995). While place encompasses a geographical and physical terrain, it is also a terrain of ideas that have grown up about how to live there (Berg and Dasmann 1977).

Meaningful engagement with stakeholders, which must be recognized as dynamic networks rather than static entities, is critical to creating management and restoration initiatives that are credible, enforceable, and practical (Leslie and McLeod 2007). Because restoration projects exist in a social context, they must produce socially acceptable conditions and provide the ecological services that humans want and need (Hull and Gobster 2000, McLeod et al. 2005). Healthy, intact, and resilient marine ecosystems have a
greater capacity to provide the full range of benefits and services that people say they want (McLeod et al. 2005).

What do people want? What are we restoring to? People often desire what they used to have that is now gone or, if the degradation took place before their lifetimes, something that they feel is more natural. They also want restoration to be permanent. Restoration concepts, goals, and initiatives must be “sold” to the public to establish social and political recruitment or committed citizen support for restoration (Cairns, Jr. 2000, Mann 2000, Baird 2005). The social context for restoration makes a process-based focus more challenging because often the very processes, including annual variations and occasional extreme events, underlying the ecosystem functions and services that society desires are disruptive to human lives and lead to calls for more preventative controls (Simenstad et al. 2006).

3.7.1. Importance of Cultural Perceptions for Restoration Efficacy

Cultural perspectives and attitudes toward resource use, ecological restoration, and conservation in a given place are shaped by the environment and local history of that place. Those perspectives shape individual and community decision-making about how places should look, act, and be managed. The resulting decisions influence local history and forge changes in the environment. Understanding this decision-making process, the factors that are important to people about their environment, how the landscape figures in the social history of a community, how the environment and community have changed, and whether people have a sense of loss attached to any of the changes are essential pieces of information for ecological restoration of landscapes in which humans are a major force (Robertson et al. 2000). Incorporating humans and their effects into ecological systems must move beyond viewing humans as sources of disturbance to embracing the social and cultural aspects of human life and behavior within ecological systems (Dyer 1994,
Durrenberger 1997, Robertson et al. 2000). This requires understanding the place-based knowledge, beliefs, values, and perceptions that local people have about their environment.

Not only do perceptions and knowledge vary from place to place, but so do epistemological frameworks and cognitive processes (Dery and Paolisso 2006, Medin et al. 2006). An epistemological framework describes how knowledge is organized while cognitive processes are ways of knowing or how we know what we know (Paolisso et al. 2006). Knowledge and how we come by that knowledge give meaning to actions (Medin et al. 2006). Meanings are not simply labels for certain objects, but the interpretations of what objects mean and the rules of interpretation form the bases by which people conduct themselves and construe reality (Alasuutari 1995). Reality exits as a product of people’s interpretations and understandings (Alasuutari 1995).

Meanings matter for natural resource management, conservation, and restoration because environmental decision-making is driven by the symbolism people attach to objects or activities and the interpretations they make about their relationship with the rest of nature (Alasuutari 1995, Medin et al. 2006). People cannot absorb all of nature’s complexity, so they construct cultural models to solve problems or interpret situations (Paolisso 2002). Cultural models are widely shared, though not exclusively, by members of a group or society as frameworks for understanding the surrounding world and their behavior in it (Paolisso 2002). While they may remain largely unexamined by those who hold them, by integrating values and beliefs about religion, spirituality, nature, morality, work, independence, and responsibility with experience-based ecological and economic knowledge, cultural models interpret experiences, provide goals for action, and represent deeply held truths (Paolisso 2002, Robbins 2006).

Together, beliefs, knowledge, and meanings can have a powerful effect on the viability of restoration and conservation efforts because they frame perceptions of the
success of such efforts (Nassauer 2004). In the public sphere, often the perception of success can be as important as actual success because actions and practices stem from these perceptions (Medin et al. 2006). If local communities perceive that a restoration project has been successful, residents may take ownership of the site, raise money for additional work, and be more amenable to restoration efforts in general (Purcell et al. 2002). Public interests and success led to greater funding for oyster rehabilitation in North Carolina in 1979 resulting in program expansion for the period 1979 through 1981 (Tschetter and Maiolo 1984). Therefore, it is important to understand the beliefs, attitudes, and other cultural factors that contribute to public perceptions of restoration success, healthy landscapes, and robust resources within human communities that share the landscape with restored ecosystems.

Building citizen support or as Mann (2000) refers to it, social and political recruitment, is a critical challenge for ecological restoration and management. Accomplishing restoration over the necessarily large spatial and long temporal scales requires the support of the human society associated with the ecosystem (Cairns, Jr. 2000). The first step toward social commitment to restoration concepts, goals, and initiatives is to reacquaint local people with the surrounding ecosystems, their ecological functions, and the services they provide (Cairns, Jr. 2000, Baird 2005). While natural systems have intrinsic value that make them worthy of our protection and restoration, increasing local support for restoration may require appealing to self-interest by demonstrating how the ecological services provided by restored systems link restoration and quality of life and carry economic value (Cairns, Jr. 2000).

Attempts to examine how the perceptions and attitudes of local communities and resource users can have a measurable effect on the success of restoration efforts have been limited primarily to terrestrial landscapes. The presence of macrophytes in a restored
urban stream increased the aesthetic value of the stream to visitors and neighbors who believed that biological and water quality conditions in the stream had improved as well (Larned et al. 2006). Participants in a study on perception found riverscapes with wood in the water less aesthetic, more dangerous, and in need of more improvement compared to those without wood (Piegay et al. 2005). Attitudes like these are influenced by the socio-cultural environment in which the participant lives and are not based on ecological benefit or restoration integrity (Nassauer 2004, Piegay et al. 2005). Indeed, pieces of wood in a river or stream provide food and habitat for fish and macroinvertebrates, and wood reestablishment has become a part of restoration efforts. However, wood is perceived as a hazard by the public and regulatory bodies, which often prompts its removal (Piegay et al. 2005). Scientific goals and social perceptions of restoration projects may be disjunct, but both contribute to success or failure of a restoration (Purcell et al. 2002).

The key factor that seems to connect attitude, meaning, and practice in these and other studies is aesthetics. Restored landscapes that are perceived as attractive are more likely to be sustained and protected over time by the surrounding community (Purcell et al. 2002, Nassauer 2004). Support for improved aesthetics is predicated on seeing the restoration sites and the changes to them. How can local communities see restored submerged estuarine habitat? This visibility issue has often been invoked concerning environmental degradation in marine systems. Degradation due to human activity in terrestrial landscapes is visible, but the ocean and estuaries can appear unchanged from the surface despite destruction of habitats and fauna by fishing practices and pollution (Bolster 2006). Even though residents are unable to see restoration efforts that target submerged systems, they may still have perceptions and attitudes towards these efforts and their results. Public perception is a critical aspect of restoration projects because the support and activities of residents can affect the implementation and long-term success of projects.
(Larned et al. 2006). When fishing people and communities are removed from the decision-making processes concerning fisheries, it becomes important to understand how they will receive policies and initiatives because views on policies and decision-makers affect policy compliance. (Tschetter and Maiolo 1984). Residents tend to want meaningful collaboration with experts (Bowcutt 1999). Successful community partnerships and accurate assessments of public opinion are important keys to building support for restoration (Baird 2005).

### 3.7.2. Tools for Incorporating Cultural Context into Restoration Efforts

By showing how people make sense of their lives and surroundings, ethnographic interviewing gives insight into cultural models. Applying a cultural model approach to studying and resolving natural resource management and ecological restoration conflicts is useful because the approach can illustrate unarticulated reasoning that connects statements and positions made by one group in opposition to another group (Paolisso 2002). Such conflicts can be viewed as clashes of competing knowledge systems and cultural constructs (Rikoon 2006). Settlements of conflicts like these are not a measure of whose construct is better, but who is more powerful, often with implications for the protection of local communities, livelihoods, and culture. A cultural model approach helped explain the public image of the Chesapeake Bay watermen as self-interested, greedy, and irrational regarding blue crab conservation by elucidating key relationships among core beliefs in God, nature, science, and regulations (Paolisso 2002). The approach clarified that watermen are resistant to regulations that they view as interfering with God and nature’s production of crabs, but support science and regulations that improve on what nature provides (Paolisso 2002). By focusing on meanings a cultural model contextualizes specific management issues within a holistic framework of cultural beliefs and values.
A shift is necessary such that local knowledge and perspectives are considered along with scientific data and models in restoration projects. Qualitative data from oral histories reveal the norms and values underpinning observable attitudes, behaviors, and practices (Honneland 1999). These data are more than descriptive; they need to be integrated with stakeholders’ economic and ecological understandings of their environment within decision-making processes (Paolisso et al. 2006). Repetition of answers or attitudes across interviews with key narrators indicates shared cultural knowledge and values (Dery and Paolisso 2006). Analyses of patterns of agreement and disagreement on different goals for oyster restoration in Chesapeake Bay and the efforts required to achieve these goals within and across stakeholder groups revealed that specific cultural-environmental beliefs and values could account for why a certain group agreed or disagreed with a particular restoration strategy (Paolisso et al. 2006). For example, watermen disagreed with the idea of a harvest moratorium if data indicated that it would help native oyster restoration due not simply to economic implications, but to the belief that oyster beds must be worked or they will be covered with sediment, and that the oysters will succumb to disease at around market size so not harvesting them would waste natural resources. To avoid tension, restoration strategies must incorporate an understanding of specific cultural views and contexts, *i.e.* understanding why the watermen disagree with harvest moratoriums and how their beliefs about habitat and disease could inform policy.

### 3.8. Conclusion

While North Carolina once boasted an economically important oyster fishery, harvest has fallen off tremendously since a century ago. Harvest took another precipitous drop in the late 1980s into the 1990s as already compromised oyster populations were decimated by disease. As population and landings numbers have rebounded somewhat in the last five
years, they have done so in a new era, an era in which the ecosystem services that oysters provide are valued in addition to their fishery value. The recognition of the importance of these services has not eliminated a desire for a healthy fishery. Instead, oysters now exist in an era of simultaneous fishery restoration and ecological restoration. So far, the challenges of achieving both have only been addressed in limited ways. While there remain a number of critical uncertainties, we should not abandon the goal of simultaneously achieving sustainability in the stock and the habitat. Recognizing the critical ecological roles played by oysters does not diminish the importance of the oyster fishery or the efforts that have been undertaken to sustain the fishery, but it does underscore the fact that an oyster population that supports an industry and the management tools need to sustain it are different from a population that provides ecosystem benefits and its requisite management scenario.

The desire to better sustain ecosystem services has been fueled in part by the expansion in scientific research and interest in the ecological roles oysters play in estuarine systems and by the involvement of environmental non-profit groups in oyster restoration as part of their work to conserve resources at the coast. Management has responded to the emergence of multiple interest groups for oyster restoration by placing some emphasis on making better use of the emerging research and creating partnerships with non-profit groups. Fishery and ecological restoration may not have to be mutually exclusive if the trade-offs between oyster restoration measures for economic and ecological results are considered early in the restoration planning process to reduce potential user-group conflicts.

An important aspect of avoiding stakeholder conflicts is a more thorough understanding of the relevant social and cultural factors that affect support for restoration and management plans, including attitudes and the cultural models that contribute to public perceptions of restoration success, healthy landscapes, sustainability, and robust resources. In addition, resource use must be understood from the resource users’ points of view. This
includes how resources users make sense of their world, their resources, the effects of use on common resources, and to whom or what they specifically attribute resource degradation (Burke 2001). Failure to discreetly consider the cultural and social context of a restoration project leads to underperformance and failure to achieve a project's ecological goals. By better connecting oyster restoration to the place where it is occurring, integration of cultural knowledge with ecological and economic knowledge can improve how oyster restoration proceeds.
References


Mann R. and E.N. Powell. 2007. Why oyster restoration goals in the Chesapeake Bay are not and probably cannot be achieved. Journal of Shellfish Research 26: 905-917.


Abstract

This study explores how stakeholders in the restoration of eastern oysters (Crassostrea virginica) in North Carolina perceive the factors, concerns, problems, and pressures that currently threaten the state’s oyster population. Conflicting perceptions of environmental pressures among stakeholders can arise from differences in knowledge, experiences, familiarity, and economic ties to activities and ecosystems, and lead to adversarial relations among stakeholders. These tensions can impede management processes and diminish the effectiveness of restoration policies. I utilized a participatory mapping methodology to ask stakeholders about their concerns for oyster survival and calculated incidence, severity, and overall importance indices for each concern. Stakeholders mentioned 22 individual concerns and 8 general categories. Across all informants, the most important concern was runoff, followed by disease. Stakeholder group membership did not affect whether informants recognized a concern, but groups did differ in their perceptions of the importance of certain concerns such as harvest issues, including the use of dredges, and natural disturbances. Many in the conservation group describe dredging as destructive and a severe concern, but informants in the fishing and industry groups view dredging as beneficial and integral to continued production on oyster reefs.
Differences in perception of threats and problems are related to differences in knowledge, data collection practices, and, more fundamentally, underlying views of nature and conceptualizations of a relationship with the environment. The study revealed that fishing and industry stakeholders conceptualize a working relationship with nature, which they view as a non-random but unpredictable system in which change occurs at uncertain intervals. Fisheries scientists, those who harvest fisheries resources, and other stakeholders hold different views about the ways in which marine and coastal ecosystems work and therefore have different ideas about how to manage them. All groups agreed that management, restoration, and conservation measures, such as harvest limits, sanctuaries, and shell planting, are critical, yet there were still conflicts over meanings, perspectives on the value of and desire for fish, and means of management. Both scientific research and practical experience knowledge will be required to address differences in perceptions of the pressures on oysters and the oyster industry in North Carolina and improve restoration success.

4.1. Introduction

Burgeoning human populations and attendant land development have drastically altered coastal drainage basins and the structure and function of adjoining estuaries. The results are degraded processes and capacities to support biological diversity and important ecosystem goods and services. Spurred by the recognition of the great value of ecosystem services, there are growing efforts to improve the effectiveness of ecological conservation, management, and restoration programs designed to address biological integrity, ecosystem processes, and production of valued goods and services. Within fisheries management, there has been a shift in emphasis from maximizing exploitation and toward conservation (Mackinson and van der Kooij 2006). This shift has not been a seamless one. Because the
extent and reversibility of human impacts are difficult to quantify and often hard to distinguish from natural changes, the resilience of marine and coastal ecosystems and their fisheries are difficult to forecast, manage, and conserve. Responses to the difficulties inherent in predicting what will happen within complex and dynamic fisheries systems reveal varying views of nature.

In addition to the challenges of forecasting, restoration and conservation programs are hampered by the mismatch between the growing urgency of the efforts and the limited availability of funding for such efforts. This mismatch underscores the importance of high-quality information from a variety of sources to prioritize projects, needs, and issues in order to make the best use of limited resources. Many methods for prioritization have been proposed, including focusing on maximized ecological benefit (Hyman and Leibowitz 2000), expert opinion (Cipollini et al. 2005), proximity to culturally important areas (Marjokorpi and Otsamo 2006), model uncertainty (McDonald-Madden et al. 2008), cost-effective hotspots that provide the greatest benefits to restoration of natural capital (Crossman and Bryan 2009), and minimization of short-term loss of species (Wilson et al. 2009).

Growing interest in restoring North Carolina’s diminished native oyster (*Crassostrea virginica*) populations, both in terms of number of interested parties and overall attention to the issue, has contributed to increased urgency of restoration efforts. The Oyster Fishery Management Program attempts to identify and use the best information to identify, design, and implement management initiatives that have the greatest potential to address the circumstances surrounding the oyster population. There are many types and sources of information and knowledgeable stakeholders, but there also numerous unknowns and uncertainties involved in oyster restoration and management. Beginning with the identification of the problems and threats to oysters that must be reversed or minimized, perception, interpretation, and consensus play important roles in answering the main
question facing this, and any, resource management program: "Precisely what matters?"

We expect that all stakeholders are interested in a larger, sustainable population of oysters. However, there may be less accord on how to achieve this outcome or the prioritization of sustainable oyster harvest compared to sustainable oyster reef habitat.

4.1.1. How We Know What We Know: Perspectives on Nature and Environmental Change

In fishery resource crises, disagreements over what is relevant, whether and how much something is worth knowing, what to make of ambiguous circumstances, and who cares most about what are likely to arise when different stakeholder groups, which produce different kinds of knowledge, are brought together by competing or shared interests (Blair 2009). At the heart of these disagreements is a disagreement over views of nature and how humans should relate to their environment. Perceptions of environmental problems and their solutions are constrained by how we view ourselves in relation to our environments (Cantrill 1996). Different groups conceptualize their relationship to the environment in different ways. At times, these differences, combined with failures in communication among stakeholder groups, have led to erosions of trust, adversarial relations, and tensions, particularly between fisheries management agencies and fishing communities. Adversarial relations can lead to low morale and serious difficulties that can further impede the management process (Kaplan and McCay 2004). Better communication and understanding of the concerns of all stakeholders, especially the people who engage in the activities to be regulated, can improve the effectiveness of and compliance with conservation regulations (Kaplan and McCay 2004).

In a survey conducted by the North Carolina Division of Marine Fisheries (NCDMF), more than half of the surveyed fishermen working in Albemarle and Pamlico Sounds reported at least one conflict with state regulations in the previous year (Crosson 2007).
Fishermen must work within the framework designated by NCDMF and the Marine Fisheries Commission (MFC) to regulate catches and ensure sustainable harvests. A central characteristic of a fisherman’s connection to the environment is that he is engaged in a working relationship with it to utilize the resources it contains (West and Garrity-Blake 2003). Fishermen often equate working the resources with caring for them. Their relationship also has a contesting aspect: fishermen perceive the natural world as resistant to human actions and humans must extract from it the resources they require (Theodossopoulos 1997).

Disparate connections to, and perspectives on, nature inform clashing approaches to what constitutes critical data, how to interpret data, and how to design appropriate management responses (Smith 1990). As a result, different information is attended to and interpreted differently leading to different views on how to make good management decisions. Views on what constitutes good management decisions, along with a conceptualization of a relationship with the environment and a temporal scale orientation, shape a group’s perceptions of nature and environmental change (Blair 2009). Fishermen are oriented to a small temporal scale because catching fish on a given day depends on knowing how conditions have changed from the last time they were on the water in terms of where the fish are located (Blair 2009). For oysters, small-scale temporal changes extend to the weather and currents, which influence the strength and direction of water movement and the ability to keep a boat in one spot in order to harvest the oysters beneath it. In this way, fishermen are concerned with the here and now of environmental change, on a day-to-day time scale, but they frame these small-scale concerns within a long-term view. Fishermen are attuned to a temporal scale of decades and centuries as they must pursue a changing variety of species in response to changes in fish abundance, habitat quality, and price. While fishermen perceive long-term environmental variation as change, it does not represent fundamental world-altering change because, in their view, environmental conditions have
always changed (Blair 2009). Alternatively, fisheries management tends to consider any change a fundamental change.

4.1.2. Perception and Restoration

The ecological pressures and threats that cause environmental change and degradation of marine and coastal ecosystems are real and objective. However, like all risks, they are experienced and assessed subjectively (Peterlin et al. 2005, Doss et al. 2008). As a result, perceptions of threats, problems, or concerns for natural systems can vary within a population. Some people may believe threat A is the main factor, while others may be more concerned by threat B. Both are real and legitimate perspectives. Perceptions of environmental pressures are influenced by connection to the environment, knowledge, familiarity, expected benefit, and economic tie to an activity (Peterlin et al. 2005). Individuals that share general environmental sentiments and perceptions may have different perceptions of specific issues about which they have different knowledge or first-hand experience. Differing perceptions are valid because they reflect a given opportunity for observation and knowledge (Mackinson and van der Kooij 2006).

Perceptions of environmental risks are formed through cultural filters that function largely without our awareness (Lidskog 2000). Different perceptions may reflect different cultural perspectives on the environment, local history, and how a place should look, act, and be managed. These cultural and cognitive factors mediate competition between disparate discourses to define risk (Lidskog 2000). The resulting differences of opinion about risk among stakeholders can erode relationships and lead to confrontation, antagonism, and interpersonal resentment (Mackinson and van der Kooij 2006).

A critical challenge for ecological restoration is resolving this diversity of perspectives and recruiting disparate views into decision-making (Mann 2000). Understanding differences
in perception is important for successful ecological restoration in landscapes in which humans are a major force because perception affects project support and acceptance (Robertson et al. 2000, Elliott et al. 2007). Restoration cannot be accomplished over the necessary spatial and temporal scales without the support of the human society associated with the ecosystem (Cairns, Jr. 2000). While ecological principles and theories are appropriately invoked when articulating restoration goals, defining goals and objectives for a restoration project is also a value-based undertaking (Davis and Slobodkin 2004). McManus (2006) instructs restoration practitioners and resource managers to appreciate the necessary role of science in restoration and ensure that it articulates with individual and community values and visions of the landscape. This articulation is important when setting goals for restoration, but also for identifying the factors that have led to the need for restoration and risks that may continue to endanger sustainability. Restoration efforts that proceed without identifying and attempting to ameliorate the processes causing degradation may be doomed because these processes can continue to operate unchecked against the restoration (Hobbs and Norton 1996).

In North Carolina’s estuarine landscape, management and restoration efforts for oysters are ongoing, but how do different stakeholders perceive the vulnerabilities of oysters? The Blue Ribbon Advisory Council on Oysters (BRACO), convened by the North Carolina General Assembly in the mid-1990’s, found no single explanation for the loss of oysters from the state’s waters, but went on to list multiple contributors to the oyster population’s historical and ongoing decline including 1) not replacing oyster habitat destroyed by harvest, 2) not developing oyster mariculture, 3) coastal land development that reduces water quality in oyster growing areas, and 4) declining markets, 5) disease, 6) failure to preserve habitat, 7) overharvest, and 8) deteriorating water quality (Frankenberg 1995). Each of these inter-related problems are comprised of an entire set of contributing
factors and complexities. Today, fifteen years after the BRACO report, oysters are still designated a “species of concern” by NCDMF, meaning they are perceived to be vulnerable to overharvest due to several factors affecting their survival including disease, habitat degradation, and harvest pressure (NCDMF 2008).

In this chapter, I describe how stakeholders in oyster restoration in North Carolina perceive the factors and changes that currently threaten oyster abundance. While an informant may have objective information about the status of oysters through familiarity with landings or other data, the assessments that s/he gives are also based on their subjective perceptions of the overall situation. One way to measure subjective perceptions is to utilize participatory methods that ask people to list their different concerns about oyster survival. Such a list gives an ordinal measure of importance that is useful in prioritizing allocation of limited resources. Using data collected through a series of interviews, I show how perception of threats to oysters is often based not only on objective data, but subjective assessments of information and views of nature. I am interested in determining whether perceptions vary across stakeholder groups. I hypothesize that due to different knowledge, experiences, stakes, and relationships to the environment, different stakeholder groups identify different factors of concern as the most threatening to oysters and efforts to restore them.

4.2. Methods

4.2.1. Concern Mapping

In order to describe the potential variation across stakeholder groups in perception of the factors that threaten oyster survival in North Carolina, I relied on a participatory research method to describe the variation in risks, worries, or concerns experienced subjectively across a heterogeneous population (Smith et al. 2000). This mapping methodology is a two-part system for ordinal ranking. In the first step, an informant identifies factors of concern,
and then in the second step s/he ranks the factors s/he has identified. When repeated across informants, the listing frequency and ranking data provide estimates of the threat incidence and severity in the study population. Asking open-ended questions for the identification step removes researcher influence over which factors are cited, how many factors are cited, and in what order factors are mentioned. This allows participants to decide what are the factors rather than be told by being presented with a list that is potentially biased by being assembled by the researchers.

To express the subjective importance of each concern, I employ two indices. The incidence index, $I$, is the proportion of informants who identify a given concern or factor. $I$ ranges from zero (no informants) to one (all informants). This index describes how widespread a concern is within each stakeholder group and across the entire informant pool.

The second index, the severity index, $S$, assesses the severity of a concern or factor on a scale of one (the most serious) to two (the least serious). As severity increases, the index decreases to one. Since different informants identify different numbers of factors, the resulting data are ordinal and have different dimensionality. This index requires converting ordinal data into a quasi-cardinal form. For each informant, the factor s/he declares to be the most severe retains the number one ranking and all other factors have their integer-valued, ordinal ranking converted to the index scale. For a factor of rank $r$ among a group of $n$ factors identified by informant $j$ the severity index $S_j$ is: $S_j = 1 + (r-1)/(n-1)$. The overall severity index, $S'$, for a given factor is calculated as the mean of the severity indices for that factor from the subset of informants identifying the factor.

The two indices can be combined to generate an overall importance or concern index, $C$, where $C = I / S'$. $C$ increases as the incidence and severity of the concern increase. In addition, the indices can be expressed graphically as a “map” with incidence or $I$
on the x-axis, ranging from 0 (none) to 1 (all), and severity or $S$ on the y-axis, ranging from 1 (most important) to 2 (least important) (see Fig. 4.1). The lower right quadrant of the resulting graph contains factors that are considered highly important by a large proportion of the informants. The lower left quadrant contains factors that are considered highly important but only by a small proportion of informants. The upper right quadrant indicates minimally important factors identified by a large proportion of informants. The upper left quadrant contains factors that are considered minimally important, each one by only by a small proportion of informants.

**Figure 4.1.** Sample concern map
The incidence ($I$) and severity ($S$) indices for all factors are plotted with $I$ on the x-axis, ranging from 0 (mentioned by no informants) to 1 (mentioned by all informants), and $S$ on the y-axis, ranging from 1 (most important) to 2 (least important). In the resulting “map”, the lower right quadrant of the resulting graph contains factors that are considered highly important by a large proportion of the informants. The lower left quadrant contains factors that are considered highly important but only by a small proportion of informants. The upper right quadrant indicates minimally important factors identified by a large proportion of informants. The upper left quadrant contains factors that are considered minimally important, each one by only by a small proportion of informants.
4.2.2. Data Collection

Use of the mapping technique was embedded within a semi-structured interview comprised of open-ended questions conducted with each informant. The results and analyses of these interviews, along with a detailed description of the methodology, are discussed in Chapter V. Interview questions covered an array of topics including the oyster fishery, fisheries management, restoration, conservation, stakeholder relations, and personal and work history. Throughout the discussion of the interviews, I refer to the research participants as informants instead of respondents as a signal that I consider them sources of information and in recognition of the structure of the interview. Informants were classified into one of six stakeholder groups: 1) fisheries resource management (Marine Fisheries Commissioners, NCDMF staff). 2) fishing (fishermen who oyster), 3) industry (fish dealers/shellfish processors), 4) aquaculture (shellfish growers), 5) science (researchers at university and government labs), and 6) conservation (staff at nonprofit environmental organizations). I define stakeholders as individuals or groups for whom oyster restoration matters. It may matter for economic, historical (personal, family, or local heritage), and/or ecological reasons.

While answering questions early in the interview, most informants would mention or discuss their concerns regarding the health of the oyster population without being solicited directly. Often, I would reference these statements when introducing the first step of mapping method, saying something akin to, “Well, we’ve talked some about this already, but I would like to revisit it more directly.” Informants were then specifically asked to list all of the factors they could think of that threaten oyster survival. I recorded each concern on a separate index card. When the informant indicated that s/he had completed her/his list, I handed her/him the set of cards asking her/him to review them, make any necessary
additions, and then rank the factors by putting the cards in order from the most important to
the least. Factors that were considered equally important were assigned the same rank and
subsequent factors picked up the numbering sequence. For example, in a list of five factors
in which two factors tied for second, the ranking would appear as 1, 2, 2, 4, 5.

4.2.3. Statistical Analysis

Incidence data were analyzed using Fisher's exact test to determine whether
different stakeholder groups recognize different concerns. This test is useful for the analysis
of contingency tables with categorical data where sample size is small. When sample sizes
are small, such that the expected values in any of the cells of a contingency table are below
5, the Fisher's exact test is favored over the Chi-square test (Bernard 2000). I tested
whether treatment (in this case, stakeholder group membership) affects outcome (here,
concerns recognized). Analyses were performed in STATA/SE 11.

I used a respondent-referral method to identify informants based on my own
knowledge of the stakeholder landscape and recommendations from other sources and
individuals both within and outside of the growing study sample. (For more details see the
Methods section of Chapter 5.) For many studies, purposive or chain referral sampling
designs such as this one can produce results of questionable representativeness that make
it difficult to determine how the study sample compares to the larger population. However,
this design is useful when the target group for the study is limited to a small subgroup of the
population such that the sample includes a large or important fraction of that limited group.
This was appropriate for the present case, in which the groups were fairly circumscribed and
the number of important individuals in each relatively limited. Instead of making an inference
about an unknown relationship in the population, the test measures whether the perceived
relationship between stakeholder group affiliation and concerns mentioned is due to chance.
This is fairly common usage for nonrandom samples. While the results of the test do not allow me to generalize to all individuals in the stakeholder group under consideration, they will be quite informative.

4.3. Results

I conducted 32 interviews between August 2008 and November 2009 with stakeholders in the oyster fishery and oyster restoration throughout the North Carolina coastal region. 28 interviews were included in the mapping analysis. Two interviews were excluded because the informants could not be ascribed to one of the stakeholder categories, and as such, their responses could not appropriately be added to a group for analysis. In another case, the informant did not seem to comprehend this line of questioning on account of partial hearing loss. The fourth informant excluded himself from the analysis by declining to answer the ranking question. Informants were distributed across groups as follows: fisheries resource management: 5; fishing: 5; industry: 5; aquaculture: 4; science: 3; conservation: 6.

Informants listed 22 concerns regarding oysters, which could be grouped into eight categories: disease, water quality, habitat, harvest/gear, natural/large scale changes, development, human attitudes, and management (Table 4.1). Table 4.1 describes each of the 22 concerns. There is no significant difference among groups in whether the informants recognize the eight concern categories (Table 4.2, Fisher’s exact $p = 0.458$, $\alpha = 0.05$). There is a nearly 50% chance, given the sample size and distribution of the observed table, of getting the same table by chance. Stakeholder group membership does not affect whether informants recognize a concern.
<table>
<thead>
<tr>
<th>Category</th>
<th>Concern</th>
<th>Description</th>
<th>Includes (Things Informants Mentioned)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>Disease</td>
<td>Oyster diseases</td>
<td>Dermo, MSX</td>
</tr>
<tr>
<td>Development</td>
<td>Coastal development</td>
<td>Increasing growth, construction and infrastructure in watersheds draining to estuaries;</td>
<td>Loss of riparian habitat, boat wakes, harbors/marinas</td>
</tr>
<tr>
<td>Habitat</td>
<td>Habitat destruction</td>
<td>Active habitat loss or damage</td>
<td>Insufficient habitat</td>
</tr>
<tr>
<td></td>
<td>Limited substrate</td>
<td>Not enough appropriate natural bottom or cultch material for oyster recruitment</td>
<td></td>
</tr>
<tr>
<td>Siltation</td>
<td></td>
<td>Sediment preventing oyster larval settlement</td>
<td>Sedimentation</td>
</tr>
<tr>
<td>Harvest/Gear</td>
<td>Overharvest</td>
<td>Removal of too many oysters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harvest pressure</td>
<td>High number of oyster harvesters</td>
<td>Maximized harvest, more people harvesting</td>
</tr>
<tr>
<td></td>
<td>Dredging</td>
<td>Destruction by dredge gear</td>
<td>Mechanical harvest</td>
</tr>
<tr>
<td></td>
<td>Tonging</td>
<td>Destruction by tongs/other hand gear</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fishing practices</td>
<td>Destruction by habits of some fishermen</td>
<td>Illegal dredging and other activities, staying too long, following others onto harvest sites</td>
</tr>
<tr>
<td>Human Attitudes</td>
<td>Lack of concern</td>
<td>Not a public priority</td>
<td>Education of the public, lack of understanding, lack of political buy-in, viewed as cheap</td>
</tr>
<tr>
<td></td>
<td>Inadequate funding</td>
<td>Limited funding for restoration/conservation</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Concern</td>
<td>Description</td>
<td>Includes (Things Informants Mentioned)</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>Disconnect between land use and estuarine conditions</td>
<td>Separation of activities in terrestrial systems from conditions in aquatic systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisheries conflicts</td>
<td>Indirect effects of other fisheries</td>
<td></td>
<td>Gears, bottom uses</td>
</tr>
<tr>
<td>Management</td>
<td>Management</td>
<td>Negative view of management decisions; Inadequate management resources</td>
<td>Insufficient enforcement</td>
</tr>
<tr>
<td>Natural/Large Scale Changes</td>
<td>Natural disturbance</td>
<td>Beyond human control or prediction</td>
<td>Weather, hurricanes, storms, inlet formation, Mother Nature, shifts in salinity, drought</td>
</tr>
<tr>
<td>Ecosystem change</td>
<td>Changes in food sources, predator releases</td>
<td></td>
<td>Cownose rays</td>
</tr>
<tr>
<td>Climate change</td>
<td>Changes in water temperature, acidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural predators</td>
<td>Predation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td>Runoff</td>
<td>Non-point source pollution from land-based sources;</td>
<td>Eutrophication, bad water, agricultural practices, stormwater</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Point sources, chemicals</td>
<td>Industrial sources, septic seepage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impacts from low oxygen and algal deposition on oyster reefs</td>
<td>Red tide</td>
</tr>
</tbody>
</table>
Table 4.2. Total counts of concerns mentioned by informants.

Numbers in each column are the number of times a concern in that category was mentioned by members of the six stakeholder groups. When an individual informant mentioned more than one concern from the same category, each concern was counted. As such there can be more mentions in a category for a stakeholder group than there are members of the group. Fisher’s exact $p = 0.458$, $\alpha = 0.05$.

<table>
<thead>
<tr>
<th>Category</th>
<th>Management</th>
<th>Fishing</th>
<th>Industry</th>
<th>Aquaculture</th>
<th>Science</th>
<th>Conserva_tion</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Quality</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>29</td>
</tr>
<tr>
<td>Disease</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Harvest/Gear</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>Habitat</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Natural/Large Scale Changes</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Development</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Attitudes</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Management</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>16</td>
<td>19</td>
<td>17</td>
<td>9</td>
<td>40</td>
<td>129</td>
</tr>
</tbody>
</table>
Table 4.3 lists the 22 concerns in ranked order by overall importance index, $C$, where $C = I / S'$, for all informants. When asked to rank their concerns, the most important concerns ($C$) out of the 22 types mentioned are: 1) runoff (0.510), 2) disease (0.467), 3) natural disturbance (0.248), 4) limited substrate (0.219), 5) overharvest (0.213) (Table 4.3). The most frequently identified concern is oyster disease, listed by more than 70% of informants (Fig. 4.2). However, on average, informants rank disease lower in severity compared to runoff, the second most frequently mentioned concern, listed by 64% of informants. Runoff and disease are the only two factors that concern more than half of the informants.

In general, severity increases with incidence though there are several notable exceptions including disease, overharvest, and dredging (Fig. 4.2). Disconnect between land use and conditions in the estuary was mentioned by a small number of informants, but they felt this disassociation between what happens on land and conditions in neighboring waterbodies, was widespread in the general public and a critical factor in the imperilment of oysters. These informants were classified in the conservation stakeholder group. The large number of concerns plotted in the upper left quadrant of Figure 4.2, factors with both low incidence and severity, illustrates that many factors are of concern to only a few informants who consider them of limited severity.

The top concern for five of the six groups was runoff or disease (Table 4.4). The fisheries resource management (after: management), industry, and conservation groups consider runoff to be the most important factor (highest $C$) whereas disease has the highest importance index for the aquaculture and science groups. Natural disturbance ranks as the most important factor for the fishing group.

A breakdown of the overall top five concerns by stakeholder group shows some differentiation in perceptions of the importance of these factors to oyster survival in North
Table 4.3. Subjective concern index.
Factors are listed in ranked order from the most concerning to least concerning across all informants (overall). The index ranges from 0 (not a concern at all) to 1 (most important concern).

<table>
<thead>
<tr>
<th>Concern</th>
<th>Overall</th>
<th>Management</th>
<th>Fishing</th>
<th>Industry</th>
<th>Aquaculture</th>
<th>Science</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff</td>
<td>0.510</td>
<td>0.809</td>
<td>0.267</td>
<td>0.727</td>
<td>0.353</td>
<td>0.333</td>
<td>0.506</td>
</tr>
<tr>
<td>Disease</td>
<td>0.467</td>
<td>0.669</td>
<td>0.413</td>
<td>0.125</td>
<td>0.529</td>
<td>0.857</td>
<td>0.444</td>
</tr>
<tr>
<td>Natural disturbance</td>
<td>0.248</td>
<td>0.355</td>
<td>0.45</td>
<td>0.343</td>
<td>0.333</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Limited substrate</td>
<td>0.219</td>
<td>0.267</td>
<td>0</td>
<td>0.24</td>
<td>0.167</td>
<td>0</td>
<td>0.343</td>
</tr>
<tr>
<td>Overharvest</td>
<td>0.213</td>
<td>0.229</td>
<td>0</td>
<td>0</td>
<td>0.15</td>
<td>0.356</td>
<td>0.454</td>
</tr>
<tr>
<td>Pollutants</td>
<td>0.181</td>
<td>0.2</td>
<td>0.133</td>
<td>0.267</td>
<td>0.25</td>
<td>0</td>
<td>0.213</td>
</tr>
<tr>
<td>Harvest pressure</td>
<td>0.174</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.25</td>
<td>0</td>
<td>0.296</td>
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<tr>
<td>Coastal development</td>
<td>0.157</td>
<td>0.24</td>
<td>0.1</td>
<td>0.279</td>
<td>0.2</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Siltation</td>
<td>0.154</td>
<td>0.249</td>
<td>0.2</td>
<td>0.111</td>
<td>0.25</td>
<td>0</td>
<td>0.125</td>
</tr>
<tr>
<td>Habitat destruction</td>
<td>0.140</td>
<td>0.305</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.485</td>
<td>0.167</td>
</tr>
<tr>
<td>Disconnect between land use and estuarine conditions</td>
<td>0.095</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.444</td>
</tr>
<tr>
<td>Lack of concern</td>
<td>0.093</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.143</td>
<td>0</td>
<td>0.339</td>
</tr>
<tr>
<td>Dredging</td>
<td>0.085</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.396</td>
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<tr>
<td>Algal blooms</td>
<td>0.065</td>
<td>0</td>
<td>0</td>
<td>0.12</td>
<td>0.2</td>
<td>0</td>
<td>0.083</td>
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<tr>
<td>Natural predators</td>
<td>0.055</td>
<td>0.207</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Management</td>
<td>0.052</td>
<td>0</td>
<td>0.16</td>
<td>0.133</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inadequate funding</td>
<td>0.048</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.222</td>
</tr>
<tr>
<td>Climate change</td>
<td>0.044</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.205</td>
</tr>
<tr>
<td>Fishing practices</td>
<td>0.041</td>
<td>0</td>
<td>0.133</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ecosystem change</td>
<td>0.041</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.167</td>
<td>0.111</td>
</tr>
<tr>
<td>Fisheries conflicts</td>
<td>0.038</td>
<td>0.114</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.083</td>
</tr>
<tr>
<td>Tonging</td>
<td>0.019</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.091</td>
</tr>
</tbody>
</table>
Figure 4.2. Concern map overview.
The severity index ranges from 1 (most severe) to 2 (least severe), and the incidence index ranges from 0 (not mentioned at all) to 1 (mentioned by all informants).
Table 4.4. Concerns of each of the six stakeholder groups from most (highest C or importance index) to least (lowest C) important.

<table>
<thead>
<tr>
<th>Management</th>
<th>Fishing</th>
<th>Industry</th>
<th>Aquaculture</th>
<th>Science</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>runoff</td>
<td>natural disturbance</td>
<td>runoff</td>
<td>disease</td>
<td>disease</td>
<td>runoff</td>
</tr>
<tr>
<td>disease</td>
<td>disease</td>
<td>natural disturbance</td>
<td>runoff</td>
<td>habitat destruction</td>
<td>overharvest</td>
</tr>
<tr>
<td>natural disturbance</td>
<td>runoff</td>
<td>coastal development</td>
<td>natural disturbance</td>
<td>overharvest</td>
<td>disease</td>
</tr>
<tr>
<td>habitat destruction</td>
<td>harvest pressure</td>
<td>pollutants</td>
<td>harvest pressure</td>
<td>runoff</td>
<td>disconnect between land use and estuarine conditions</td>
</tr>
<tr>
<td>limited substrate</td>
<td>siltation</td>
<td>limited substrate</td>
<td>siltation</td>
<td>ecosystem changes</td>
<td>dredging</td>
</tr>
<tr>
<td>siltation</td>
<td>management</td>
<td>management</td>
<td>pollutants</td>
<td>limited substrate</td>
<td></td>
</tr>
<tr>
<td>coastal development</td>
<td>pollutants</td>
<td>disease</td>
<td>coastal development</td>
<td>lack of concern</td>
<td></td>
</tr>
<tr>
<td>overharvest</td>
<td>fishing practices</td>
<td>algal blooms</td>
<td>algal blooms</td>
<td>harvest pressure</td>
<td></td>
</tr>
<tr>
<td>natural predators</td>
<td>coastal development</td>
<td>siltation</td>
<td>limited substrate</td>
<td>inadequate funding</td>
<td></td>
</tr>
<tr>
<td>harvest pressure</td>
<td>harvest pressure</td>
<td>overharvest</td>
<td>pollutants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pollutants</td>
<td>fishing practices</td>
<td>lack of concern</td>
<td>climate change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fisheries conflicts</td>
<td>natural predators</td>
<td>habitat destruction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Runoff
- Natural disturbance
- Disease
- Habitat destruction
- Overharvest
- Limited substrate
- Siltation
- Management
- Pollutants
- Coastal development
- Lack of concern
- Fishing practices
- Algal blooms
- Natural predators
- Inadequate funding
- Harvest pressure
- Siltation
- Ecosystem changes
- Coastal development
- Tonging
- Fisheries conflicts
- Algal blooms
Carolina. Runoff was highly important to the management and industry groups, but less so to the fishing group (Fig. 4.3). The science and conservation groups are not at all concerned about natural disturbance whereas the fishing and industry groups are not at all concerned about overharvest (Fig. 4.3).

All members of the management group are concerned about runoff and disease (Fig. 4.4a). The next most mentioned concern in this group is natural disturbance (60%). All concerns regarding habitat had medium incidence and severity. Few in the management group mentioned harvest pressure and pollutants, but those that did ranked them as highly severe.

Natural disturbance is the concern of greatest overall importance for the fishing group. The majority of fishermen mentioned disease, but considered it of low severity (Fig. 4.4b). Limited substrate, siltation, and harvest pressure were considered highly severe, but only by a few members of the group. Management was also considered quite a severe concern by a few members of the group. Fish dealers and other stakeholders in the industry group are also not highly concerned by disease. Most concerns for this group are considered low incidence-low severity (Fig. 4.4c) Runoff is considered highly severe by the majority of this group. Fewer mentioned natural disturbance, but consider it a highly severe concern.

The aquaculture group most frequently mentioned disease, water quality and natural disturbance (Fig. 4.4d). While disease was mentioned most frequently, the group considered it of equal severity with runoff. Siltation and harvest pressure were mentioned infrequently, but considered highly severe.

The science group mentioned the fewest concerns (5) (Fig. 4.4e). All members of the group listed disease as highly severe. The only concern considered more severe is runoff, but it was not mentioned frequently. Natural disturbance, considered most important (C) by
Figure 4.3. Concern indices \((C, \text{ where } C = I/S)\) for the top five overall factors by stakeholder group.
**Figure 4.4.** Concern maps by stakeholder group.
The groups are: a) fisheries resource management; b) fishing; c) industry; d) aquaculture; e) science; f) conservation. The severity index ranges from 1 (most severe) to 2 (least severe), and the incidence index ranges from 0 (not mentioned at all) to 1 (mentioned by all informants).
the fishing group, was not mentioned by the science group or the conservation group. The conservation group listed the most concerns (18) (Fig. 4.4f). This is the only group in which more than half mentioned harvest and attitude concerns and considered them of moderate to high severity. Runoff is the most important concern for the conservation group.

4.4. Discussion

Stakeholders in oyster restoration in North Carolina recognize 22 concerns. Informants across stakeholder groups share several concerns for North Carolina’s oyster populations. Runoff and disease are cited by more than half of all informants and considered very severe problems. Other concerns, such as natural disturbance and harvest gear, are considered highly important by only one stakeholder group.

4.4.1. Views of Oyster Population Status: “There were oysters out there.”

Perceptions of risks or threats to a population can be influenced by a perception of the tenuousness of the population’s circumstances. While there are important differences between declining and small populations, both of these tend to be at greater risk of extinction caused by disturbances than large or growing populations (Caughley 1994). A discussion of perception of risk is predicated on perception of loss or change: do concerns vary with perception of the number of oysters out there? Most stakeholders across the spectrum are in agreement that there are more oysters today than in the recent past though none could say how many more or estimate the current overall population. Fishermen describe plentiful oysters.

“But we’re liable to catch, most of the time, fifteen bushels a day with a mechanical harvesting rig, which is pretty good. It gives people a chance to make a living and it conserves the resource at the same time. Oysters seem to be fairly plentiful.”

-- Fisherman
“Well, there’s plenty of oysters, even as we speak. The sound is full of oysters. We
had places that’s been dead for twenty years, oyster places - just weren't any oysters
- has all come back alive. Everything that's ever been around with a shell has come
back alive. ... The water's got salty, and there's oysters everywhere. And on the
outside, right out here on the outside there, there’s oodles of oysters. There's just
loads of oysters, right now, as we’re speaking onto it. ... And the water is so salty that
you can throw anything overboard - a rock, an old beer can, or whatever - and an
oyster will go on it, and in a year it'll be three inches long. They're growing so fast
until they're "tonguey" and they're thin-shelled, every place we put. And it's just
unbelievable.” -- Fisherman

“There's oysters that are out there, ... In other words, it wouldn't be nothing for me to
catch forty or fifty bushels a day. ... And I wouldn't have to work no more than a
regular day, six or seven hours. ... As long as they're growing like they've been
growing the last couple of years, they're getting built up, they're getting thicker.”
-- Fisherman

Research scientists offer diverse assessments of current numbers. Some describe
loss, others recovery, and some point to related changes in the population.

“So ... in the Pamlico Sound, lower Albemarle Sound, Neuse and Pamlico Rivers,
significant loss of populations; with that, significant loss of fishery. Somewhat lesser
loss in the intertidal populations to the south. But there, of course, the fishery has
declined because of water quality. So, the oyster populations are not as reduced, but
the fishery is reduced because of other issues.” -- Scientist

“And there appears to be - you know, the few that are commercially mechanically
harvesting oysters this year are getting their limit before the end of the day. You
know, they're getting their fifteen bushels, you know, by lunchtime or the afternoon.
They'll be back to the dock. So, the catches are there. You know, is it sustainable?
Will they be there next year, you know, as effort increases? You know, all of this kind
of stuff. But the good news is that oyster reefs are recovering.” -- Scientist

“So, my feeling is that the chronic pressures that we have exerted on the oysters may
be leading to this sort of perception that the oysters are dying and not there. But you
go out there, and in many places there are lots and lots of oysters, lots and lots and
lots and lots of oysters. They're all really small.” -- Scientist

Stakeholders who work in conservation seem to straddle the divide between
scientists and fishermen. Many conservation organizations in North Carolina largely do not
get involved in fishery policy. Instead, they work in partnership with researchers, fisheries
management, and fishermen alike and do not view commercial fishing as a negative factor.
The perspectives of many of these practitioners many not be typical of those working
elsewhere.
“I mean, we hear different facts, like our oyster harvests are down 90 percent. Estimates are that the oyster population is about 50 percent of its historical high. So, you know, if I just were to take a snapshot today and look at the oyster population, I would say it's struggling pretty strongly at this point, but that there's enough of an intact oyster population for us to be able to restore it. ... We've got a lot of intact oyster population, but it's struggling.” -- Conservation practitioner

“I mean, population-wise, I couldn't tell you if there are more oysters today, or less, than when I started ... in North Carolina. I'd hope there would be more, but ... I don't know. I couldn't tell you that for sure. You know, I know we're - in some areas we're gaining habitat, and in some areas we're losing habitat. So, you know, in North Carolina we don't have a good - we don't have a stock assessment. We don't have - our shellfish maps are outdated. ... But so, population-wise, I couldn't tell you.”
-- Conservation practitioner

“You know, I don't - it seems to me like we were getting like - that first time we went out there and really measured with quadrants that we were getting like fifty to sixty oysters per square meter, which was - you know, the people in Morehead City were kind of going, "Whoa, that's pretty good," you know. And then, the next time we went out, which was probably the next growing season, or the end of that growing season, or whatever, we were getting like, you know, twice that many or something. And then, eventually, by the last time ... you know, we were using quarter-meter quadrants to make it manageable. And it was to the point where, I mean, we couldn't even count all the oysters that were in that quarter-meter, because they were on top of each other. They were just layered. And we were getting - although we were seeing some mortality, we were seeing tremendous recruitment and survivorship, and young oysters growing on top of old oysters, and all kinds of stuff going on. And it was just incredible. And it seems like, you know, when we stopped counting, we were up at like five hundred or six hundred oysters per square meter, and we just couldn't count any more. So, that was just a rough estimate. So, in four years, we had gone from seeing these piles of rock in the sound covered with sea squirts, you know, to these incredibly complex communities that were truly becoming reefs, you know, living reefs, self-sustaining reefs. And it was very exciting.” -- Conservation practitioner

But this informant also sums up the feelings many in the conservation sector seem to share despite high counts of oysters in quarter-meter quadrants: “Oysters are fairly rare, you know?”

Informants in the management group seem optimistic about the oyster population trajectory.

“We are just, hopefully, in the early stages of recovery from 12 or more years of disease, Dermo, which [pause] nearly decimated I'd say North Carolina's oyster population. ... But we are seeing our spatfall and recruitment indices increasing. They're not what they were back in the 80's, but they're definitely a whole lot better than they were through most of the 90's. So that's, that's very hopeful that you're getting increased recruitment and survival during the second and third year on a lot of these sites. That gives me hope. ... So hopefully we're recovering. I don't think we're
back to pre-Dermo. … So I think our oyster population is still stressed and stressed due to water quality especially, maybe even more so than disease at this point.” -- Management staff

“On the increase.” -- Management staff

“But, I mean, I tell people, you know, in the last few years, about three or four or five years, there is an increase in population, and I like to say a lot of it is done from the restoration work that Marine Fishery does, you know. I like to say we contributed quite a bit to that.” -- Management staff

Those who have worked with the agency longer appear more cautiously optimistic. Their longer careers provide them with a baseline that recalls extreme low points in the oyster program.

“Unfortunately a lot of [the] biologists came in kind of at the middle or the end of the Dermo event and so they don't remember what it was like before or what it was like during the real bad times of ’89 and ’90 when the bottom was just dropping out and we were squaring around trying to figure out what in the world to do.” -- Management staff

Stakeholders in the aquaculture group take a more dismal view of the population.

“So, you know, with the limited supply out there, the regulations on harvesting, I mean, which have to be in place because there's just not that many oysters left anymore, I would say we're almost at the bottom end of the fishery now.” -- Aquaculturist

“And it's dwindling at such a small degree every year. But over a twenty-year period, you know, if you look at the numbers of acres of bottom, of shellfish bottom, the bottom that actually has shellfish on them, you know, that dwindles a little every year. And we probably - that's something we need is more mapping and surveying of the area. But that costs money. And Marine Fisheries is trying to do that, but that's a budget item that usually gets cut every year, you know. Because what are you going to prove, something we already know?” -- Aquaculturist

One might infer that the aquaculture group’s economic interest influences their perception of the status of the wild population, but these informants never indicated that they believed their success was dependent on a diminished wild population. Excluding some members of the aquaculture group, stakeholders generally concur that oyster populations in the state are healthier at the present time than in the not-too-distant past and continuing to expand.
4.4.2. Taking Stock of the Oyster Stock: What do the Data Say?

North Carolina does not conduct a stock assessment of its oysters. The stock is the abundance and age distribution of individuals of a species that share a physical territory (McGoodwin et al. 2000). Culch planting sites are monitored annually by NCDMF for three years after planting, but NCDMF sampling of natural reefs is limited.

“We go out and do some bushel sampling, which is just going out, pulling a dredge on it like a commercial operation would, and just kind of bringing it onboard and just seeing what the general health of that rock is, you know. Are there a lot of dead ones? Are there a lot of oysters, but they're all small? You know, that type of thing. And that's not - that's just kind of something we do every year just to, you know, give the fishermen an idea of what to expect for a season, but we don't - there's nothing in a database about that. So, I think that we do need to really look at these natural oyster rocks and monitor them and see if they are growing, see if they are - see what they're doing, you know, because if you don't know from year to year what they're doing, you can't make a prediction.” -- Management staff

Without an expansive sampling program, the sustainability of current harvest levels and oyster population status is estimated indirectly from trends in landings and effort data on a regional or per-waterbody basis for each gear type. Catch-per-trip is expressed as a percentage of the trip limit. Percent of the trip limit for hand gear showed no change from 1994 through 2005 for eight of the assessed waterbodies. Five waterbodies exhibited declining trends, and three showed increasing trends. For the three waterbodies assessed for mechanical harvest, percent of the trip limit showed mixed trends, but two of the three had only low numbers of trips per year. The percent of harvest to the trip in Pamlico Sound remained constant during this period. More informally, increasing landings are interpreted as population growth.

“The last four or five years - currently in North Carolina, we do not have a collective number that we put on our oyster pollution. We don't know statewide what the oyster population is. We don't have a factor that we can use. So, typically what we use as our indicator is the landings, in pounds of meat or bushels, whatever, it doesn't matter. And so, over the past three or four years, the oyster landings have been on an increase. Now, you know, and if they keep increasing, I mean, that's good. You know, that's great.” -- Management staff
“We don’t have the data to do a population estimate like they do for fish. So, we don’t have quotas on oysters, or caps. So, what we're trying to do is trying to look at - when the oystermen are fishing, when should we stop them from fishing? At what level, or what population, or what catch-level are they getting that they’re doing more damage than good harvesting?” -- Management staff

Annual landings track the overall trend in oyster abundance, while in-season catch parameters like time required to catch the daily limit monitor in-season changes in the population. Comparing the following two statements illustrates that there are mixed thoughts about using landings as a proxy or indicator of population health in the absence of a stock assessment. Some informants feel landings are a good indicator while others decry the lack of rigorous measurement.

“I do think harvest is probably a fairly good indicator of the oyster population. And it kind of goes back to my respect for commercial fishermen and their ability to catch the resource. Some people say, "Well, landings really aren't a good indicator of the resource." But I think it is because I think oystermen, especially, know where the resource is, they know how to harvest it, they're not going to go out there and spend their time and not catch it. And so I think looking at how long it takes them to get their limit and how they're doing over the season, as far as a month into the season are they still getting their limit and that kind of stuff, you know, those are good indicators of the population.” -- Management staff

“The fishermen, when they are hand tonging or dredging would call up the Division and say, “You ought to close the creek now. There’s not anymore big ones in here, legal oysters.” And then the Division would close that creek. Same with the dredgers before. Can you imagine any fishery being regulated by the fishermen? Being told by...when the fishermen call up and say, “Close the season now, there aren’t any left.” I found that ... I fell off my chair. Now they are, the Division now is sending some guys out on dredger boats and they'll pull up and they'll count how many are legal size. When it reaches like there’s only 20% I think is the number, then they close the fishery. But they drag that thing back and forth, back and forth, back and forth, pulling up four oysters, banging them around, crushing them, uprooting them to get one. Then they'll knock that one off.” -- Conservation practitioner

Informants recognize the problems inherent in using landings as a proxy for an assessment.

“Of course, our fishery is kind of unique in that a lot of fishermen who oyster might oyster if its good, but yet if it's not good or if the drop-netting's good out in the ocean, they might go drop-netting. ... Then you got crabbing, if you're a crabber, you're a crabber. That's what you do. You stick it out in the good times and hard times, or whatever. But with oysterling, it's a short season so it's like you don't make your living from that. If it's good, you get in it. If it's not, you go drop-netting or you go crab dredging or you do something else, bang nails, whatever. So in that aspect, if you talk with a fisherman or look at landings, it's kind of deceiving maybe because you don't really get the full scoop. It there's tons of croakers and bluefish out in the inlet in December and January and February when the oyster season is going on and they're
right outside the inlet, and you don't have to go far, and they can go get all those fish to sell, then who's going to go oystering for fifteen bushels when they can go out in the ocean and make a lot more money?" – Management staff

“Why sell them to a dealer for sixteen and eighteen when you can take them over to your neighbor for twenty-five? You see what I'm saying? So, their numbers - they don't even know what resources is took. … Yeah, right, the landing's useless. But when you've got a twenty-five or thirty-dollar oyster, you probably - probably that ticket goes up to eighty or eighty-five percent. … There are no numbers on the resources when oysters go to that prices. If we're looking at twenty-five or thirty dollars, you get good numbers. If you're looking at eighteen dollars, sixteen dollars, twenty, you don't get no good numbers. And these numbers have increased by five or six fold, you know, so what do you do with all that?” – Fisherman

While a reduction in landings can mean there are fewer oysters to harvest, it can also have nothing to do with oyster abundance. Changes in catch levels can be reflections of the level of effort being expended in the fishery. Effort depends on the market and the price fishermen can get for their oysters versus other species. If high dollar species are plentiful, fishermen may target those species, and effort in the oyster fishery will decline. A lower price per bushel of oysters may lead to lower effort and catches or the possibility of selling oysters to someone other than a licensed dealer. Such sales are not reflected on the trip tickets that are collected by NCDMF, nor are recreational or private harvests. A trip ticket is the form submitted monthly to NCDMF by fish dealers to report commercial landings information about the fisherman, the dealer purchasing the product, the transaction date, the number of crew, area fished, gear used, quantity of each species landed for each trip, and bottom type (public or leased). An increase in the price per bushel of oysters can encourage fishermen to go oystering and sell their catches to a dealer. Landings are a definite indicator of the oyster business, but not necessarily of the oyster population. Much of the market for North Carolina oysters is local; only a small percentage is shipped inland or out of state. Changes in demand in that local market can also dictate effort.

“But like I said, we've had a problem with the oyster market. People go all spring and all summer and they don't have oysters. And it starts turning cool in the fall, and everybody around here, local people, they want oysters. You know, it's something that comes with the season. Cool temperatures and, you know, people getting, “I
want some oysters.” Well, when you get this local market around here east of Beaufort, the first week of oyster season in October, maybe a couple of weeks, and then around Thanksgiving, everybody wants oysters Christmas and New Year’s at parties and social gatherings and things. They want oysters. Well, when that season’s gone, that’s about it for the winter, local. People have had oysters several times, and they kind of get their belly full of oysters. Say, “I don’t want no more oysters right now.” See, the best part of the oyster market is early in the year in October, Thanksgiving, Christmas, and New Year’s. After that, it slows right down.” -- Fisherman

“So, after you get your share, your belly full, people don’t buy no more. Then the price goes down. People don’t want them. Like last year, I was doing good until after Christmas. Then I only started going a couple of days a week because my market was gone. Everybody had them, because nobody was buying them. See?” -- Fisherman

Even though the season is still open after January 1st, landings decline because demand falls off and the market price follows. After examining obscure information regarding the decline in landings along the U.S. east coast from 1890 to 1940, MacKenzie (2007) concludes that the prominent factor in the decline in oyster production during that time period was falling consumer demand for oysters. As with most any good, production of oysters must follow demand. Informants in the fishing industry indicate that they wonder whether management knows that landing data can be misleading because low landings might not mean low abundances:

“But that don’t mean there weren’t any! But they don’t take that into consideration that the market weren’t there and we couldn’t catch them even if they were there. See, that can be misleading! Do you see what I’m trying to say?” -- Fisherman

A stakeholder in the conservation group agreed that landings were not an appropriate measure of the population and decried the lack of an official assessment:

“You know, it’s a little unusual, but you know how oysters are managed, pretty much? We don't know how many oysters we have. There's no oyster assessment. If it's such an important fishery, why don't we have an assessment? Virginia does; they know how many oysters they have. How do you measure the success or failure of any fisheries management plan, if you don't know how many fish you have to begin with?” -- Conservation practitioner

As indicated in an earlier quote, management is aware that landings data are imperfect. However, the landings are currently the data they have to go by.
4.4.3. How Perceptions are Made: Different Kinds of Knowledge

One informant described the process of making a determination the oyster population’s status this way:

“There's a lot of data and research, so that's part of it. It's working with some of the shellfish growers and harvesters, hearing them, you know, and listening to them: "There's not a problem; there's tons of oysters out there." You know, but you balance what they're telling you on the day-to-day, you know, both in terms of what they're seeing, some of the factors that are affecting them, some of the things they have to deal with. ... And so, then I balance that with our work in terms of the conservation and restoration practitioners. So, I get it from researchers. I get it from data journals. I get it from the management - the Division of Marine Fisheries, their Management Section, in terms of their data, their statistics. I get it from the shellfish growers and harvesters. So, it's a wide variety in trying to pull all those together, both the ecology, the economic, the social - all those, trying to put together sort of how you understand and how you deal with issues facing oysters.” -- Conservation practitioner

This list of sources reflects an ongoing struggle within fisheries in the relationship between different knowledge systems. The central tenet of science-based fisheries management through its development in the 20th century has been that sustainable harvest requires knowledge of changes in the size of the breeding stock (Schneider et al. 2008). To gather this knowledge, fisheries science takes a comparative approach in order to gain a universal understanding of a stock (Fischer 2000). In this approach, scientists operate at large spatial scales making infrequent observations and employing sampling techniques and technologies that allow them to move beyond visual observation (Fischer 2000).

In contrast, knowledge generated by fishermen operates over a fine spatial scale involving nearly continuous sampling over a decades-long career through largely visual inspection (Fischer 2000). Data are not standardized across members of the group in terms of temporal scale, territorial coverage, technology, effort, or expertise (McGoodwin et al. 2000). Two broad areas of expertise are fishing performance, factors related to catch and effort, and the physical-chemical environment and living resources (Fischer 2000). Fishermen tend to develop and prioritize locally detailed, small-scale knowledge of fish locations, movements, abundance, habitat use, and factors related to spatial patterns and
timing such as spawning, mating, and trends in abundance (Neis et al. 1999, Greer and Harvey 2004). For oysters, this includes observations of extreme catches, changes in average size, sites for good harvest, timing of spawning and attachment, and changes in bottom characteristics over space and time.

The knowledge generated by fishermen is a form of local or practical experience knowledge (PEK), knowledge that is acquired through personal experience, local history, and extensive observation of an area or a species (Berkes et al. 2000, Griffith 2006). More than simply information, PEK is a knowledge-practice-belief complex such that it has a component of observational knowledge regarding species and ecological phenomena, a component of practice in terms of how to carry out resource usage, and a component of belief regarding how people fit into larger ecological systems (Berkes 1999, Berkes et al. 2000). PEK is stored in memories and passed down orally and by example (Grenier 1998). Fishing practice, fishing and fish-finding technology, and what the fisherman considers to be important influence fishing PEK (McGoodwin et al. 2000).

Fishermen explain changes in observed factors based on their observations, impressions, perception of the changes, and values that may or may not be scientifically defensible (Pederson and Hall-Arber 1999). Like scientific understanding, PEK is dynamic, continually generated and evolving through continued involvement with the environment (Berkes et al. 2000, Ingold 2003). PEK and fisheries science are the result of the same general intellectual process of creating order out of disorder, but the dynamics and evidentiary basis of users’ knowledge differ from that derived from more traditional scientific sources (McGoodwin et al. 2000). PEK systems tend to be locally embedded and bounded in space and time, while scientific knowledge systems tend to disembedded and universal (Berkes 1999). Fishermen tend not to develop knowledge that is as geographically broad as it is locally contextualized and deep because fish and fishing effort are spatially
heterogeneous and the complexity and specificity of the knowledge obtained in a local setting may make it inapplicable in other settings (Griffith 2006).

Scientific surveys and fishing trips are different. It is difficult to combine fisheries science and PEK because of differences in the contexts, tools, training, and technology that shape these knowledge pools as well as how observations are recorded and checked.

“I just don’t believe – a lot of data they use I question it. They’ve got an independent gillnet survey. All right, they take from two-inch mesh to six-inch. And they’ll have some of their people go set that. They’ll go set their gillnets and, of course, they’ll record everything they catch. If they go out March the fifteenth of this year, and say he catches fifteen flounders, ten spots, and nine speckled trout. And he goes out next year and catches five flounders, three spots, and two speckled trout. Then they automatically take those numbers and figure percentages, and that’s how bad off the fisheries got in a year.

Well, now, that is not a proper way to do things. I have told them, “Our pound nets, we see a lot of thirteen and a half inch fish in.” I mean, there’s times that you’ll have – we had one last year that had forty-five hundred pounds in it, because we know about what it will hold. She had about five thousand, and we picked the big ones out and rolled the rest overboard, because we couldn’t do anything with them. They were too small. If you see that kind of recruitment, then evidently, things are not too bad. In the independent gillnet survey, they put a lot of stock in that that I don’t.

One year, long hauling – like I told you before, we have a six-man crew – we went six weeks in a row, never paid a fuel bill or never paid a grocery bill from them boats. We were ready to quit. And I told the boys, I said, “Let’s try it one more week.” The next week everything turned to fish. And that was probably the best year we had had in a long time. But, now, look, I’m not saying that I’m real sharp as far as that. But I’ve done it all my life and I feel like I’ve got a fair idea about fishing. And if I went six weeks and didn’t pay the fuel or grocery bill, then what precludes them from going a week in the spring of the year – and if they don’t catch anything, you know, it’s all doom and gloom.” -- *Fish dealer*

PEK is predicated on the utilitarian aim of maximizing catches and less often on the quest for bio-ecological understanding (McGoodwin et al. 2000). The scale and location of a fishing trip reflect this aim. Fishermen are critical of the temporal scale of surveys because the infrequency of sampling means that the survey can only collect snapshots of a stock. Fishing informants refer to this snapshot as perception, whereas they themselves see reality in their more frequent fishing trips. In a study comparing fishing strategies to scientific surveys, significantly more fish and greater clustering of schools were found on the fishing
than scientific transects (Mackinson and van der Kooij 2006). Scientists employ search strategies to assess average densities over a large area, whereas fishermen strive to find the maximum densities to support a commercial catch. By focusing on the hotspots, where fish may continue to congregate even when their abundance outside of that area is declining, fishermen can maintain high catch rates and opinions of healthy stocks in the midst of a decline. While a scientific survey might be able to detect early signs of decline when conducted over the long-term, annual surveys are only snapshots. Over the course of a year, fishing boats cover large areas getting to and from these hotspots and make many more observations. Clearly the different spatial and temporal scales of these two strategies produce different data and opinions about species abundance and distribution, impacting what they can tell us about a stock. Because scientists and fishermen have different spatial and temporal scales of observation, their observations may be complementary. Patterns in species abundance and distribution known to fishermen may not be detectable by scientific surveys (Williams and Bax 2007). PEK could make scientific studies more directed, and survey data could provide more rigorous interpretation of PEK.

“I think that North Carolina does have a comprehensive trip ticket program. They have good data collection, although a lot of times I don’t agree with the way the data is used. You can take numbers and turn them any way you want to. You know, a negative person – we can set a glass of water here, and it can be halfway from the bottom to the top. A negative person will always see that as half-empty, and a positive person would say it’s half-full. You know? So, you know, I just – I think there should be more input from the industry in the regulatory process than there is. … I would contract commercial fishermen. Let the biologist go with them, of course. Let him go with him, and get good commercial fisherman to do what they were doing. And, “Okay, you’re going to go out today. We’re going to contract you so much to go with you and record what you catch. You’re going to sell what you catch. It’s still going to be yours.” The hungry dog hunts the best. [Phone rings and continues]

And let him go. Then they would get an accurate assessment of what’s really going on. You can’t – somebody that – and I’m not pointing any fingers. I’m not taking anything away from anybody, but I’ll go back to what I just said just a minute ago: A hungry dog hunts the best. A man that’s getting a salary that’s got to take a skiff and go out there and set a thousand yards of gillnet, well, it doesn’t make any difference to him what he catches. You know, if it’s a bad day, he just doesn’t go, you know. He’s not going to shovel like a commercial man will.” -- Fish dealer
While the geographic scale of fishermen’s knowledge may be limited, knowledge of natural processes is situated within a larger context and the entirety of their fishing practice. Greater contextualization is something that fisheries management is striving for through enhanced efforts at ecosystem-based management. The divergence in scale and mode of investigation between scientists and fishermen can lead to divergent knowledge and status assessments. These divergences indicate a need for nested investigations (Neis et al. 1999).

4.4.4. Diverging Perceptions Among Stakeholders

While there is widespread concern across stakeholder groups regarding runoff and disease, perceptions of other issues are more diverse. There is less agreement about the importance of oyster harvest issues and the role of natural disturbance in structuring the current oyster population.

4.4.4.1. Perceptions of Oyster Harvest

Concerns about issues related to harvest and gear vary across stakeholder groups. Impacts from overharvest and use of dredging gear are highly important concerns (high C) for the conservation group. Overharvest is a moderately important concern (lower C) for the science, management, and fishing groups. Harvest pressure is a moderately important concern for the fishing group. The distribution of these three factors across stakeholders highlights the complexity of oyster harvest. Different stakeholders focus on different specific factors within a complex of harvest factors, underscoring the difficulties inherent in teasing apart the various aspects of harvest.
Overharvest

Most stakeholders agree that historical overharvesting represents a bigger problem for current oyster populations than present day overharvesting. Beginning with the migration of Chesapeake Bay oystermen into North Carolina waters during the late 1800s, the era of record high catches ushered in not only the harvest of more oysters than ever before by more harvesters, but also the introduction of a much more efficient harvesting method without concomitant reintroduction of cultch material and other appropriate management efforts. Many stakeholders agree that severe overharvest of the state’s oyster resource would have been less likely after dredging began if habitat had been sufficiently replenished.

One informant describes the beginning of the boom in the oyster fishery this way:

“The whole industry was new. And so they were basically harvesting on virgin rocks that had never been harvested before because they were deep-water rocks. They brought the dredge in which allowed them to go into those deeper rocks and so they were harvested pretty heavily. There was a lot of cannery that sprung up, railroad lines that came in to move the oysters out. There was a lot of infrastructure that resulted just from the oyster population and the oyster harvest. We've never regained that level of population or fishery.

And a lot of people, I guess... We've had a graph that shows the decreases in landings. Somebody was looking at that and they said that's not a graph of harvest; that's a graph of mining. And you basically mined the resource and did not allow it to rebuild at all, but just continued to just take, take, take. And I think in the past years, our rehabilitation efforts have been at kind of such a scale that they're right. You know, we didn't manage or rebuild at an appropriate level. And I think that's a lot of what got us into the situations we were in.” -- Management staff

There were possible evolutionary effects of intensive harvest or mining and limited rehabilitation efforts.

“But fishing, if you’re removing all the big ones, you may be selecting for an oyster that matures early, spawns at a small size, and as soon as it starts to shift that allocation of energy to reproduction, it stops allocating as much to growth, and so you end up – so, maybe because they reproduce earlier, and I don’t know if they do, but that would be a great question if we could go back in time and figure out when was the age of maturation at 1900 versus the age of maturation at 2009. It may be that the reason we don’t have, again, big fat wild oysters is that they’re reproducing at age six months, instead of waiting until they’re three years old to become reproductive.” -- Scientist
While the historical oystering effort could have had still unknown genetic impacts on today’s stock, informants state that current levels of harvest are not adversely affecting the oyster populations.

“I guess I see harvest as being so minimal at this point that it's not the factor that it has been throughout the history of the oyster industry. When you hear tales of... And I've talked to Marine Patrol pilots that have retired, and they talk about flying around in the 70's and you just about jump from boat to boat to boat - all the boats that were oystering in all these places. And I said, "Yeah, they're still oystering there, but we're only seeing two or three boats here and a boat there." And so I just think that the impact of harvest now is way reduced to what it has been.

And I'm a firm believer that, historically, harvest and overharvest has probably been one of the main contributing factors through history. And I'm talking about from the 1800's up to the 80's. And I think part of that is the Division's fault for not managing better. I mean, throughout time you can see different management measures, but they never were sufficient to address the amount of impact. At this point in time, I don't see that as a large impact on the resource. I see water quality issues being more the limiting factor to the rebound than the harvest.” -- Management staff

Other informants concur:

“Whether you want me to say that or not, but overfishing is not problem. I don’t see that as an issue to why oyster landings are down. You know, way, way back in the early 1900s, there was a lot of oysters harvested with a dredge. And it probably was to a point back then where we were taking more than what the sound could produce. But now? No. That's not an issue. It's a non-issue, overharvesting, in my opinion. That's my opinion. Everybody has their own opinion. But that's not an issue.”

-- Management staff

“And I do not associate oyster harvest with demise, because I understand that it's being a managed fishery, you know, that we can manage it. So, I know that many would make that association. They would say, "over harvesting." But, to me, over harvesting is something that can happen one year, and the next year, it can not happen.” -- Scientist

Some informants are careful to point out that while oyster populations are not currently being overharvested, one does not have to go back to the 1800s for the last episode of overharvesting. It may have occurred within the memories of active fishermen.

“But we were talking to - the three of us and some other people were talking one day, and [he] was sort of talking about, yeah, he could remember when they'd come back in with the boat so full of oysters that it was almost too much, you know. It was almost like the boat was going to flood. And [ ] just looked at me and said, "That's what happened to our oysters." And I just went - and he's not the only person who's said that kind of thing, old fisherman who's said that. There's some recognition there that that over-harvesting - ... And I'm sure [he] would never - I mean, I was shocked when he said it to me. You know, but he would never say it to anybody in Marine
Fisheries, that, "Yeah, I know that I am part of the problem." You know, it was always that they were not doing enough to help him." -- Conservation practitioner

Most stakeholders agree that while overharvesting is not currently occurring, historical overharvesting continues to affect today’s oyster populations.

**Harvest Pressure**

Some informants perceive pressure, the number of harvesters, as the greatest harvest issue for oysters. They believe that harvest pressure on oysters has increased as a result of coastal population growth, more recreational harvest, and the poor general economic climate.

“And that's what I hear about Lockwood Folly River, you know, a lot of my family talking, that there were just a few of them. There were only a few of them that went out, you know, or just the family and folks from Sunset Harbor that would come over and fish in that - harvest in that river. But now, so many people live and are moving into that area, or I think the economy has hurt a lot of people, to where they're trying to find ways to make money or food. So, there's a lot more people out there in the water than what there used to be. In some ways! And then, in some ways, a lot of them are not out there oystering anymore because the cost of fuel, it's just hard work, you can't get anything for a bag of oysters - they're still the same price as what they were like ten or fifteen years ago. So, it's kind of weird. I'm hearing that, you know, there's more people moving to the coast, or, you know, learning more or wanting to eat, or, you know, go out there and get their own oysters. It's hurting the ones that are trying to sell them and make their living that way, because they don't know anything else. But, also, you hear a lot of them are getting out of it because of that reason. So, I don't know, [laughs] there are so many different things you hear.”
-- Management staff

“Well, I would say, it's not over-harvest, but it's maximum harvest maybe. Okay? Too many people out there, too many fishermen, both commercial and recreational. Because every year they go get every oyster they can. At the end of the season, every year, it's very hard to go out there and find any oysters that are over three inches. Essentially, you can't do it. You just get real lucky. You know?”
-- Aquaculturist

In addition to population growth and economic woes resulting in greater effort in oyster harvest, regulations that limit daily catch limits, known as bushel limits, are blamed by some in the industry for creating increased harvest pressure and reef damage.

“I mean, there's stuff here - I've seen my father when I was a boy, a hundred, a hundred and twenty-five, a hundred and fifty bushels a day, day in and day out, day
in and day out. I've helped unload them where five or six boats would load a tractor-trailer. The way we used to do it when I was a boy - after school I'd have to come help them load the trucks. And the guys wouldn't try to count what they had. They'd shovel them in a basket, and every time they'd throw an oyster in another basket. ... When we got through, lots of times they'd have a bushel there that they had to count out to see how many baskets they had put on the truck. And we'd load them and load them and load them.

Now, a lot of people will tell you that's what killed oysters. But that's not what killed oysters. As far as a man going out there and catching a hundred bushels off a place and leaving and going to another place and catching a hundred, that's not what killed them. What killed them was after he caught a hundred bushels, somebody come there and caught fifteen a day for the next ten or fifteen days, and caught it right down to nothing.

See, the man that could catch seventy-five or a hundred, he didn't stay there for fifteen or twenty bushels. When he left a lump, that lump was in perfect condition to reseed itself and to grow out and have them hundreds of bushels on it again the next year. But when that man come back there behind him that couldn't find those places and saw where he was at and got on there and just stayed there and ground and ground and ground until he caught or killed every last thing, that's what killed oysters." -- Fish dealer

This informant went on to describe his perception that the 15-bushel limit created oystermen and that without it “the best oystermen would put the rest of them out” reasoning:

"It's the natural order of everything that's ever been: the survival of the fittest, the strongest. The ones that's good and can do, do; the ones that can't find something else to do. And the fifteen-bushel limit - my argument is there'd be half as many oystermen, catching twice as many oysters. And the oysters would be better off, because a man that knows what he's doing doesn't hurt oysters." -- Fish dealer

Stakeholders posit that population growth, the economy, and/or bushel limits may be attracting more individuals and effort into the oyster fishery, with negative consequences for oyster sustainability.

Dredging

The aspect of harvest that is most contentious among stakeholders is the gear used to harvest oysters. Some comments define dredging as one of the most pressing issues while others indicate that it is not an issue at all. One informant likens trying to restore oyster populations while continuing to allow dredging to “trying to fill up the bathtub with the plug
out” or “schizophrenic.” Other informants, primarily in the conservation group, similarly describe dredging as destructive behavior.

“To me, the number one threat to the fishery, the commercial fishery and the viability of the commercial fishery is the continued use of dredges in North Carolina waters, because they wear down the rock. I mean, they actually destroy the habitat, you know, that the oyster grows on. ... And, you know, what we all want is for oysters to come back so that there is a sustainable commercial fishery and clean waters. How do we do that? You know, it may be that there needs to be some restrictions put on dredging.” -- Conservation practitioner

“And it’s just something that ... fishermen love to find oyster reefs, especially deep water oyster reefs. They serve as, you’re a scientist you know what important structure and habitat that they have for other shellfish - the clams like to, you know, you can find the clams right on the border, they’re in there thick, crabs, crustaceans, shrimp, and at high tide they get all covered with mullet. And they’re also nursery areas for other larger game fish as you know, the snapper-grouper complex. Up in the Oriental area, the guys all know that if you can find a deep water oyster reef, they fish tarpon on it. In August they are full of tarpon. And everybody who knows where the shallow reefs are, that's where the red fish are. I'm a red fish fisherman. So that's something that would benefit all the other commercial fishermen, all the recreational fishermen, if we stop dredging. These rocks take forever to get this three-dimensional structure and to get those oysters off of the bottom silt. And when you smash them, many of them that you don't take, that might be too small, die and you lose this great habitat.” -- Conservation practitioner

“But, yeah, I think dredging is probably detrimental. I think they allow it in Virginia. You can power dredge. In Maryland, you can power dredge from a skipjack only on Mondays and Tuesdays. Traditionally, it had always been strictly under sail power. And I did notice under sail power, you catch half as many oysters as you do under motor power. But in the early ’60s, the oyster industry up there was in such turmoil. I mean, these guys had been, you know, trying to make a living. The oysters had been on the decline from disease, over harvesting, whatever, loss of habitat. But the state legislature in Maryland, I think it was in ’62, allowed skipjacks to use motor power on Mondays and Tuesdays. So, we very seldom missed dredging on a Monday or a Tuesday, unless, you know, the weather was so terrible you couldn't get out. But, yeah, it's probably not good for the marine life on the bottom. You know, we'd pull up fish and sometimes crabs that were trying to hibernate and things like that. We had a big propeller, boat propeller, came up in the dredge one time, this big brass propeller, and we sold that and split the money.” [Laughter] -- Aquaculturist

According to these stakeholders, dredging is destructive to oysters and oyster habitat. For them, by penetrating into the bottom, removing and leveling reef substrate upon which young oysters attach and grow, mechanical harvesting with a dredge results in less settlement and growth area, lower profile habitat for subsequent generations, and reduced oyster densities (Rothschild et al. 1994, Lenihan and Peterson 1998, Breitburg et al. 2000,
Lenihan et al. 2001, Lenihan and Peterson 2004). An assessment of oyster populations within North Carolina’s oyster sanctuaries implies that safeguarding reef height by prohibiting fishing or preventing gear damage may improve restoration outcomes by ameliorating oyster disease impacts (Powers et al. 2009). Restored oyster reefs in a tributary of the Chesapeake Bay that have remained closed to harvest have also demonstrated success that is attributed to maintenance of height and structure in the absence of dredging pressure (Schulte et al. 2009).

While recognizing the negative impacts associated with dredging, informants also stress the controversies and complexities of actually outlawing dredging.

“And many will tell you that oyster harvesting - you know this - that oyster harvesting is in itself a destructive practice that harms the ability for the oysters to regenerate their biomass. And the process of mechanically harvesting oysters is really, you know, very closely related to mining … and … people … will frequently draw that analogy. The difference is that from a commercial fisherman's perspective - and I am not naive to think that this is always the case, and certainly it's not, and certainly from an academic or research standpoint, it is certainly not the case - that nature will run its course, that fisheries will rebound when over harvested naturally, you know, that a fisherman will move on to another resource and give that resource a resting period where it can come back. That certainly doesn't work for a lot of organisms. You know, sharks, for example, which are relatively long-lived, very low fecundity, and other fisheries, can certainly draw that comparison. It does work for some fisheries, interestingly.

I don't think it works very well for oysters, unfortunately, because the habitat is removed. And if fishermen were more careful and valued and had an understanding of that process, across the board, practices such as culling out on the rock, you know, where you're returning the shell back to the reef, keeping the reef height where it needs to be for larval recruitment and things like that. Certainly the state, in planting cultch and creating reefs, certainly helps along those lines. But the practice of harvesting … is certainly very, you know, very controversial." -- Scientist

“You know, I think we're looking at it, we're managing it, but - you know, are there different ways that we can look to, for example, to get rid of oyster dredging? You know, we shouldn't be oyster dredging in North Carolina, and we're just not looking at how to - we're looking at ways to minimize the effects of that, looking at ways to control it, all those kinds of things. But we're not really having a good discussion about how to get rid of oyster dredging and, you know, making sure that we take care of the people who are engaged in that fishery through other avenues, whether it's getting them involved in oyster growing and things like that. But I think that's one big thing is a really hard look at the fishery.

And, you know, I think there will probably be people who will never want to get out of it. There may be people who are willing to jump out of it because they're not making
any money the way gas costs are and everything else. But there will be people who
want to stick with it and see it as losing a heritage. So, I think there will be issues
associated with it that have to be tread very carefully. But, you know, I don't know if
we have a choice. I don't know if you can, you know, have a good sustainable oyster
population and fishery and still have the impacts of dredging that we're having.”
-- Conservation practitioner

Stakeholders who believe that without dredging oyster beds become less productive
disagree with those who advocate for phasing it out. These stakeholders, primarily in the
fishing and industry groups, describe dredging as a critical means of cleaning, maintaining,
and caring for oyster habitat.

“See, if them shells are there, and you don't mess with them, and you can't dig them
out and turn them over where they can catch, they're just going to sand up, bury up,
made hard bottom and be gone. See, so that's foolish. ... You keep them up, where
they - turn them up, clean them up a little bit when you're working with them, then
they'll catch. But if you leave them, they won't catch like that, you know. It's a less
chance.” -- Fisherman

“I think dredging is a good thing, within reason. You can take what we call snappy
ysters, cat tongues, oysters that are - they grow real fast, they have a real soft shell,
and aren't nice round single oysters from a hard bottom. You can take an oyster that
is a cat tongue or a snappy oyster, and work that bed with an oyster dredge, and the
next year that bed will be - the quality of it will be a hundred percent better than it was
before. Dredging is a good thing, as far as maintaining these oyster beds. I mean,
not to the point where there's nothing left. Don't get me wrong. They have to be
regulated. But, no, oyster dredging is a good thing. I mean, for them to phase that
out is bad.” -- Fish dealer

“So, you know, I'm sure that somebody else has got a different take on that. But I
have to deal with reality. Perception doesn't do it for me. I only go -- I can't pay the
bills on perception. Has to be reality. And in most situations, reality and perception
are 180 degrees apart, you know. Perception will tell you if you close this bay off,
and nobody ever drug it or anything, that everything would take off. But what
happens to a farmer's field if he doesn't plow it? It grows up and becomes
nonproductive. Well, believe it or not, that's the same way it is with this here. I'm not
saying go everywhere and take everything.” -- Fish dealer

There is some evidence to suggest that dredging action does clear sediment from oyster
bottom. Dredging, by turning over shell and exposing clean surfaces may enhance
recruitment (Powell et al. 2001). Smith et al. (2005) and MacKenzie (1996) suggest that
some form of tilling process would be useful shortly before spawning to clear sediment from
oyster bottom. MacKenzie (1996) describes equipment reminiscent of a trawl for towing over
shell bottoms to scour away sediment. In Virginia, an hydraulic excavating machine has
been successfully adapted to turnover and exhume shell on reefs covered by a layer of sand
or sediment (Wesson et al. 1999). An important caveat to the use of such a machine or any
sediment-clearing process is reef elevation or height. Only taller reefs may benefit from
sediment clearing because they are higher above the estuarine bottom where they receive
enhanced food and oxygen delivery. Clearing sediment from short reefs many not promote
oyster recruitment or survival.

In addition to seeing a benefit to dredging, the same informants perceive tonging, an
alternative harvest method, as destructive.

“A lot of people are tight in tongs. Marine Fisheries is hardcore on that: hand tongs,
hand tongs, hand tongs. The most destructive method of oysterling there is. Don't
make no sense to use. That's all they done in Virginia for years. Dredges were
illegal. Okay, they had no oyster industry, none. They had wiped it completely out.
They done a little study. They financed - the state actually paid boys to gear up to
dredge, and they went out there and let them dredge old bars that had quit producing,
that tonging had made quit producing. The first thing you know, those bars were
producing, opened up more area to dredging. Now, they don't tong; they dredge.
And they've got more oysters than they've had in fifty years. The dredging has
brought their old bars and stuff back.

And Marine Fisheries don't want to tell you that, but I'll give you a list of folks from
Virginia that you can call and they'll explain it to you. I've actually been in there
where VIMS, the people from Virginia Institute of Marine Sciences, told them that.
Because at that same meeting we were talking about, I asked them, I said, "Look, are
y'all's oysters coming back?" They said, "Yeah." I said, "Coming back for tongers or
dredgers?" Said, "Dredging is bringing it back. We're seeing that the bottom's got to
be turned, the silt's got to be knocked off of it."

But what tonging does - they go on a place. They pick up everything. They go off of
the place into the mud to cull, because they don't want to put their scrap back on the
lump. The dredgers don't do that. Dredgers stay right there in one spot. They'll
spread it, but they'll spread it in the same area. Tongers won't. They haul it off
somewhere. Plus, with the tonging, the bottom never gets turned, and it ought to.

But the dredging has actually helped the oyster industry up there. North Carolina is
trying to go the other way, and you can look right at Virginia and see that dredging is
a positive thing for oysters. But, like I say, you don't hear that very often.” -- Fish
dealer

Though not everyone in the fishing industry agrees that tonging is more destructive than
dredging:
“And my basic thing is I would like to see the hand harvester go in Middle Bay or Rock Hole or wherever and tong his ten bushels to help him out through the winter and keep the dredger out of there. So, whatever it takes to keep him out, that's what I want to do. I want to be able to do it, these people to do it. And they need it especially with the crabbing situation like it is.” -- Fisherman

Informants in the management group do not prioritize dredging as a concern. They perceive that both dredging and tonging have impacts on the oyster resources that necessitate management. They also recognize that all management decisions carry social impacts. Despite management informants' seeming lack of concern about dredging, by designating areas for hand methods only and prioritizing cultch material for those areas, NCDMF is attempting to promote a transition from dredging to tonging within the industry.

“But there's some level, I think, and I think we're probably getting close to it where - I mean, everything has impacts. Even hand harvesting has impacts. I mean, one of the studies that everybody quotes in Virginia was a study done back in the '50s. And it says - well, the one-liner that everybody cites says, "Oyster habitat was reduced by, you know, a foot in so many years of harvesting." And everybody has picked up on that, and they cite it and all. But if you read the report, the guy was talking about hand harvesting." [Laughter] -- Management staff

“And plus, part of the harvest now is that we have designated hand harvest only areas where a large part of the areas that were traditionally harvested with dredges, although they were shallow water areas, now dredging isn't allowed. It's hand harvest. To me that's a much more responsible, less destructive harvest gear.

… I don't like regulating people out of fisheries as a way of management. I like to do it more through providing them the means to be able to transition by really adding a lot more cultch material, building new oyster rocks in those hand harvest areas. Hopefully they will find it an attractive way to harvest. So I'm hoping that in time that we can help that transmission rather than regulate. Regulating I think leaves a bad taste in everybody's mouth. The fishermen don't like it. We don't like it. Marine Patrol doesn't' like it. To me, it's a whole lot better if we can kind of work together and transition the fishery into a more responsible means of harvest.

And it's pretty difficult to manage a resource without knowing that the impact of your management is going to impact people's lives and livelihoods too. That's difficult. Again, it would be much easier if they were using a less destructive means of harvesting. If there were more people hand harvesting, I would have... It would be a whole lot easier to extend the season and that kind of stuff.” -- Management staff

Powell et al. (2001) conclude that over a long period of time dredging influences oyster bed physiography and community structure as evidenced by a reduction in the number and size of oyster clumps on fished beds. However, once a bed becomes a fished
bed, their work suggests that moderate dredging, equivalent to an annual swept area of up to four times the area of the bed, is unlikely to have significant further impact on the oyster populations on those beds. It is not clear if this is the level of dredging the beds in North Carolina experience. Repeated dredging breaks up oyster bottom reducing bed consolidation and improving the catch efficiency of the dredge (Powell et al. 2002). The authors maintain that once this has happened on a bed, routine fishing may not have important negative impacts.

The critical to caveat to informants’ conclusions about dredging is moderation of the effort. A need for moderation and know-how is reflected in the comments from fishing informants.

“In other words - but see, that gets to another thing. You've got to have enough sense to know what you're doing. You can't work them to death. You work them, but you don't work them to death! [Laughs] That's it. That's the part, see, that everybody don't look at, you know. And see, I know that I don't stay there until I get - "I'm getting an oyster or two. I've got to keep going." Uh-uh, I don't do that. When I catch what I - you know, the best of it, I go on to somewhere else. Now, there's a good chance someone stupid might come behind me and just dredge that place to death, you know, but I try to give it a chance, you know. And see, that's the main thing. That's where the fisherman needs an education. He knows when, "Hey, you've got to get off of this, Bud. You can't keep on doing that. You'll kill it." And it will.

… And they don't know how to - see, if you get a certain depth of water, you don't put but so much of your cable out with your dredge. If you don't, that dredge is plowing. You know, it's digging. You know, it'll go right on in the bottom with you, stop you, if you put too much cable out. And you've got to have enough sense to know when the dredge hits the bottom, just a little bit more and that's it. That's all you need. In other words, the nose of that dredge is up and your teeth's digging. That's it.

And, now, if you're in the mud, you don't need that dredge plowing around there. If you're culling and you can't keep it caught up, you don't need that dredge down there keep right on plowing, plowing, plowing, plowing. Matter of fact, when I'm at a place where there are some oysters at, when I get some on that table, I leave the dredge up until I get it culled near about off, and then I'll put it down just where I can get it back. When I've got it culled off, I'll wind it back in again. Leave it up. And I've seen people like that, with all, a whole bunch right there beside of them, with a whole bunch of cable out, dredging, with a table slam full, and they're still plowing. … You're not doing anything but killing everything, you know. But, now, you do have a lot of that, you know - well, not a lot, but you do have some of that.

But if you take that dredge like we use, it's fine if you use it like you're supposed to. It'll work, and it won't hurt nothing if you don't overdo it with it, you know. But I reckon
you could take a fifty-pound dredge and overdo it if you keep right there and keep right on digging, you know. You have to know what you're working with. You can overdo anything.” -- Fisherman

To this informant, and others, the dredge itself is not doing damage. Rather, inexperienced or ill-instructed fishermen, by not using good dredging practices, are damaging the oyster resource. The possibility that proper dredging is not as destructive as some believe is reflected in conversations with management:

“I really want to get some of those recreational fishermen out there on a dredge boat, an oyster dredger, and let them see how they operate. I think they have this vision of this, you know, big dredge out there, and they're just banging away on the oyster rock, you know. And an inexperienced oysterman might do some of that, but the guys who know what they're doing, you know, they've got that dredge going up and down. That dredge doesn't stay on the bottom more than a minute or two. It's coming back up, and they dump it, you know.

And they see this dredge as going in and just plowing through the rock. Well, you see the teeth on an oyster dredge, everybody thinks that they pull a dredge like this [demonstrating] and the teeth are like that, you know, scraping across this rock. Well, the dredge is tilted like this. I mean this is the top. This is where he's pulling it from, and the teeth are stuck out there like that. And they're pulling this dredge, and the teeth are going that way. And it's hitting the oysters and knocking them loose, and they go in the bag. I mean, and it hits cultch, and cultch goes in the bag, but you don't see black shell. I mean, you don't see shell from deep within. So, they don't understand that. And they've got this, you know, "He's dragging this big hundred-pound piece of equipment." You know. They don't realize.” -- Management staff

With evidence and strong perceptions on both sides of the issue, perhaps allowing moderate effort in selected areas can bridge conflicting perspectives on dredging.

“I think if you had an area with the perfect spot in the sound that was you could hand harvest and dredge, if you did it over time, you could probably hand harvest on that area a lot longer than you could dredge on it. I think common sense tells you that. If you're taking - of course there are some good hand harvesters that can get as much as a dredge can, you know. So it depends on who's doing it also. But you would think that a hand method harvest would be more sustainable than a mechanical method of harvest. However, with proper regulation, I don't see that as an issue. I think you could have sustainable dredge areas like you could have sustainable hand harvest areas. I don't think the answer to our oyster population is because of a dredge. That's not the answer to making oysters come back, is to outlaw the dredge, that's not the answer. It's a lot more than a dredge.” -- Management staff

Overall, the differences in importance attributed to harvest factors by the stakeholder groups reinforce the expected foci of these groups. A priori, one might have expected conservation
group informants to prioritize issues related to habitat destruction by dredging while
expecting informants in the fishing groups to prioritize issues related to catch and livelihood.

4.4.4.2. Perceptions of Nature

The fishing and dealer/industry groups emphasized the role of the natural
disturbance in determining the population status of oysters more than the other stakeholder
groups. Natural disturbance concerns mentioned by informants include weather, hurricanes,
storms, droughts, salinity, and inlet formation. Some informants refer to this class of threats
as nature or Mother Nature, and all imbue it with a sense of uncertainty.

“Yeah, and sometimes, depending on how the weather affects them, they might be
better. You never know, just according to how the situation works. You know, some
years they might be good over here, and some years they're better over there, you
know, just according to how the weather affects them or whatever. So, you don't ever
know.” -- Fisherman

“And a storm can come. Anything can happen, and oysters can get full of sand, and
they're going to die. It's done real well for the last few years. I applaud the state for
the effort they've done planting and closures and trying to protect the resource. And
through a combination of it all, I think oysters have done real well. There are oysters
all over the state. It's not just here. There's oysters down to Wilmington; there's
oysters to Avon; there's oysters everywhere. It's nothing that can't be destroyed, I'm
sure of that. One bad Dermo season or one bad, bad storm, anything could happen,
and they could be gone.” -- Fisherman

In some fishing communities, environmental factors are perceived to shift through
balanced change such that when one part of the environment alters, another compensates
(Blair 2009). In North Carolina, fishermen also describe a cyclical pattern of change.

“And, you know, ever since there's been a fish in the water – it's just like the animals
in the woods – there's always been a balance. Nature will balance itself.” -- Fish
dealer

“And I can see trying to build them up, you know, whatever, save them or do what
you can, but you can't save them but so long. In other words, you know, if it's there,
you know, you need to get something out of them while you can, because they're
eventually going to die or they're going to get killed or something. It's got a cycle to it.
I don't know exactly what the right cycle is, but I'd say three or four years. [ ] And
they're going to die anyway. They're going to spawn themselves to death, you know.”
-- Fisherman
“It’s a combination of a lot of things. I’ve always thought, and it could be the same thing with oysters, they’ve got cycles, maybe over the years. Maybe there will be a few years one good thing, and a few years there’ll be something else good, you know. I always thought fisheries worked in cycles. But for the last ten years, I’ve been thinking there’s something stopping the cycle. I really do.” -- Fisherman

Fishermen believe that there is a cyclical pattern to environmental change and that the pattern is unpredictable. There is no way to tell when something will change, just that it will change.

“See, they were talking about planting all these places around here, these creeks, to get, to catch a big oyster spawn. See, the oysters were about all gone. It was hard to even catch four or five bushels a day, working hard, I mean, it got so bad, you know. So, there weren’t many around. But the next year, the lumps out in the river, they were caught slam full. They caught back just that quick. Everybody was going. It don’t take many oysters to get some spawn.” -- Fisherman

“And a lot of things that's happened down there to Louisiana and them places, especially with them hurricanes and all, a lot of that - we have got - I'm not an Al Gore man, don't get me wrong. But the water is getting higher. In my lifetime, the water right here is probably ten to twelve inches higher. You know, I don't need him to tell me that. You can go to Tangier Island and whatever, and it's happening. Down there they've had these hurricanes, you know, lately, kind of beating up on them pretty strong. Down there where the marsh was, and it's gotten beat down flat, and it's down now where it's probably three or four feet of water over that, the oysters have took in that just like I'm telling you here. And they've had a bonanza. And they have built these barges-types, and they pull four dredges. And they're just loaded with oysters now, on bottom a few years ago that was sitting high and now it's under. It's unbelievable. And the oysters is going with it. It's unbelievable how it's going. So, they've had different changes.” -- Fisherman

A perception of change as unpredictable reveals a perception of the non-human world as something that is beyond human knowledge and comprehension. It depicts non-human forces as more powerful than human ones in a world where humans can never fully know the impact of their interventions (Blair 2009). In order to survive in such a world, fishermen must expect and embrace changes occurring over large time scales at uncertain intervals. They do not seem to consider such changes to be fundamental changes (Blair 2009). Instead, environmental change is a long accommodated reality that determines what is possible. The abstraction of a fisheries model seems far removed from their reality.
The fishery that I know about, the long haul net fishery in North Carolina, continually is declining, in spite of all that Fisheries have done. That tells me there's something controlling it besides man. If they could have fixed it, they would have fixed it. Not that they don't want to. They want to fix it. They want to see fisheries rebound. But it's continually going downhill all the time.” -- Fisherman

“But anyway - but oysters can't truly be managed, other than opening and closing it, and trying to leave enough stuff there for the next year, and hoping for the best. That's the only management tool you've really got. For anybody to be able to tell you they know how to have oysters every year, year-in and year-out, they're fooling you. I can't tell you that, and nobody else can, and be truthful. But they can't do it with any fishery, either. But all you can do is say, "Well, this has been caught down enough," and close it. ‘We'll open it up back up next year.’” -- Fish dealer

“And I ain't got all the answers. There are people there to Morehead, and they've got their PhDs and their Masters and all that. And they come up with these figures, you know, a certain pound. They don't know that. There's no way. That's just guesswork. Yet, they'll base regulations on guesswork. They call that science. They've got the science, they say, behind it, but it's false science. I read a piece in the paper about three weeks ago, the county paper, where somebody said there was 2.3 million pounds of gray trout in North Carolina. They don't know that. There's no doubt there's a problem with gray trout in North Carolina, but they don't know. How can you know? All the sounds and rivers and the coastal waters and the ocean waters in North Carolina, how can a man come up and say, "There's 2.3 million pounds of gray trout in North Carolina?" -- Fisherman

“And just because you don't see it, that doesn't mean it's not there. And, you see, there's a lot of area that fish can be, I mean, you know.” -- Fish dealer

For fishermen, fisheries management appears foolish by asserting that a person should fish based on modeled projections of a fish population because fishermen believe that nature is fickle or cyclical and cannot be predicted (Minnegal and Dwyer 2008a).

Fishermen have adopted behaviors for adaptability in response to this uncertainty.

“So, what have you got to do? You've got to quit. That's the only thing you've got left. And that's what everybody does. In other words, you just go on to something else. I reckon that's, like I say, you know, whatever is going on, you do it. That's the way fishing is. You do what you got to do, and you go on to something else. You can't depend on one thing being there for you all the time.” -- Fisherman

By employing strategies of diversification and prey switching when abundance or pricing are low, fishermen manage the risks inherent in the variable environments of the ocean and marketplace. They perceive this kind of risk management as becoming increasingly difficult with the implementation of limited entry programs and other kinds of regulations that lead to specialization. Specialization results in greater vulnerability to variation in fish populations.
“But a commercial fisherman will never destroy a resource because he depends on it for a living. And when it gets down to a point that he can't make it, he'll switch and do something else. You know, he'll never deplete that stock. The economics of it won't allow it. It's just simple economics is all it is. But what is happening is they're tightening the box, like you don't have the latitude to move from one fishery to another like you used to.” -- Fish dealer

“And that's the biggest problem I see now with management strategy. They're isolating people into certain sections of this industry. When I was a boy, back when I was talking about, if you were willing to work, if oysters played out, you could go flounder fishing, or you could go horn-dogging, or you could do anything. You know, you could go do something else. Well, now, they're saying if you ain't flounder-fished for these years, you can't go flounder fishing, and you can't go horn-dogging, and you can't go crabbing, and you can't go sand-sharking. And they're locking them into just two or three industries.

Well, when those industries have these down cycles, which they all - all sectors of this industry does have those. When they have them, those people are going to be left out in the cold. They're not going to be able to go somewhere else and survive, like we used to. And that's part of the reason the oyster management is backwards.

When we used to have oysters, these bays would get worked two or three weeks out of the year, and that was it. And we'd go in the sound and we'd find more oysters. If that started playing out, we might go to West Bay, we might go to Neuse River, we might go down to Bluff, we might go to Stumpy Point, and find more oysters, or not. But we could catch enough oysters if we found some oysters to make it worth going after them.

With the bushel limits like they are, you can't do that. You can't afford to run six hours one way for fifteen. You can't do it. It's just not feasible. You're better off to stay here and catch five that you know you're going to get and do it every day. And that's what happens: the places get worked down too low with a bushel limit. They won't -they could do a weekly limit. They claim that they can't, but they could. They could do a weekly limit and say, "Well, we're going to give you seventy-five a week." -- Fish dealer

Fishermen manage perceived cycles in nature by practicing prey switching or moving in and out of different fisheries in response to changes in catch success. Switching will be hampered if participation in a fishery in a given season is predicated on recent past participation. When fishermen cannot participate in other winter fisheries, either because the fisheries are not productive or entry is prevented, they will typically turn to the oyster fishery. The daily bushel limits in place in the oyster fishery, which fishermen agree are needed to protect the resource, mean that the economic gains from a day of harvesting oysters do not compensate for the expense of making long transits day after day to oyster grounds.
Because going further a field is financially unsustainable when fuel prices are elevated, participants in the fishery, tend to stay closer to port and accept catching a smaller amount everyday, day after day. According to the fishing informants, this is how oyster beds get overworked. With a weekly limit instead of a daily limit on oysters, fishermen might retain greater adaptive capacity, which would allow them to choose when and where to go further into the sound to oyster. Making these decisions could spread harvest effort spatially.

Within modern fisheries management, there tends to be only limited recognition of the capacity of fishermen to respond to threats and opportunities in ways that may enhance their own interests, and thus of the mismatch that can arise between the practice of fishing and the intentions of fisheries management (Minnegal and Dwyer 2008b). As a result, fishermen are repositioned from contexts in which risk is significant to contexts in which uncertainty is increasingly important (Minnegal and Dwyer 2008b). Risk describes situations in which actors are able to assess the likelihood that a particular event may occur while uncertainty encompasses contexts in which no such assessment is possible (Cashdan 1990). In a context of risk, fishermen orient to their past and draw on previous experience, knowledge, and skill to make decisions (Dwyer and Minnegal 2006).

“So, you don't ever know. You don't go, "I know I'm going to do that next year over there." No, you don't do that. You've got to start working. If you don't do it there, you go over there and the first thing you know, "Oh, right here this year, that's where I'll be there." That's what you do, see, and chances are, you'll do good there. I've seen it when in some areas there wouldn't be nothing, you know, and you say, "Oh, durn, there ain't going to be nothing this year." But you keep on moving and first thing you know, say, "All right!" When you find out where they're at, they're right there on it, you know, and you can catch them right off of it for a ways or whatever. But it's just a matter of going out there and seeing. Like I say, you can't predict.” -- Fisherman

To make decisions, fishermen use the skills gained over years on the water to assess current conditions and risks, instead of attempting to predict future conditions. Fisheries models often must employ incomplete or questionable data to predict the future status of a
stock. By doing so, fisheries management links scientific uncertainty with allowable exploitation forcing fishermen into a context of uncertainty (Dwyer and Minnegal 2006).

“North Carolina has been a little bit better. We are developing some more good models of circulation. We’re getting a little better idea about where to put oysters. We’re still doing science, so we’ll still have to figure it out. The state is aware of those issues. They’re trying to make their best guesses. They’re making mistakes. But I won’t say it’s money wasted, because they’re making the best guesses they can from the available information. And where it doesn’t work, it’s not because there wasn’t an attempt to use what was there. It’s just - it’s faulty still. And I’d rather for them to try something than nothing, because if we just keep waiting and waiting until we know everything, it’s going to be too late. So, I think we’ve been a little bit better about it. I think part of the kudos go to simply the fact that we can pay attention to those areas that didn’t do so well. And so, you know, that helps.” -- Scientist

Continuing research is improving the science available to manage and restore oysters, but uncertainties remain. The quote above outlines a precautionary approach such that management proceeds with caution when information is uncertain, unreliable, or inadequate, but does not use the absence of adequate scientific information as a reason for postponing management measures (FAO 1996). In this world of institutionalized uncertainty, fishermen’s past experience is of limited use. This amounts to a crisis. According to Minnegal and Dwyer (2008a), an uncertainty paradox exists such that in seeking to sustain a system of natural resources through attention to the uncertainties inherent in those systems, scientists and managers may, unwittingly, create an experience of uncertainty that has deleterious consequences for the physical and mental health of the individuals that are dependent upon those resources and the sustainability of their communities.

The precautionary approach implies both sustainable usage of resources and protection of fishing communities. This is consistent with the Magnuson-Stevens Fishery Conservation and Management Act requirement that management plans provide for sustained participation of fishing communities and minimize adverse economic impacts on them. However, despite increasingly stringent management attempts to address uncertainty,
there is little evidence that these measures have ensured the sustainability of fish populations or enhanced the viability of fishing communities (Dwyer and Minnegal 2006).

4.4.5. Shortcomings of the Methodology

There are numerous problems for oyster populations of North Carolina and those that are of concern to stakeholders are heterogeneous. The concern mapping method is a useful tool for eliciting concerns from stakeholders, but there are limitations to its value in the current case. A major shortcoming is attempting to rank factors that are interconnected.

“There are a lot of those things that are intertwined. And so by putting them in just one particular order, that doesn’t... If you’ve got one thing right you may actually take out a couple other things. And therefore, so they’re tied together.” -- Conservation practitioner

“It’s really hard to fix a problem you can’t articulate, [laughs] which is the situation we find ourselves in, with due respect to the economy and health care. [Laughing] Why are the banks failing? But I think – there’s actually sort of two ways of looking at this. How did we get here? You know, what problems brought us to this? Or what problems are keeping us here? And I see those as being – you would approach those differently, with respect to solving them.” -- Scientist

“So many of them interact. It’s a question of the Stone Age, not a question of today. And one of the major papers...showed how the hypoxia risk and the effect on reef elevation by mining the oyster reef interact. So, if your oyster reef stands up two meters, it can stick up into waters that are mixed with surface waves and wind with oxygen. But if your reef is degraded, then down below the oxy-cline, when the waters stratify, then the death of oysters there is a joint effect of the fact that there’s bad water down below, plus a low reef that shouldn’t be low but should be high. And so many of these others are interacting factors as well. Specifically take the sedimentation. A tall reef there is much more resistant to damage from sedimentation, because while its base might get covered and uncovered just by shifting stuff, the top sticks up. And similarly, because the physics of higher flows as you get away from the benthic boundary, that sedimentation that’s derived from clam kicking or derived from trawling or derived from bad land practices will get swept off a tall reef when it then settles on with the more slow energy, low energy environment of a short reef. So, I rant and rave about over-simplification and prioritization.” -- Scientist

“It’s completely artificial. They’re all interconnected. And you can't work on one without working on the other and everything. No, I mean, it’s a very superficial thing to do. Well, I guess I should say over-simplistic. It’s over-simplistic. ... And obviously every marine ecosystem in the country at some point in time in the very recent past has, you know, ecosystem management as one of the top priorities. That's one thing we've learned in the last twenty years of fisheries research is that, you know, ecosystem based science is where we need to be. We don’t have the tools, you
know, statistically, mathematically, data limitations, to manage that way. ... But it's where we have to go, you know, to do this right.” -- Scientist

“I think, really, any one of them three, you know, are interchangeable, some kind of way.” -- Fish dealer

These and other informants describe complex circumstances and interactions that mandate a complex, holistic, system-level approach. An ecosystem-based approach to fisheries is one that explicitly considers the interconnectedness of ecosystems and applies ecological principles to efforts to integrate the management of activities that affect the estuarine and marine environments (Levin and Lubchenco 2008). In this sort of approach, a ranking system for threats to survival and sustainability is far too simplistic. However, there were important reasons for pursuing this line of questioning. Part of my interest in using this technique was to get a sense of how stakeholders think about these problems, i.e., Why are oysters a “species of concern”? Why have over half a century of management efforts not changed this status? What factors need to be addressed? Use of the participatory concern mapping methodology revealed important differences in perception among stakeholder groups. Subsequent discussion around the ranking exercise provided insight into how stakeholders conceptualize the complexity of restoring oysters.

The interconnectedness of so many of the concerns informants mentioned makes categorization of responses difficult. For example, many informants discussed how burgeoning populations promote more coastal development, which increases the amount of runoff, sediment, and pollutants entering coastal waterways and estuaries. Are these one concern or several or more? Similarly, harvest and reef habitat quality are related issues. When an informant describes dredging as destructive and then lists habitat degradation separately, are these the same concern or separate ones? Because the index cards were recorded as informants were talking and then shared with them immediately afterward such that they could be corrected, I feel the cards are a valid reflection of how concerns are
perceived. In addition, because different informants used different terminology to represent the same concern or concept, the data were potentially subjected to my own subjectivity during categorization. In practice, categorization was not too difficult because if the word choice on the cards seemed unclear during processing and analysis, I could refer back to the audio recordings of the interviews to listen to how informants talked about their concerns and assess how informants were using different terms and concepts in order to categorize them properly. Ultimately, the utility of the mapping tool is to illuminate how informants think about the problems facing oysters in North Carolina and articulate a vision for what must be addressed in a restoration plan.

Another potential shortcoming of my adaptation of the mapping methodology is limited replication. The technique, as developed by Smith et al. (2000), was first applied to a sample of N=120. The smallest sample size in a study utilizing this methodology that I could find in the literature is N=46 (Tschakert and Singha 2007). My goal was to compare concerns among stakeholders groups. Distribution of the total N across 6 groups meant that each group N was small. However, the concerns of the members of each group are relatively similar and more similar to each other than to other groups.

4.4.6. Usefulness of Analytical Addition

Application of Fisher’s exact test is not part of the original mapping methodology, and its utilization is not a seamless addition. Fisher’s exact test can determine differences among groups when samples sizes are small and resulting contingency tables have many zeros and low values, which invalidate using a Chi-square test. To create the contingency table for this test, I assigned the 22 individual types of concerns mentioned by informants to 8 broad categories. The resulting 6x8 table still contained many small values and did not show significant differences among groups. A 6X22 table would likely tell us even less.
Conflating informant concerns in this way is artificial. It is best to let the informants decide what is the best categorization for concerns and my doing so post hoc imposes my organizational scheme onto how informants understand the problems for North Carolina’s oysters. The intent of doing a free-listing task with each informant was to highlight the heterogeneity in perceptions across individuals and groups. While the concerns “runoff” and “pollutants” are both aspects of a broader “water quality” issue, when an informant lists and discusses them separately, s/he likely has a reason for doing so. Assigning both of them to one category during data analysis erases some of difference and specificity that I was seeking to understand. Otherwise, I could have presented each informant with a list of possible problems and concerns and asked which ones concern them. Asking informants to choose amongst standard broad responses that could encompass many different concerns would mask some of the variation among informants. Aggregating concerns for analysis impedes the process of unpacking the concept of concern.

What this test statistic does show us is that, considered across broad categories of concerns, mentioning concerns for North Carolina’s oysters is independent of stakeholder group assignment. Still, because sample size is limited, it is difficult to fully accept the null case. Including more informants might show differences among groups. In addition, because the data used in the calculation were not ranked (i.e. the numbers in the table are counts of times a concern in that category was mentioned or step one of the mapping methodology), this test cannot illuminate the differences in perceived importance of concerns among informants. These differences are critical to understanding what types of management, conservation, and restoration measures informants would support.
Part of the aim of banishing uncertainty from our understanding of natural systems is to be able to predict their future states and analyze the costs and benefits of management decisions. Fisheries scientists, those who use fisheries resources, and other stakeholders hold different views about the ways in which the oceans work and therefore have different ideas about how to manage them. An encounter between stakeholders entails a struggle over meanings, resources, perspectives on the value of and desire for fish, and means of management as two systems of knowledge call the other into question. Managers tend to take a linear approach that involves identifying relevant variables and conducting a stock assessment to determine levels of sustainable harvest (Smith 1990). Sustainable oyster harvest is not currently calculated in North Carolina, but management is considering adopting a standing stock survey method based on density estimates of harvested and non-harvested areas (NCDMF 2008). The standard theory underlying stock assessments offers fisheries policy-makers options for “what to do” that are derived from the premises that 1) less fishing effort means more spawners and 2) more spawners means more recruits (Wilson and Kleban 1992). According to this view of fisheries, fishermen will have more fish, better income, and more stability while consumers will eat more fish at lower prices and stocks will be restored (Wilson and Kleban 1992).

Linear approaches to management tend to be rejected by resource users because they violate user perceptions of what are relevant data (Dyer 1994). To resource users, the very natures of marine and coastal systems prevent the development of comprehensive forecasting abilities.

“Yeah. You can't predict. That's one thing about fishing. You can take all the biologists, and all the Marine Fisheries, or anybody, the scientists, anything you want to, and they're not going to take care of Mother Nature out there. They might change up a few things here or there, do some things. But, they - you know, it's going to take care of itself. It's on its own. There's too many things, you know, variables, to say ...
Fishermen cite the mysteries of Mother Nature and God’s plan in rejecting the notion that ecosystem trends can be predicted or managed. Resource users tend to take a non-linear view of nature as non-random but unpredictable based on their awareness of these mysteries or chaos in the system (Smith 1990, Smith 1995). Chaos does not offer any prescriptions for “what to do” to manage fisheries. Chaos points to complicated chains of causation that are more intimately tied to other interactions within the ecosystem (Wilson and Kleban 1992, Smith 1995).

Both linear and non-linear views are cultural constructions. Differences between linear and non-linear views of nature likely involve different constructs of time (Ward and Weeks 1994). The non-linear view critiques management for not portraying the cyclical nature of changes in oyster abundance. This view arises from spending a career’s worth of days on the water, observing changes and perceiving a cycle to those changes. Fishing informants tend to be critical of annual assessments, which they consider mere snapshots of the populations. Landings data as reality erase the on-the-water reality of the fishermen.

In addition to being the proxy for population size, landings are also the only things management can control. NCDMF has no control over salinity, disease, runoff, storms, or pollutants, though many more recent management initiatives are attempting to overcome their impacts. So while these factors are recognized as contributors to population status, they are excluded from the NCDMF construct of harvest. NCDMF can control harvest, so this becomes the factor through which stakeholders interact: defining how harvest relates to the other factors in oyster survival. Even though most stakeholders agree that overharvest is not presently a problem, mode of harvest remains a contentious issue. According to many
conservation informants and some science informants, dredging negatively impacts oysters population growth and sustainability by destroying substrate and habitat and reducing habitat quality (e.g. reef height). They claim that fishermen continue to dredge for oysters because it is more economically productive at the expense of future production, habitat quality, and other ecosystem services. However, many fish dealers and those fishermen who dredge maintain that doing so is vital to continued oyster bottom productivity because it cleans away sediment, and exposes clean shell for spat attachment. All of these stakeholders desire enhanced oyster sustainability, but they have different ideas about how to contribute to that cause.

Knowledge production of environmental risks regularly includes the experiences and insights of persons other than scientists (Lidskog 2000). Managing risk in chaotic fisheries depends on information and knowledge about those ecological parameters of the fishery that are relatively stable (Wilson and Kleban 1992). This is the kind of knowledge that fishermen acquire through observation and experience. Fishermen have long been suspicious of the data fisheries managers and scientists use to develop conservation measures (Acheson and Wilson 1996). When the fishermen themselves are the sources of these data and they provide false information, they know the science is flawed. To be successful, fishermen must know a great deal about the habits of various species including feeding, predation, life cycle, and seasonal movements. They can contribute important geomorphological information including bottom types and boundaries, which can improve our understanding and mapping of the seascape (Williams and Bax 2007). Based on this knowledge, fishermen give accurate observational input that is important in generating rules to conserve a species. Those who exploit a species know a great deal about what influences its numbers, and their conservation rules are designed to maintain those biological processes they know or believe are essential for stock well-being and their livelihoods.
(Acheson and Wilson 1996). However, they may not have adequate understanding of important interdisciplinary processes to correctly interpret the observations.

Consequently a theory of chaotic fisheries is consistent, not only with the perspective of fishermen, but also with the kinds of institutions and management techniques fishermen are likely to devise for the governance of fisheries (Wilson and Kleban 1992, Wilson et al. 1994, Cinner and Aswani 2007). Management based on this kind of knowledge may not only be an effective way to conserve our fisheries resources, but it is also likely to be a management approach that is credible with fishermen (Smith 1995). Fishermen believe that fisheries are chaotic so policies that ignore this seem ineffective, unrealistic, or foolish (Acheson and Wilson 1996). Policies appropriate to the management of a chaotic fishery are derived from a working knowledge of the basic ecological interactions in the system and can be viewed as an extension of the ecological parameters of the fishery (Wilson and Kleban 1992). In this regard, calls to manage for the complexity of a fishery are similar to arguments for ecosystem-based approaches to fishery management. Such policies are also essentially the technology and rules that govern fishermen’s interactions with the system (Wilson and Kleban 1992). Cues from practical experience knowledge and traditional management systems cannot be applied without thoughtfulness because there is limited hard evidence they conserve marine and estuarine resources: where they are assumed to have been effective, many other factors could have affected populations (Acheson and Wilson 1996).

Resource management and conservation organizations advocate for the use of practical experience knowledge in fisheries management as a means of addressing the perceived holes in the fisheries science prescriptions being applied to the fisheries issues. In North Carolina, resource managers and biologists in NCDMF’s oyster program hold public meetings to discuss locations for planting cultch material and conduct pre-season sampling with fishermen using fishermen’s boats and rigs. Management and conservation informants
speak respectfully of fishermen’s knowledge of the estuarine systems they work within. Ultimately though, discussions with fishing informants did not reflect this, with references to various occasions of feeling disrespected and disregarded. While the North Carolina oyster fishery may currently be much less controversial than others, such as flounder, speckled trout, and dogfish, a feeling of unease and suspicion on the part of fishermen towards management seems to seep from these other fisheries into oystering. Addressing lingering differences in perceptions of the concerns for oysters and the oyster industry in North Carolina may demand renewed efforts to more fully hybridize different forms of knowledge.

This research does not advocate for a linear or non-linear approach, but instead, recognizes there could be benefits from renewed efforts to hybridize the two. Conversations about concerns for North Carolina’s oyster populations with a cross-section of stakeholders reveal the importance of reassessing the oyster debate from other than the dominant or published perspective and offer some documentation of the counter-narrative to the dominant discourse. It reveals that how groups conceptualize nature is critical to understanding inter-group conflict over resources as well as differences in perception of resource risks, problems, and concerns. For example, while some in the fishing and industry groups describe oyster harvest as, in part, the result of an unpredictable and vast entity called Nature or God’s plan, they also describe a working relationship with nature, such that their own actions doing the work of harvest promote continued oyster production. Their work is intimately linked within nature. Therefore they do not perceive dredging, within limits, as a problem for oysters. Many in the management group also had limited concerns about dredging, but such perceptions contrast with some other informants who view dredging as a negative force that is applied to nature.

As with many resource dependent communities with a relatively recent history of geographic and cultural isolation, North Carolina fishing communities have been
tremendously impacted by the influx of outsiders especially government agencies, environmental organizations and tourists. It is not environmental protection or stock management per se that fishing communities are opposed to, but the perceived use of it as an agent to usurp the control the fishing industry feels it can exert over its own destiny (Rikoon 2006). Stakeholders view these and other concerns through cultural or cognitive models that filter experiences, knowledge, and perception, largely without awareness (Lidskog 2000). Understanding how locals perceive the main problems associated with resource use is important to designing successful community-based management regimes (Quinn et al. 2003, Aswani et al. 2007).
References


Chapter 5

ONE SHELLFISH, MULTIPLE VALUES: CULTURAL MODELS FOR UNDERSTANDING OYSTER RESTORATION IN NORTH CAROLINA

Abstract

Ecosystem- and process-based approaches to fisheries management and restoration focus on the interconnectedness of ecological systems. The interconnectedness extends beyond geographical, ecological, and physical factors to incorporate cultural and social factors as well. Culture is an adaptive system of beliefs and values, knowledge and perceptions, that gives meaning to environmental decision-making and actions. In this study, I examined whether perceptions of oysters and oyster restoration efforts in North Carolina differ among stakeholder groups and if the degree of difference in these perceptions suggests shared or distinct underlying cultural models in order to understand how the meanings, knowledge, and perceptions that people have about oysters sharp their perspectives and attitudes towards oyster resource use, management and restoration.

Eastern oysters (*Crassostrea virginica*) support a winter-time fishery and supply ecological benefits such as habitat provision and water filtration through the ecosystem services they perform. To elucidate the cultural models, I conducted semi-structured interviews with informants in six stakeholder groups (fisheries managers, fishermen who harvest oysters, fish dealers/shellfish processors, shellfish growers, scientific researchers, and conservation practitioners).

Each stakeholder group’s cultural model is unique in certain propositions, but there are also important overlapping perspectives among all of the models. Stakeholders consider
oyster restoration a success when it encompasses economic, ecological, and heritage values. Even though the economic value of the ecological benefits of oysters transcends their economic value as a fishery, successful restoration is about what stakeholders want the world they live in to look like, not what makes sense economically. They value a connection to the water that includes a wild oyster fishery. The complexity of both individual and group values and knowledge about specific places, processes, and resources suggests that there may not be right answers to management questions, but rather cultural plurality, which informs notions of right and wrong behavior towards nature.

5.1 Introduction

Bounded by more than 8,000 miles of shoreline, North Carolina’s extensive estuarine landscape is ecologically complex, with great local and regional variation in habitat and associated fauna influenced by changes in climate, geology, hydrology, land use, and human population. The geographic and ecological characteristics of this landscape are even more complex when considered from the varied perspectives of human stakeholders. The well-being of the system matters to a variety of individuals and groups. The estuaries provide commercial fishermen with livelihoods that support their families and ways of life. For scientists, they are the setting for research and its application. For environmentalists, they are a symbol of the wonders of nature slowly being encroached upon by development. For residents of North Carolina’s coastal counties, connections to the landscape are sources of pride and identity. For visitors, the estuaries are sites of recreation, aesthetic enjoyment, relaxation, and exploration. The use, study, protection, and appreciation of these systems tie together the sentiments, knowledge, and perspectives of many different groups and individuals. North Carolina’s estuarine landscape is a touchstone for ecological values and beliefs, a connection to the past, and a reminder of the inevitability of future change.
Situated within this complex and changing estuarine landscape are the state’s coastal commercial fisheries. The top commercial fishery species landed in North Carolina in 2008 - blue crab, shrimp, croaker, southern flounder, and summer flounder - spend considerable portions of their life history in estuarine waters. The economic impact or secondary effects of commercial fishing in North Carolina, which include indirect impacts generated by the purchase of intermediate goods and services used by fishermen and the induced impact from their household expenditures, was over $152 million in 2008, an increase from $115 million in 2005 back to its approximate value at the beginning of the decade ($147 million in 2001) (NCDMF 2009). Data on the value of North Carolina commercial fisheries for finfish and shellfish, inflation adjusted to the base year 1972, are available for the period 1972 to 2007. The value of finfish commercial fisheries increased from 1972 to a maximum value of $19 million in 1979 and then remained steady until 1990 after which it experienced a slight decrease followed by a slight increase until 1997 (Fig. 5.1) (McInerny and Bianchi 2009). Declining again after 1997, it remained relatively steady until 2007. The value of commercial fisheries for shellfish declined from 1976 to 1980 (Fig. 5.1) (McInerny and Bianchi 2009). Remaining steady until 1993, the value reached a maximum of nearly $18 million in 1994. It then declined until 2006, but increased the following year.
A critical component of sustaining fisheries involves making habitat conservation and restoration explicit components of fisheries management and shifting the predominant management paradigm to a more ecosystem-based approach (Pikitch et al. 2004). The historical fishery-science management approach of managing single stocks and societal preferences for iconic species have resulted in a large number rehabilitation efforts that favor certain species by implementing short-term management schemes. Ecosystem-based management (EBM) is a more integrated approach to management that explicitly considers the interconnectedness of ecosystems, the interactions among ecosystem components, including humans, and the cumulative impacts of multiple activities (Christensen et al. 1996, McLeod et al. 2005, Leslie and McLeod 2007). EBM approaches to coastal and marine systems focus on protecting ecosystem structure, function, and process to secure long-term sustainability of marine ecosystem health, services, production, and resilience, and the human communities that depend upon them (McLeod et al. 2005, Levin and Lubchenco 2008).
The need for this shift to integrated resource management in North Carolina has been described this way by a state fisheries management agency staff member: “We don’t need to be managing just fish over here, and the fish people aren’t talking to the Environmental Management people, and they’re not talking with the Coastal Resources people.” The Coastal Habitat Protection Plans (CHPPs) provision of the North Carolina Fisheries Reform Act of 1997 recognizes the importance of the state’s fisheries and symbolizes a desire to improve fisheries management through more ecosystem-level management initiatives and a focus on fish habitat. The CHPPs seek long-term enhancement of fisheries associated with coastal habitats by identifying threats and recommending actions to protect and restore the habitats that are critical to North Carolina’s coastal fishery resources (Street et al. 2004).

5.1.1. Integrating Interests: Consider the Oyster

Shell bottom is one of the six CHPP habitats. Oysters are the principal builders of natural shell bottom in the state’s estuaries. While all six of the CHPP habitats support the state’s fisheries, this is the only CHPP habitat that is itself a fishery species. As with the use and protection of the estuarine system in which they live, there are diverse interests in the use and protection of oysters.

“It used to be a big thing here. Used to, in the winter, that's what - I would say that directly or indirectly probably ninety percent of the people here depended on it. You had the wintertime in December until about the twentieth of January. My father was a hunters’ guide. He carried hunters in the wintertime a lot of times. The days he didn't have parties, if it were pretty, he'd be oystering. So, it was a mainstay. But I don't know. I think what happened in oysters, a lot of it, when it first started there were oyster rocks everywheres. I've heard some of the older people talk about it. It used to be solid oyster rocks. And when the '33 hurricane come, it destroyed it. ... I mean, it's adequate now. ... It would never be a great big fishery anymore, because they have limits set onto it. And they need to be, because there's not a - you know, the resource isn't there like we had before. But even at that, if they had it like hand harvest. If a man could go out here, hand harvest, and catch five bushels a day, he could get twenty-five dollars a bushel for them. He could cull them up good and he could get twenty-five or thirty dollars a bushel for them, easy. Well, five days a week, you wouldn't get five days a week. Probably at best you'd get maybe three in the wintertime. But that's better than
nothing, a whole lot better than nothing. When you work with a natural resource or work with your hands, the first thing you need to put in perspective is a little bit of something is worth a whole lot of nothing. And that's the way you have to approach it. Every day is not a holiday, and every meal is not a feast.” -- Fish dealer

“And we'd walk through, and when we'd get just about to the river, you could smell that marsh smell, and you couldn't wait to get onto there. And then we'd get out and go out there - walk out onto the rocks. You could walk out onto the oyster rocks and gather oysters, and come back and build a fire, and get up there on the shore and roast them. And Mama would take cornbread and a gallon of water, and we'd set up there. And Daddy would gather us all around. There was eight of us. I don't know whether all of us was there every time. But he'd gather us around, and we'd kneel and pray, and then we'd eat them oysters. And I thought that was some of the best times.” -- Shellfish dealer

“I've also gotten very interested in oyster habitats, initially as a structural habitat that's critically important for a variety of species like blue crabs, which are commercially important, finfish, as well as other benthic animals, and then later just interested in oyster restoration in its own right for the various ecosystem functions that oysters provide, including shoreline stabilization, habitat provision, filtration, as well as productivity. Now, with respect to oysters in particular, we're conducting work with shoreline stabilization, being conducted both with private groups and municipalities. We're doing habitat restoration projects and looking at what characteristics of reefs provide greatest utilization by the most diverse set of fauna as well as higher abundances of target species. We're looking a little bit about the interaction between filtration and water quality, and water quality in reducing filtration. And, to a lesser extent, looking at just characteristics of the oysters themselves that may affect productivity and transplant and other aspects.” -- Scientist

“Oysters are an important part of the landscape here, so when you're kayaking, oysters are a dominant component of the system that you're in.” -- Scientist

“And an oyster roast - I like to have - to go to oyster roasts. They're fun, you know. But I won't scarf down - I'll scarf down maybe a dozen, and I have friends that will eat three and four dozen at a time. Yeah. [Laughs] … So that, you know, when in January and in February, you know, like to have a party at your house and fire up a pig cooker with oysters on it, I mean, it's what people do. You know, it's such a part of the tradition here.” -- Conservation practitioner

Oysters are an historically important fishery that provides commercial fishermen with important winter income and supports populations of other fishery species. Scientists study oysters to understand how they function and how restoring them can contribute to improved estuarine health and water quality. For environmentalists, their troubled populations are emblematic of the effects of water pollution, and coastal development on our estuaries. For residents and visitors to North Carolina’s coast, oysters are a part of the distinctly local fare and landscape.
The evolution of efforts to manage the oyster fishery and restore oyster habitat into more ecosystem-based efforts will bring more changes to the already fundamentally altered oyster ecosystem. At issue is the balance between the physical/ecological environment and the socio-cultural needs of the region. How will different stakeholders and their concerns fare? Fisheries management is concerned with the conservation and sustainability of fishery resources and aquatic ecosystems through management of the biological aspects of the system. The state’s fisheries management agency is tasked with taking into account the socio-cultural aspects of the human relationship with the estuarine landscape. Insight into the perspectives, beliefs, and values of the community of stakeholders would facilitate this accounting and inclusion.

This chapter investigates stakeholder perspectives through two guiding research questions:

1. Do perceptions of oysters and oyster restoration efforts in North Carolina differ among stakeholder groups?
2. Does the degree of difference in these perceptions suggest shared or disparate underlying cultural-ecological models?

Documenting shared cultural models among stakeholders could have important regulatory and policy implications. Identification of the knowledge, values, and beliefs that structure these models will improve our understanding of how stakeholders will respond to management and restoration decisions and of the impacts of those decisions. My objectives in addressing these questions are to identify the explicit and implicit cultural-ecological knowledge that different stakeholder groups have about oysters and use in combination with beliefs and values used by different stakeholder groups to form their perspectives and perceptions of oyster, management, and restoration through a cultural modeling approach.
5.2. The Cultural Model Approach

Culture, as a complex that includes knowledge, belief, art, morals, law, and custom, amongst other capabilities and habits acquired as a member of society, is critical to the comprehension and construction of a group’s understanding of and relationship to the natural world (Power and Paolisso 2005). As opposed to a study of culture as objects in time and space to be studied and catalogued, culture as an adaptive system of beliefs and values can be studied for its effects on how a group utilizes, protects, manages, and restores natural resources. Beliefs are what people think the world is like, and values are their guiding principles for deciding what is moral, just or right (Kempton et al. 1995). Values create meanings, which provide a group with bases for action, telling the group how to live in the world, manage resources, and understand science and nature (Power and Paolisso 2005).

A mental or cultural model research approach seeks to understand these meanings. A mental model is a simplified representation of the world that allows a person to interpret observations, generate inferences, and solve problems (Kempton et al. 1995). Shared mental models can be considered cultural models. Cultural models are widely shared, though not exclusively, by members of a group or society as taken for granted frameworks for understanding the world around them and their behavior in it (Quinn and Holland 1987). By integrating values and beliefs about religion, spirituality, nature, morality, work, independence, and responsibility with experience-based ecological and economic knowledge, cultural models interpret experiences, provide goals for action, and represent deeply held truths (Paolisso 2002). Cultural models are not recognized explicitly by those who hold them, but when elucidated, the structure of a cultural model offers an outline of how the group conceptualizes the world around them (Quinn and Holland 1987). Like scientific theories, cultural models make sense of most of what people see (Kempton et al.
Unlike an expert’s theory, cultural models are only used when they are suitable and are not applied in a consistent manner (Quinn and Holland 1987). In fact there are conflicting cultural models in many domains such that individuals can hold onto more than one at a time or trade part of one model for another or switch between competing models depending on the circumstances at hand (Quinn and Holland 1987).

Models are composed of interconnecting building blocks or schemas arranged in a nested hierarchy (D’Andrade 1987). A schema might be an image (e.g. “oyster habitat”) or a proposition (e.g. “harvest needs to regulated (or not)”; “oysters provide ecosystem services”) (Quinn and Holland 1987). Linked together, schemas organize culturally shared knowledge to create a model that is a storyline chain of events unfolding in a sequence of simplified phrases (Quinn and Holland 1987). The metaphors that individuals use provide clues to the schemas being used (Quinn 1987). Metaphors and other analogies allow an individual to construct new models by mapping their knowledge of one domain onto another, unknown domain (Collins and Genter 1987). Cultural models are also often revealed in the explanations people offer in discourse. In offering an explanation of why something is the way it is, one presents an understanding of a situation in terms of how one perceives a state of affairs based on the cultural model in use (Power and Paolisso 2005).

A cultural model approach is useful in the study of natural resource management conflicts because it can illustrate the unarticulated reasoning that connects statements and positions made by one group in opposition to another group (Paolisso 2002). Differences in underlying worldviews among groups can result in differences in how they act toward nature and in their goals for conservation or restoration (Medin et al. 2007). As constructions or representations of shared information, cultural models provide a view of how members of a community can talk meaningfully in their own terms about their understandings and experiences (Blount and Kitner 2007).
5.3. Qualitative Research and Data

To address my research objectives, I am taking a cultural model approach. Before I describe the research and methodological framework I have employed to understand whether the perceptions of oysters and oyster restoration efforts in North Carolina differ among stakeholder groups and if the pattern of perceptions suggests a shared (or not) underlying cultural-ecological model, I will provide some of the context and background that influenced the development of this framework. The next sections provide an overview of the use of qualitative research methods, qualitative interviewing, and grounded theory in a cultural model approach followed by detailed descriptions of the data collection and analysis methods.

5.3.1. Quantitative and Qualitative Distinctions

Observing the rich animal life that oystermen collected in their oyster dredges in the late 1800s, Karl Möbius (1877) described an oyster bed as “…a community of living beings, a collection of species, and a massing of individuals, which find here everything necessary for their growth and continuance…a community where the sum of species and individuals, being mutually limited and selected under the average external conditions of life, have, by means of transmission, continued in possession of a certain definite territory.” Möbius’s studies of the order, structure, and function of oyster reefs as they relate to habitat and biotic associations amongst the plants, plankton, benthos, and fish sustained by the reefs were the first descriptions of the interconnections between members of a community and between a community and the abiotic environment to articulate clearly that changes in one factor would result in a form of regulation of other factors (Nyhart 2009). Möbius termed his conception of a community biocoenosis, taken from the Greek words for “life” and “sharing” or “to have something in common”.

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While biocoenosis was a qualitative term, its focus on functional relationships among organisms and between organisms and the physical environment concerned the interactions of organisms not just the relations of descriptive zoological systematics. The quantitative nature of this work made it distinct from the more descriptive and taxonomically-oriented natural history studies of the time. Coincidentally, Möbius’s theorizing about community regulation was part of his work regarding oyster culture and production along the coast of Germany, where annual oyster catches were dropping rapidly (Nyhart 2009). As time went on, studies of biocoenosis from natural history perspectives were increasingly critiqued for perceived low levels of quantitative rigor, predictive power, and generalizability (Kingsland 1991). Ecological research took on a more distinct quantitative dimension. Acquiring a quantitative focus was critical to advancing the field of ecology, but a quantitative focus alone can leave a large realm unexamined, and there are questions it simply cannot address. The main difference between quantitative and qualitative data comes down to the questions being posed (Dey 1993). Quantitative methods answer questions that measure variables that can take on a range of absolute values while measuring relative values to do with meanings and experiences requires qualitative questions and approaches. Using both quantitative and qualitative data and methods to answer different questions on one topic ultimately develops more holistic understanding.

To be sure, qualitative research involves quantitative elements. In the case of oyster restoration, there are important quantitative data to gather and interpret: numbers of organisms, salinity, temperature, spatset, bushels of shells recycled, oysters harvested, income generated, fishing trips per fisherman, and funding spent. These and other aspects of the research are quantitative not just because they collect numerical data, but because their results can be neatly expressed as a table of numbers (Weiss 1994). Quantitative data also result from asking the same questions in the same order of a series of people. Such
standardization will result in the precise rendering of a set of opinions, but such an approach to data analysis does not develop thick descriptions of the phenomenon under study (Dey 1993). Thick descriptions are more thorough and comprehensive than thin descriptions, which only state facts (Dey 1993). Sacrificing uniformity of questions to allow for such development occurs in qualitative interviews. Analyzing data gathered through qualitative interviews relies less on counting and more on summarization, interpretation, and integration of responses that are not as easily categorized and tabulated as quantitative responses (Weiss 1994). Qualitative interviewing can preserve chronological flow, assess local causality, derive fruitful explanations, and make serendipitous discoveries (Miles and Huberman 1984a).

5.3.2. Producing Qualitative Data Through Qualitative Interviewing

Reducing the study of ecological restoration to a solely quantitative undertaking sacrifices something important. Information such as the experience of the work, what it means, and why we do it, are decidedly qualitative and valuable, not merely anecdotal or impressionistic. Making actions meaningful to others and accounting for actions not just in terms of the actors’ intentions – interpreting and explaining qualitative data – requires a conceptual framework through which the actions or events we research are made intelligible (Dey 1993). This framework accounts for patterns in the data, connecting different variables that recur and are problematic for population under study (Glaser 1978).

Qualitative interviews allow informants to provide an observer’s report (Weiss 1994). Qualitative interviews reveal reactions, perceptions, and interpretations of events that have transpired not just a catalog of events. Analyzing data from qualitative interviews allows the researcher to integrate multiple perspectives to describe a phenomenon or process that no one person could have observed in totality or to assemble information about different
processes in order to begin to understand a larger system (Weiss 1994). In these research situations, asking standardized questions will not produce useful results. Departure from a more survey-like approach means that each interview produces greater depth and density of information that really informs (Weiss 1994). This is why I refer to the interviewees in this study as *informants*.

By producing well-grounded, rich descriptions, qualitative data provides enriching insight into the processes and local contexts that ecological research examines (Miles and Huberman 1984a). Inclusion of qualitative research and data in ecological studies expands their multi-disciplinary boundaries and is especially valuable for applied research. For ecologists assessing conservation or restoration policies and practices or addressing other applied questions, qualitative information can provide access to different theoretical perspectives. The main intent of the qualitative research I have undertaken is to develop a theory regarding oyster restoration in North Carolina. By theory, I mean an idea about how other ideas are related (Dey 1993). The goal of this research is not necessarily to define a relationship between dependent and independent variables or test a hypothesis, but to better understand the phenomenon of oyster restoration (Strauss and Corbin 1998).

5.3.3. Grounded Theory

The formation and execution of this project was guided by the tenets of grounded theory. Grounded theory, as first described by Glaser and Strauss (1967), is a systematic process for generating theory from qualitative data wherein hypotheses and concepts develop from the data themselves during research (Glaser and Strauss 1967). A grounded theory is an idea about how other ideas are related developed by remaining “grounded” in, or close to, the data (Dey 1993). A valid theory is one that fits the data, captures essential features of the phenomena, explains variation, and has predictive capacity (Glaser and
Strauss 1967, Glaser 1978). The two key intentions of grounded theory are to produce generalizable theoretical statements that transcend specific times and places while simultaneously conducting context-based analysis of actions and events (Charmaz 2006). In this way, a grounded theory is simultaneously broadly meaningful and specifically suited to the present case.

Doing grounded theory work involves identifying categories and concepts that emerge from data and linking those concepts into substantive and formal theories (Bernard 2006). This occurs through the process of coding. Many authors have suggested paradigms for coding since the initial articulation of grounded theory, though its intention remains largely the same. Coding breaks data into bits or segments, names each segment of data with a label that assigns it to a category, thereby summarizing and accounting for each piece of data (Charmaz 2006). Sorting and re-sorting the data into categories defines what is happening, grapples with what it means, and then reassembles the data in a new way. Coding is analysis (Strauss and Corbin 1998).

Importantly, data collection and analysis are not intended to happen in isolation from each other or one after the other. Collection and analysis occur simultaneously, with analysis beginning soon after the data begin to come in. Throughout the collection and coding processes a multitude of ideas and questions will occur to the researcher. Grounded theorists write memos in order to record and catalog these thoughts. Memos are theorized write-ups of ideas about codes and the relationships among codes (Glaser 1978). Memos act as conceptual space for developing categories and trying out integrative frameworks, a space that links data to theory and keeps the research grounded (Miles and Huberman 1984b).

Since Glaser and Strauss first articulated grounded theory, the methodology has evolved and been adopted in many fields. Grounded theory as I have applied it utilizes many
of these later incarnations. The expansion and variation in grounded theory has been attended by serious disputes regarding its application. The greatest criticisms stem from the perceived imposition of pet theories or conceptual frameworks on data instead of letting theories and frameworks emerge through analysis. However, as Charmaz (1983) argues, data do not really speak for themselves because they are reflections of the questions that were posed. Theories cannot emerge without the researcher. Research questions, interests, and even codes do arise from observations of real world phenomena or insights from existing literature and theory. Researchers must begin their work, and stay in it, with an open mind, not an empty head (Charmaz 2006). However, the methodology maintains an emphasis on staying open to perspectives and explanations as they present themselves in the data. In short, while Glaser’s and Strauss’s original articulation and subsequent refinements of grounded theory influenced my work, I took a more constructivist approach that recognizes my role in the data and theory creation processes.

5.4. Methodology

5.4.1. Interview Guide Development

To gather the qualitative data to address my research questions, I conducted semi-structured interviews based on an interview guide, an ordered list of questions and topics to be covered in each interview. The topics in the interview guide were informed by the scientific literature, the North Carolina Oyster Fishery Management Plan, and current issues for North Carolina oysters. The interview guide was composed of six basic sections of questions relating to 1) personal history, work history, fishing tradition, fishing practices, and involvement with oysters; 2) oyster fishery; 3) conservation, management, and restoration; 4) oyster restoration and management; 5) relations with other stakeholder groups; and 6) demographic information. I field tested my questions with three individuals who are familiar
with oyster issues in the state, but were not intended research subjects in order to cull the
list and finalize content, number, and wording of the questions. This study was approved by
The University of North Carolina Behavioral Institutional Review Board (IRB) to conduct
research involving human subjects.

5.4.2. Semi-structured Interviews

The interviews were semi-structured based on an interview guide consisting of open-
ended questions (Bernard 2006). In a semi-directed interview, there are intended topics to
discuss, but informants are able to freely add detail, tell stories, make associations beyond
those anticipated by the interviewer, or follow a chain of the thought (Huntington 2000). I
asked open-ended questions in order to limit questioner influence over answers. After many
questions, I posed follow-up questions to solicit reasoning or elaboration or to probe for
additional ideas. The semi-directed nature of the interview also acknowledges my admission
that I am not omniscient. I do not know all of the topics that might be important to
stakeholders. When an informant would mention something that I had not anticipated while
answering an open-ended question, I could explore that topic with additional questions not in
the guide before moving on to my next intended topic. In this way, the interviews were more
like directed conversations, and a large part of my role was to listen and make comments or
ask questions that encouraged an informant to articulate their thoughts. Informants would
often cover answers to subsequent questions in their answers to initial questions. Interviews
often took unexpected turns or informants. When asking open-ended questions, I could
never fully know what someone might say. As such, the interviews are not really replicates:
no one interview is exactly like any other in terms of the questions asked, topics covered,
amount of time spent discussing any one topic, or the total length of the conversation. If my
intent had been to get the same questions asked and answered with every informant, I
would have administered a survey. My intention was to have a real discussion with each informant.

5.4.3. Sampling: Identifying Informants

Informants were categorized as one of six stakeholder types. Types were identified primarily by employment, but individuals may also differ in terms of demographics, background, culture, and history. I define stakeholders as individuals or groups for whom oyster restoration matters. It may matter for economic, personal family/local historical, and/or ecological reasons. The six stakeholder types are 1) government agents (Marine Fisheries Commissioners, resource managers with NCDMF). 2) fishermen who harvest oysters, 3) fish dealers/shellfish processors, 4) aquaculturists/shellfish growers, 5) scientific researchers, and 6) conservationists. Each informant is identified by a three-digit code. The first digit (1-6) of the code signifies the informant’s stakeholder group affiliation, and the next two digits are a unique identifier.

I used a respondent-referral method to select informants. Before I began the interviews, I compiled a list of potential informants based on recommendations and my own knowledge of the groups. For each stakeholder group, I selected a few key informants from the list, based on the strength and frequency of recommendations and my own sense of their influence, and attempted to contact each one by email and/or phone. Those individuals who responded positively and were willing to set up an interview became the first informants. Thereafter, to find each “next” informant, I referred back to the list and relied on peer or chain referrals, with each informant suggesting the names of further interviewees. In many cases suggested names were repeated among informants.

For many studies, purposive or chain referral sampling designs such as this one can produce results of questionable representativeness. When using these types of sampling
designs, it can be difficult to determine how the study sample compares to the larger population. However, this design is useful when the target group for the study is limited to a very small subgroup of the at-large population such that the sample includes a large or important fraction of that limited group. It was appropriate for the present case, in which the groups were fairly circumscribed and relatively limited in size. While the results do not generalize to all individuals in the stakeholder groups under consideration, what we learn about this sample will be quite informative about stakeholders in general.

5.4.4. Sample Size

I interviewed a relatively similar number of informants for each group. I conducted 32 interviews between August 2008 and November 2009. Informants were distributed across groups as follows: (7) government agents; (6) fishermen who harvest oysters; (5) fish dealers/shellfish processors; (4) aquaculturists/shellfish growers; (4) scientific researchers; and (6) conservationist practitioners. A small sample size for each stakeholder group is appropriate because the total membership in each group is relatively small, and, further, the number of influential members who are seen as key informants for the study is also small. These numbers are a representative sample for a research using qualitative interviews.

5.4.5. Potential Power Dynamics and Distrust Issues

The interviews were highly contextual, each providing an account from a particular point of view (Charmaz 2006). In some ways, the semi-directed structure gave informants a good deal of control during the interview. It is possible for informants to bring their own agendas to such interviews and use the open-ended questions to steer the conversation around to their own pet topics. This is especially possible in situations where there is a large difference in power and status between the interviewer and informant. A powerful person
could take charge and control various aspects of the interview including pacing, timing, and content (Charmaz 2006). There were a few instances where this did occur. In these cases, continuing to ask follow-up questions would allow an informant to exhaust her/his pet topics. If the individual feel heard, s/he could eventually be redirected to my topics of interest. In all cases, asking follow-up questions underscored for the informants my real interest in what they had to say, and helped them feel more engaged and at ease.

Age and gender differences between the interviewer and an informant can impact an interview. Male informants may feel threatened when questioned by a female interviewer (Charmaz 2006). This was unlikely in this study since the questions were not of a sensitive nature. If age and gender were factors, they were at least relatively consistent across the majority of the interviews. All but four informants were male, and only two informants were younger in age than me.

It is also possible for informants to distrust the interviewer, the stated purpose of the interview, and how findings will be used (Charmaz 2006). Distrust can lead informants to tell half of the story or misrepresent the truth. It is unknown if or when informants told half of the story or untruths. Researchers have to trust the informants and work from the caveat that only their statements can be collected, the things they are willing to say, not the entirety of what is in their heads and hearts. These may not always be one in the same. Informants are aware that their statements are made in a sociopolitical context and that what they say can influence the behavior of others or management decisions. Differences in sociopolitical interests, among informants, even those in the same stakeholder group, may contribute to differences in statements and reported knowledge (Palmer and Sinclair 1996). Informants did not seem to distrust me, in large part due to my status as a student. Some informants associated student status with a pursuit of truth and youthful optimism in ways they likely do not associate government agents, employees of environmental organizations, academic
researchers, journalists, or others who may have asked them questions in the past. In fact, some informants may have perceived me as relatively innocuous or viewed the interview as a way to educate me. These perceptions offered me a great deal of access that I likely would not have been granted had I had some other status or been in some other employ. It was critical for me to be clear about my intensions and goals and not exploit that access.

5.4.6. Data Collection

Despite the field tests and my best efforts to craft “good questions’, not all questions worked well in practice. Some questions did not generate much response or were consistently misinterpreted. Over time, I weeded these questions out of the interviews; I simply did use them anymore. In addition, in keeping with a grounded theory framework of allowing data to drive some of the collection process, issues or ideas offered by one informant became the basis of questions in subsequent interviews with other informants. In this way, I could gauge if a view was commonly held or not.

I conducted each interview in a location that was convenient for or suggested by the informant. If an informant had an office, s/he was typically interviewed there. Most others were interviewed in their homes or at fish houses. The interviews varied in the length of time they took to complete, ranging from just under one hour (0:59:48) to four hours and thirteen minutes (4:13). Interview time was largely dictated by the length of the informant’s answers and coverage of topics outside the interview guide. On average, each interview resulted in just under two hours of recorded time (1:54). All but one of the interviews were digitally recorded as .wav files using a Sony PCM-D50 Linear PCM Recorder. The unrecorded interview was documented with handwritten notes, which were later transcribed. Each interview audio file was transferred to my laptop on the same day it was recorded and then burned onto CD and DVD for back-up storage. All recorded interviews were transcribed.
verbatim with details including pauses, interruptions, laughter, and other background or ancillary noises.

5.4.7. Analysis

Interview transcripts were the data for the analysis. Analysis of the transcripts was facilitated by use of Atlas.ti v.6 software. Atlas.ti is a data management and qualitative analysis software package that allows researchers to store, code, annotate, arrange, reassemble, and manage research material. Tools in the package helped me organize, navigate, and visualize my data in order to interpret them.

I utilized several tools from grounded theory to analyze the data. I coded the transcripts in three phases of coding: open, axial, and selective (Strauss 1987). In open coding, I began to break apart the dataset and identify each piece. For this study, a piece of data ranged from a sentence to several paragraphs. I categorized different phenomena in the dataset like conditions, interactions, goals, events, changes, variables, and outcomes by giving them labels. I wrote memos to tell each stakeholder’s “story” based on the codes attached to quotes from the transcript. I used the stories of all the members of each stakeholder group to determine the commonalities of the group and unique features of each individual. I asked: What are the similar views and values being expressed? How do the members of the group differ from one another? What are the unique views or values?

In the second phase of coding, I continued constructing a conceptual framework of the data by determining how different categories are related. In this phase, I connected and reorganized categories, which allowed me to begin to reassemble the data in new ways. During the final phase of coding, I selected and focused on core categories for each stakeholder groups and for the main ideas of the study.
Direct quotations from the interviews are interspersed through the results and discussion section in order to let informants speak in their own words. Quotations are included if they illustrate similar points made by several people. Quotations denote informants’ occupation or stakeholder group affiliation.

5.4.8. Reliability, Validity, and Other Perceived Weaknesses of Qualitative Research

Analysis of qualitative data has been labeled a mysterious, half-formulated art (Miles 1979). Answers to open-ended questions vary in complexity, which, along with differences in word choice, complicates interpretation and analysis. In addition, though they limit interviewer bias, it is possible that responses to open-ended questions are not relevant to the questions. Collecting and analyzing qualitative data is highly labor intensive and time consuming. The data can easily overload a researcher with the sheer range of possible phenomena to observe, the length of recordings and transcripts, and the time it takes to thoroughly code the data.

For these and other reasons, qualitative research tends to be dismissed as unreliable and subjective, but the quantitative view of reliability is not really applicable to qualitative data collection. While it is important to consider the reliability and validity of any measure a researcher chooses to use, certain kinds of reliability must be violated in order to get a real depth of understanding about a context or phenomenon (Miles 1979). A researcher’s behavior must change in varying degrees from informant to informant in order to fit into each research setting and set each informant at ease. In my research, I tried to behave in the ways in which each situation seemed to implicitly call. This included how I dressed and presented myself at each interview and some of the questions I asked. I asked some unique questions of each informant in order to get to know them better or to seek clarification of statements they made or information they had volunteered. However, by
addressing the dynamism and uniqueness of each interview and informant, these violations of tenets of reliability improved the validity and reality of the findings (Miles 1979).

The subjectivity of qualitative research manifests itself in terms of the exclusivity of its conclusions. No one explanation or conclusion can be established exclusively and unequivocally from qualitative data. Different researchers could draw different conclusions from the same qualitative data. However, clearly some conclusions will be better than others, and we must be confident that other researchers would find conclusions that resemble our own (Miles and Huberman 1984a). In all of the conclusions I have drawn, I am attempting to represent the informants, and what they said, fairly. The conclusions that I draw are my own, and I believe, complete for the purposes of this study, but it is possible that someone else might have seen something else in the data or presented the information in a different way. Despite this, qualitative research is not a less than systematic inquiry (Glaser and Strauss 1967).

5.5. Results and Discussion

To understand oyster management and restoration in North Carolina, we must situate these processes within the context of stakeholders’ knowledge and experience. In this section I present findings about the propositions and theories of fishermen, fish dealers, fisheries managers, conservation practitioners, shellfish growers, and scientists. For each group, I present a suite of themes that recurred during interviews with the members of that group and informants’ knowledge, perceptions, and views on each theme. While many topics were covered during these interviews, I have selected and present those that have particular relevance for the continuing efforts to restore oysters. The explicit knowledge described in the themes below was analyzed for underlying cultural models. A cultural model called “How many oyster there are” is then described for each group in a subsequent
section. Each group is unique in certain themes, but there are also important overlapping perspectives. The complexity of both individual and group values and knowledge about specific places, processes, and resources suggests that there may not be right answers to management questions, but rather cultural plurality, which informs notions of right and wrong behavior towards nature (O’Brien 2006).

5.5.1. Fishing Group

Fisheries management and conservation regimes that sharply limit harvest as a means to manage or restore fish populations conflict with the perception among North Carolina fishermen that fish, including oysters, cannot be truly managed by humans. In the fishermen’s conceptualization of marine and coastal systems, there are too many variables that management regimes cannot affect or control for them to really manage the systems. Some refer to these variables as part of God’s plan. Others describe them as dictated by Mother Nature. Both designations describe a stewardship beyond human capacity to manage the resource. Though largely unpredictable, variation in these factors leads to changes in finfish and shellfish abundances and is what manages nature.

5.5.1.1. Nature, Cycles, and Oysters

Even though low catches are not desirable, fishermen believe they are part of a natural cycle. For fishermen, nature and fisheries work in cycles. One fisherman described the cycle for oysters:

“It's got a cycle to it. I don’t know exactly what the right cycle is, but I'd say three or four years. ... And they're going to die anyway. They're going to spawn themselves to death, you know. ... Because we had a few years that stuff caught good, and they grew good, and they caught again and grew good, and the lump hadn't been messed with for three or four or five years, probably, and they lived, you know. I don't say five years. I'd say maybe three - in other words, it was about time for it to go if somebody hadn't caught them, you know. Probably by the next year - as a matter of fact, the
next year, everything was dead. So if we hadn't found it when we did, because the next year we went out there, and there weren't many oysters, because stuff had died.” -- *Fisherman*

Bad years will be followed in the cycle, at some unpredictable time, by good years.

According to fishing informants, downturns in the cycle are a means of managing the system because they prevent humans from ever harvesting the last oyster. A down cycle protects oysters or other fishery species by reducing harvest effort. During periods of reduced effort, species abundances rebound. When oyster catches decline, fishermen believe they will come back. They lay the oysters’ resiliency to their high fecundity. One fisherman believes that:

“…one bushel of oysters will put out enough spat to fertilize this whole sound. You could walk on the oysters.” -- *Fisherman*

A low population level is not a problem for the oysters. It is a problem for the fishermen. In the down-cycle, fishermen do what they have to do to support their families. Fishermen maintain that no one, no biologist, no manager, no fisherman, can predict the outcome of a harvest season before it begins: whether oyster abundances and catches will be high or harvesting the daily limit will be accomplished in small time period. Fishermen hope for both of these, but they do not expect them. In the face of this uncertainty, fishermen maintain a “you never know” type of mindset.

**5.5.1.2. Weather**

Fishermen discuss several underlying variables that cause cycles in fisheries:

“One bad dermo season or one bad, bad storm, anything could happen, and they could be gone.” -- *Fisherman*

Weather is the most commonly mentioned driver of the patterns that fishermen observe in fisheries. Fishermen specifically discuss droughts, large rainfall events, strong wind patterns that enhance tide heights and wave energy, and hurricanes. While no management regime
can control the weather, fishermen see a need for greater flexibility and responsiveness in management programs in order to take advantage of changing conditions. For example, recent droughts led higher salinity to which some fishermen attribute the high oyster recruitment and growth rates that they report over the last couple of years. Expanded funding from the state legislature for cultch planting efforts during this time would have taken advantage of the enhanced production by providing more settlement habitat for more oyster larvae. A fisherman explains:

“But I was getting at a golden opportunity. You could have took every place in North Carolina and filled every place that you could have with resources, and it would have been oysters unbelievable would have [taken] there. … I'm talking about if you could have got it up there to the top, to the governor and them, to really put some money out, or got hold of some grants somehow or another. Say, "Look, boy, this is an opportunity we've got right here. We can pour these rocks. Boy, now we can fill up these places and make all these reefs or whatever you want, or sanctuaries or whatever." It's a bonanza, could have made a bonanza out of it. It's unbelievable what you could have done with it.” -- Fisherman

Oysters do exhibit higher growth and reproductive rates and lower mortality in waters where salinities consistently range from 15 to 30 ppt (Shumway 1996). However, salinity can also influence parasitic infection levels and predator prevalence. Many predators of oyster coexist in higher salinity waters. Salinity also interacts with temperature: *Haplosporidium nelsoni* and *Perkinsus marinus*, the parasites that cause the diseases MSX and Dermo respectively, thrive and spread quickly in warm, high-salinity waters (Soniat 1996). During the recent period of drought, disease-related mortality remained low despite the increase in salinity:

“Just talking about the last few years, it's been a decrease in the loss of oysters because of Dermo mortality. And last year the salinity was as high as it's been, and Dermo likes warm, salty water to grow in, so I can't really explain, especially this past year, why it's (the oyster fishery) better.” -- Manager

“I keep looking at the events in the late 80's and the droughts and the high salinities and kind of look at the trends that we're having now, and I'm very fearful that we'll have a relapse of the same thing. But so far we've seen fairly low Dermo levels, which is really comforting because I don't want to lose what we have gained and what we've built.” -- Manager
The apprehension and uncertainty these informants express seems rational. To them, it was not clear that expanded cultch planting would have boosted the oyster population at the time because their past experience told them to expect expanded mortalities due to disease.

Hurricanes and other high rainfall events produce high-volume freshwater inflow to coastal creeks, bays, and sounds that has the opposite effect as a drought: it decreases salinity. Of course, freshwater is not the only component of stormwater runoff. It can also contain various contaminants, pollutants, and sediments.

“And I’ve seen it when we’d find lumps like that - when I was young, about eight or ten, working with my daddy, we’d find lumps where nobody (had) been on, that big, that wide, dead. Where the bad water the summer before - oxygen got out of the water and killed them, see, so didn’t do nobody no good. We’ve been lucky like the last two or three years, we haven’t had it. But you could have it anytime, especially if it rains a lot, or something, and you get a lot of fresh water down there, it takes the oxygen out of the water. Then there’s a good chance you’ll lose them, you know.” -- Fisherman

Clearly, management cannot control rainfall patterns. It does not seem like an outlandish expectation for management to be responsive to environmental changes, but, as the salinity example illustrates, the effects of these changes can be complex, complicating possible management responses. One management tool that many fishing and industry informants believe could improve responsiveness to changes in environmental factors is a hatchery. Oyster spat produced in a hatchery could be used to reseed beds damaged by hurricanes or other destructive events.

The effects of hurricanes and other disturbances on oyster reefs, or the resilience of the oyster population, depend on the timing of the event, existing habitat conditions, and life history stage of the oyster population (Livingston et al. 1999). Despite causing physical damage and oyster mortality, if a hurricane strikes before oyster spawning is completed and enough habitat is available for settlement, spat accumulation and population recovery will occur in the hurricane’s aftermath. A hurricane that occurs after the spawning period will thin
newly settle oysters, but may improve growing conditions for the surviving oysters by reducing competition and thereby increasing oyster biomass.

5.5.1.3. Predation

Another suite of variable factors is predator pressure, abundance, and distribution. Fishermen state that increased predation by protected species on fishery species results in declines in fish abundances, which lead to more stringent fishing regulations. Fishermen believe that certain types of management efforts, especially those that preferentially protect one species over others, upset the natural balance of species. According to fishermen, there is room in the system for fish biomass removals by fishing, as long as the removals are not unlimited, but occur within certain catch limits. They claim that regulatory protections such as moratoria or severe limits on commercial catch levels of large predator species can lead to overpopulation of the species.

“I mean, you know, there'll be a lot of comments about over-fishing. We are experiencing some over-fishing in some things. But the over-fishing is occurring by predators. … We are protecting red drum, striped bass, and spiny dogfish. All right, they are three of the largest predators we have. Now, you know they've got to eat something, and it's going to be a species smaller than they are. So, you've got a drum, especially a drum, and rock, too, or striped bass, they love crabs. All right, North Carolina's crab problem is only going to get worse before it gets better. And they've got striped bass and red drum protected to the point that they're also going to be like the spiny dogfish. They're going to stay here until they eat their food supply up. And they also have got two choices: stay here and starve or move on. Either way, North Carolina is going to lose those.” -- Fisherman/Fish dealer

Blue crabs are important oyster predators; the problems in the blue crab fishery that this informant mentions may lead to enhanced oyster survivorship. Recently, concerns have arisen about the effect of predation on oysters by surging populations of cownose rays. One informant likened young oysters to cornflakes for rays. Instead of growing due to the effects of regulatory protection, populations of rays in North Carolina and elsewhere are growing
due to a separate anthropogenic impact: the cascading effect of the loss of predatory sharks
due to enhanced exploitation (Myers et al. 2007).

“But we've got a problem now. The way it used to be, there would be about two to three
weeks in the spring those rays came through. They would migrate. They always claimed
they went up the rivers. I don't know where they went. But anyway, you'd get about two
weeks in the fall they came back and they, you know, went back the other way. But now they
stay here year-round. Or, I say year-round, they're not here, not too many right now. But
when they come here in the spring, they'll stay all summer. They don't ever leave. And now,
again, they've got to have something to eat.” -- Fisherman/Fish dealer

Scallops, clams, and oysters are all vulnerable to cow nose rays.

5.5.1.4. Heterogeneity

The effect of the variables underlying the cycles that fishermen perceive in nature
vary by location:

“Yeah, and sometimes, depending on how the weather affects them, they might be
better. You never know, just according to how the situation works. You know, some
years they might be good over here, and some years they're better over there, you
know, just according to how the weather affects them or whatever. So, you don't ever
know. You don't go, "I know I'm going to do that next year over there." No, you don't
do that. You've got to start working. If you don't do it there, you go over there and
the first thing you know, "Oh, right here this year, that's where I'll be there." That's
what you do, see, and chances are, you'll do good there. I've seen it when in some
areas there wouldn't be nothing, you know, and you say, "Oh, durn, there ain't going
to be nothing this year." But you keep on moving and first thing you know, say, "All
right!" When you find out where they're at, they're right there on it, you know, and
you can catch them right off of it for a ways or whatever.” -- Fisherman

The effects of weather, predators, and other variables on oysters are unpredictable in space
and time. From year to year a fisherman cannot predict where the most productive harvest
locations will be. Instead, a fisherman must explore, testing the bottom at a variety of
locations, searching for where s/he will “do good.” Even though this form of testing is
different from the sampling a scientist might conduct, with it, a fishermen develops an
detailed knowledge of the bottom and how different factors influence that bottom. This
knowledge supports the widely held view among fishing informants that fisheries are
unpredictable, but non-random systems whose unknown controlling mechanisms defy
human efforts at management and conservation. In this view, management must function
within the balance that Mother Nature creates.

5.5.1.5. Anthropogenic Factors

While no fisherman described details, pattern, or duration of the cycles of nature, the
cycles define their relationships with the water and their work. Cycles are real to a fisherman
because s/he and others have lived through them and learned about them from older
fishermen. Yet within this conceptualization of fisheries cycles, there is awareness that
environmental modifications related to human activities are changing the system in ways
that natural variation never did.

“It's a combination of a lot of things. I've always thought, and it could be the same
thing with oysters, they've got cycles, maybe over the years. Maybe there will be a
few years one good thing, and a few years there'll be something else good, you
know. I always thought fisheries worked in cycles. But for the last ten years, I've
been thinking there's something stopping the cycle. I really do.” -- Fisherman

Fishermen are accustomed to accommodating changes in production that are dictated by
nature through fishing practices, such as prey switching, but these practices may not
accommodate exogenous production drivers as well.

Economics

Many of these drivers — markets, imports, fuel costs, and fish house closures — are
related to economics. Oyster landings in North Carolina have grown over the last seven
years while the price fishermen get for them has remained steady, but the fishery is still
considered by many to be minor. While prices for oysters are relatively healthy, the market is
primarily local and small.

“After locals get their belly full of oysters - that's the way they put it. In other words,
you can sell a few oysters right now, because everybody wants them, because
there's not been none all year. But after Christmas, people have had their belly full of
them. You know, you've had your couple of messes during the year. They're expensive to buy on the market. What we get for them, we don't get that much, but when you go to buy them - and the way the economy is, too. You know, it's a luxury. You know, it's like lobster. You know? How many lobsters a year are you going to buy? You know? So, after you get your share, your belly full, people don't buy no more. Then the price goes down. People don't want them. Like last year, I was doing good until after Christmas. Then I only started going a couple of days a week because my market was gone. Everybody had them, because nobody was buying them. See?” -- Fisherman

However, the oyster season may be gaining additional importance for many fishermen because of troubles in other historically important fisheries including shrimp and blue crabs, and increasing restrictions on gill netting. Cheap imported shrimp mean low prices for local shrimp while more restrictive regulations are limiting gill netting. The results are reductions in income from fisheries where fishermen traditionally made the bulk of their annual income. A fisherman explained it in some detail:

“Oystering is something to do in between where you make the money. You don't make money out of oystering. You make a paycheck. You follow what I'm saying? So, that's just something to fill the little gaps in. Well, that's fine. Them little gaps are nice. But when you take the big gaps out, and you've just got little gaps, you can't survive on the little ones, because that makes them the big gaps.

Like I said, used to, like I told you earlier, you start shrimping in May. You'd get two dollars a pound for anything you put in a bucket called a shrimp. You know, anything you put in the boat. Now you can't get two dollars for 10-15 count shrimp. You follow what I'm saying? And there are none. So, the season's been taken - the big money things have been taken away. Now you've got these little things.

Well, now we're into gillnetting. That's good money. It's not big, big money like it used to be, but it's good money. It's a good paycheck every week, anywhere from five hundred to a thousand to twelve hundred dollars a week. But now they're trying to take that from us. Well, that's like the oystering. You go from gillnetting, you follow the pound netting, you go to oystering, that keeps the paycheck going. You know, as long as there's something coming in, you're not taking out. You know what I'm saying? You're putting a little bit in while you're waiting for the next thing to come back again.

Well, if they take gillnetting away from me, two months of oystering - follow what I'm saying? It doesn't work that way. It doesn't work that way. So, I mean, oystering is a part of the puzzle, but it's a small part. It's a fill-in. it's a fill-in. That's all it is, is a fill-in.

But you can still fill in little blanks here and there, and make that check, and go through until the next little thing you do, you know, where you can make a little bit comes along. So, every little piece is very important, yes. Don't get me wrong. I'm not saying it's not important. I'm just saying it's a small piece of the puzzle. But you
can't survive just on - if you take them little-bit-bigger pieces away. The big pieces are gone. They're not coming back. But the little-bit-bigger pieces are still there. But if you take them away, you can't survive with that little piece, because there's not that many of them either. Because what used to be the medium thing now is the big thing. These little things were so far - they were a little sidepiece of the puzzle, but now they're coming more in the middle. But you can't take none of them away now, because they're all important now." -- Fisherman

Concomitant with lower income for fishermen from traditionally high-income fisheries are higher operating costs. For example, the relatively high cost of fuel means that it is not financially feasible for a fishermen to motor long distances to oyster bottoms when the allowable daily catch limit is low. The cost of getting the oysters does not compare favorably with the income they produce.

“If somebody went out there, like on Monday, and found a lot of oysters, he could go ahead and catch his weekly limit. It'd be easy to do it in one day if you could find the oysters. You wouldn't be out but one day's fuel, and you wouldn't have to go back. If they had like a seventy-five-bushel - and they could do it - it's been discussed among Fisheries people. Instead of letting people go five days a week and get fifteen bushels a day, let them - if they find them in one day, let them catch them. That's it for the week. That would save out a lot of expense, a lot of fuel, a lot of wear and tear on your rig. But, yeah, I have heard that talked about. They don't seem like they want to do that, but I believe it would be good, being fuel is so high" -- Fisherman

It makes more sense for a fisherman to stay close to port even if that means catching less than the daily limit. This behavior results in the same locations being harvested multiple times in a season for many weeks by multiple people.

*Development and Water Quality*

While many drivers of landings are economic, a host of others are derived from expanded coastal development and resulting declining water quality.

“Yes, it's just accumulated over a matter of time. There's more of me and you. There's more of us on the street every day. There's more development. And there's more towns springing up and communities and factories, and there's just more me and you, more buses and cars and trucks and boats on the road, boats on the water. And over a period of several hundred years all that mess is being forced into the water, and it's beginning to take a toll." -- Fisherman
Fishermen have a distinct awareness of the water quality problem. All oyster fishermen recognize that water quality is poor and contributing to problems in the fishery. A fish dealer described the aftermath of Hurricanes Dennis and Floyd in 1999:

“Okay, you don't know - I don't know. I say you don't - I don't know anymore than you do. But in my opinion everything that had been on the banks of the Tar River since Reconstruction days came down the river, because that water had to go somewhere, and it took the path of least resistance and it picked up everything and brought it with it. It was nothing to see barrels afloat, trees afloat. Well, that was what was on the surface that you saw. But it was what was on the bottom that you didn't see.” -- Fisherman/Fish dealer

The scale and cumulative impacts of poor water quality and the precise mechanisms of how polluted water affects estuarine chemistry, flora, and fauna may not be well understood, but fishermen agree that the quality of our coastal waters must be improved. They believe that the filtration capacity of enhanced oyster populations could make an important contribution to clean-up efforts.

“In other words, if you - like if somebody wants to save shells and plant them and so-and-so, yeah, it helps. You know it helps. It's got to help, you know. You've got more oysters. You've got more something filtering the water, you know. I think it's a good idea. Put them out there, you know.” -- Fisherman

Unfortunately instead of seeing water quality issues addressed, fishermen feel they are the ones who suffer most when fish stocks decline due to poor water quality because they face more stringent regulations while pollution seems to continue unabated.

“But I'm just saying it's an accumulation of a lot of things over the years. And pollution - our rivers are polluted. And it seems like it doesn't matter what happens, the commercial fisherman gets blamed for it. In other words, he gets stopped from fishing, or he gets a quota, or we're going to close the season on you or something because these things are happening, even though it's not our fault. They'll say, "We're going to limit your catch next year, because the stock's continually declining." You know, I don't understand that.” -- Fisherman

Fishermen seem troubled by the kind of “end of the pipe” regulation that they face. Use, pollution, and largely intractable environmental problems like non-point source runoff, are at least as significant as commercial fishing pressure in causing changes in commercial fisheries, but commercial fishermen feel their industry unfairly bears the regulatory brunt for
these cumulative effects (Endter-Wada and Keenan 2005). Because historically they were one of only a few sources of data on extractions, commercial fishermen were blamed for the state of fish stocks (Blair 2009). Instead of improving the regulation of what goes into the systems, regulations of what is removed from them in the form of fisheries catches and harvests are added. There is a certain sense of unfairness among fishermen regarding these aspects of the State’s attempts to maintain the estuarine and marine systems.

“I just don’t like to be breaking the law. I’ve always been like that. I mean, in other words, it's hard for me to even go out there right now without breaking the law, there's so many laws, you know. You feel like a criminal when you leave the dock, you know. That's the way I feel. When I was growing up, it was the most exciting and the most fun, you know, to be out on the water working on your own, you know. But now, in the last ten years, there are so many laws and regulations and so much mess being put onto it until it's just disheartening to even think about, you know.” -- Fisherman

“Every time you start making money, they regulate it and regulate it. Somebody comes up, "Well, you're catching too many of it, or there isn't enough of it, or you're not -.") I mean, it's the same old story. I mean, you can ask any fisherman, and he'll tell you the same thing. We're being regulated to death. What is the end of the regulations? There's got to be an end somewhere. I mean, it's like taxes. My God, eventually you get taxed to death. You know, we're being regulated to death. Everywhere we turn, no matter what we do.” -- Fisherman

5.5.1.6. Regulation

For some, these fishermen’s feelings about regulations might reflect the stereotype of fishermen as solely interested in making money today without thinking of the consequences of today’s harvest on tomorrow’s harvest. However, my interviews illustrate an important distinction: these are their feelings about regulations not about sustainability. Fishermen describe a perspective in which fish were put in our coastal waters to be harvested and if a man “can’t get a little something out of them” then they have less of a purpose. A perception of cycles contributes to “get it while you can get it” reasoning: harvest now because the next down cycle could start at any time. According to one fisherman:

“And I can see trying to build them up, you know, whatever, save them or do what you can, but you can't save them but so long. In other words, you know, if it's there,
you know, you need to get something out of them while you can, because they're eventually going to die or they're going to get killed or something. It's got a cycle to it. “There's no doubt if you can leave them two or three years, they'll do better, you know, if you know they're going to live, or whatever, you know. It's better, but you ain't got no guarantee of that, you know. There's no guarantee of nothing.” -- Fisherman

However, “getting a little something out of them” “while you can get it” does not equate with “taking them all.” There is a strong sense in the fishing community that resources need to be protected so that they will be sustained into the future to continue supplying ecological and economic benefits. Fishermen share with managers and conservationists the goal of sustaining estuarine and marine systems and the species within them. Fishermen agree that regulation of the fishery industry is necessary in order to accomplish this goal, but would change how such regulation is accomplished.

“They need to look at a balance. And, you know, ever since there's been a fish in the water - it's just like the animals in the woods - there's always been a balance. Nature will balance itself. And they feel like if they don't take stringent measures to curb all this stuff, like, commercial fishing will destroy it. But a commercial fisherman will never destroy a resource because he depends on it for a living. And when it gets down to a point that he can't make it, he'll switch to something else. You know, he'll never deplete that stock. The economics of it won't allow it. It's just simple economics is all it is. But what has happened is they're tightening the box, like you don't have the latitude to move from one fishery to another like you used to.” -- Fisherman/Fish dealer

Fishermen demonstrate faith in economics and cycles in nature to limit harvest and regulate fisheries by promoting fishery switching among fishermen to prevent species from getting fished to extremely low levels. One fishermen explained the benefits of this kind of regulatory system compared to the daily bushel limit for oysters, which is perceived as an incentive for multiple revisits to beds located close to port:

“Too much regulation right now - that's what's wrong with that. Definitely too much regulation. When something's there, you catch it. That's the way we used to do, see, when we didn't have those laws. When there was something there to catch, you caught it. When you caught it, you quit and went on about your business. Like oystering - we used to do all our dredging like from the season opening though Thanksgiving and Christmas and maybe a little bit of January. And after that, the season would still be open. But a lot of times, it was about over, so we quit and find something else to do. We'd caught up the best of the oysters, you know. Who wants to go out there and dredge for nothing, you know? The market usually wouldn't be as
According to this fisherman and others, the market used to regulate the oyster fishery. Demand and harvest typically stayed high through the holidays, but after January, harvest effort would continue to follow the market and decline. Harvest would be intensive, but for a shorter duration than today. Today, because bushel limits cap individual catches, fishermen continue harvesting longer, and there is potential for more participation.

**Input vs. Output Controls**

There are two main types of fishery regulations: input and output controls. Bushel limits are a form of output control. These and other quantitative controls, including quotas and harvest prohibitions based on size, sex, and life stage, regulate what fishermen are allowed to catch (Morison 2004). Regulating who is allowed to fish, where they are allowed to fish, when they are allowed to fish, and how they are allowed to fish are controls on inputs to a fishery (Morison 2004). Input controls include protected areas, closed seasons, and gear restrictions that limit location, time, stage of life of the target species, or fishing technology instead of limiting the amount that can be caught.

If fish and shellfish populations are unpredictable, as fishermen describe them, they still vary within specifiable limits when the system parameters are undisturbed, suggesting that fisheries can be managed by maintaining those parameters through a parametric approach to management (Acheson and Wilson 1996). The goal of a parametric approach is to maintain critical life processes such as spawning, prohibit fishing during certain parts of the life cycle, and maintain areas essential for the well-being of the species such as breeding grounds and nursery areas (Acheson and Wilson 1996). This can be accomplished by creating rules concerning fishing areas and techniques – implementing input controls.
Input controls such as area-based rules and management converge with fishermen’s ecological knowledge and their conceptualizations of how oyster ecosystem function. Short-term conservation over the course of two or three years is possible whereas long-term conservation is impossible. Fishermen emphasize short-term closures are beneficial to catch levels; protected beds catch oyster larvae, the oysters grow to harvest-size, and harvest turns over and exposes clean shell for new oyster recruitment. In spite of a strong belief that populations of oysters cannot be conserved over the long-term because they are vulnerable to changes in unpredictable variables like weather or water quality that can have devastating effects, fishermen support the idea of rotating closures of small bays or other areas, which they believe would allow each area to “get worked some” each year and prevent any one area from becoming overworked.

_Closures and Dredging_

In addition to allowing periodic harvest so that fishermen can “get something” out of a closed area, fishermen believe that harvest is critical to the long-term production of oyster bottoms and to oyster survival. While fishermen do acknowledge that oyster beds can be overworked, they seem to believe that oyster bottoms permanently closed to harvest will not survive over the long-term. To thrive, they believe that oyster bottom requires working or dredging. They compare a fisherman working oyster beds to a farmer tending fields. Oyster beds are like farms that require tending so that they stay productive and do not get overgrown and weedy; without harvest oyster beds will stop producing oysters. Oyster beds are colonized by a variety of sessile organisms, including tunicates and sponges as well as algae and barnacles, which compete for space with oyster larvae and whose presence reduces spat density (Ortega and Sutherland 1992). Instead of tearing up oyster beds, dredging is like turning the soil. It clears fouling organisms and exposes clean shell for larval
attachment preventing the resource from becoming unproductive. In a rotating system of closures, fishermen could periodically clean oyster beds by dredging to maintain productivity. This kind of system fits the fishermen’s conceptualization of the processes that structure these systems: Oyster beds can be worked to the point of stress and failure, but they require maintenance to continue producing oysters.

In conversations about harvest closures, when asked about their awareness of the state-designated oyster sanctuaries and their utility, some fishermen did not seem aware of the sanctuary program. The state’s oyster sanctuaries are oyster management areas intended to support high spawning stock biomass in order to address potential recruitment limitation. They are intended to promote the survival of older, large oysters, which may be disease-resistant with the potential to act as a broodstock and establish disease resistance in areas surrounding the sanctuary. Possible disease resistance is assumed from survival to large size and beyond three years in locations with known disease mortality. Harvest of oysters and use of trawls, long haul seines, and swipe nets are prohibited within sanctuaries. There are nine sanctuaries in the state totaling over 48 developed acres with a tenth site under development. Instead, fishermen were more familiar with seed oyster management areas or Mechanical Methods Prohibited Areas, which have more direct impact on their oyster harvest practices.

Seed oyster management areas are designated areas that typically contain stunted or slow growth oysters in crowded conditions or at the limits of the oyster’s salinity tolerance. When transplanted to more suitable environmental and habitat conditions, they can produce a marketable product. There are six seed management areas in the state, though outside of Pender County, they seem to be used in only a limited capacity. Relaying oysters from polluted sites is more common than relaying from seed management areas because polluted areas are more widespread and contain more oysters.
Like sanctuaries, Mechanical Methods Prohibited Areas (MMPAs) are considered a protective status. In the northern part of the state, MMPAs are located behind the Outer Banks, to prevent disturbance of the extensive beds of submerged aquatic vegetation. The designation was extended to several bays along the western side of the Pamlico Sound in 2003. MMPAs can be considered another type of input control because they function as a gear restriction. They are open to harvest by hand gear (tongs, rakes, or by hand) only. Areas in the southern region of the state are already closed to dredging; expanding MMPA designations predominantly affects harvesters in the northern region of the state where the majority of oyster harvest is accomplished by dredging. To promote a transition to hand harvesting in the northern region, in combination with MMPA designations, NCDMF has increased cultch plantings in hand harvest areas in the Neuse River, Pamlico River, western Pamlico Sound, and Roanoke Sound. Still, fishermen in this part of the state refer to MMPAs as “closed” areas. The following exchange, which took place in Hyde County, illustrates how closed is equivalent to non-productive to many in the fishing industry:

FISHER: That year I was working in Abel's Bay, dredging. Nobody else was dredging. Me and my brother - he was dredging, just me and him. He had a boat, and I had one. And we were getting fifty - we were getting the limit every day. We went to that meeting, and they went to showing us on a map what they were going to close and everything, you know. And they said, "Yeah, we're closing this here, and we're going to close Abel's Bay."

I said, "Whoa! Why are you doing that for?" "Well, there ain't nothing been caught in there for -." I said, "Go look at my trip tickets. I've been catching my limit in there every day." "Huh?" I said, "Yes. Goes to show what you know." I said, "There's oysters in there, I know, because I've been there," you know. And they were, pretty oysters. But see, now, they closed that bay.

LINDA: THEY DID?

FISHER: You can't pull a dredge in there no more.

LINDA: SO, WHEN YOU SAY "CLOSED" YOU MEAN CLOSED TO DREDGING, BUT YOU CAN TONG.

FISHER: Still tong, yeah. But it's too deep in there to tong, and most of the time it's in the open where the wind's blowing, where you can't get settled down like this, you know. It's not a very good place to do no tonging, you know.
Despite actually being open to harvest, because dredges are not permitted, productivity is limited and fishermen perceive these areas as closed. The efforts to encourage more hand harvesting and less dredging do not seem to be working. While hand gear landings rose to nearly 20% of the total oyster landings in Hyde County in 2007, the following year hand harvest fell back to less than 10% of the total landings (NCDMF Trip Ticket Program). MMPAs are not sanctuaries, but for dredgers both of these areas are simply areas that are closed to them.

Fishermen in the northern region of the state are critical of MMPAs because they believe that dredging is critical to the continued production of an oyster bed.

“See, if the shells are there, and you don't mess with them, and you can't dig them out and turn them over where they can catch, they're just going to sand up, bury up, make hard bottom and be gone. See, so that's foolish. ... You keep them up, where they - turn them up, clean them up a little bit when you're working with them, then they'll catch. But if you leave them, they won't catch like that, you know. It's a less chance.” -- Fisherman

By keeping dredges out, MMPAs are perceived as threats to not just the oyster fishery, but oyster survival. Oyster sanctuaries also prohibit dredges, but the height of the mounded reefs constructed in the sanctuaries likely eliminates the need for “cleaning.” Greater mound height promotes oyster growth and production because the oysters on these mounds are higher in the water column where food and oxygen resources are greater and sedimentation is minimal due to enhanced water flow. As a result, reefs do not need to be maintained by harvesting action. In addition, sanctuaries are intended to protect a disease-resistant spawning population, which fishermen believe is critical to recovery after unpredictable disease outbreaks.

Beyond the balance they see in nature, fishermen cite another type of balance in their discussion of dredging, the one between proper and improper use of the dredge.

“But if you take that dredge like we use, it's fine if you use it like you're supposed to. It'll work, and it won't hurt nothing if you don't overdo it with it, you know. ... You've
got to have enough sense to know what you're doing. You can't work them to death. You work them, but you don't work them to death! [Laughs] That's it. That's the part, see, that everybody don't look at, you know."

— Fisherman

Some fishermen perceive their fellow harvesters as more dangerous to oyster beds than the gear they use.

Fishermen believe that non-permanent area-based harvest closures maintain oyster bed productivity, which is one of their primary concerns. These closures balance two needs that fishermen prioritize: 1) protecting a spawning population of oysters and 2) periodically working bottom to clean shell material. Fishermen do not believe that a daily bushel limit, which is the primary oyster management tool in North Carolina, does the same. In addition to the economic aspects, including higher operational costs, of the daily limit discussed earlier, fishermen claim that smaller limits encourage novice or uninformed fishermen to follow more informed fishermen that know where productive beds are located. When the knowledgeable fisherman has caught the limit and must leave, the followers begin harvesting in the same spot. Experienced fishermen claim that the work of these harvesters, who may not have as light of a dredging technique, is what is damaging oyster beds.

“When I catch what I - you know, the best of it, I go on to somewhere else. Now, there's a good chance someone stupid might come behind me and just dredge that place to death, you know, but I try to give it a chance, you know. And see, that's the main thing. That's where the fisherman needs an education. He knows when, "Hey, you've got to get off of this, Bud. You can't keep on doing that. You'll kill it." And it will." — Fisherman

Input regulations are seen as economically inefficient because they set limits on how productive a fisherman can be and make fishing more costly for those who are highly productive (Olson 2006). Dredgers tend to view 15-bushel daily limit on oysters in this way.

5.5.2. Industry Group

Many fish dealers and other oyster industry stakeholders agree with fishermen that
fisheries management and conservation regimes that sharply limit harvest as a means to manage or restore fish populations are unworkable because oyster populations cannot be truly managed by humans. There are too many variables that management regimes cannot affect or control for them to really manage the system.

5.5.2.1. Storms, Development, Water Quality

Storms, development, and water quality are an important tripartite theme for oyster status and restoration among fish dealers. Freshwater influxes caused by large rainfall events, especially those events with concomitant impacts to bottom habitat as occurs during hurricanes, are critical determinants of the status of the oyster fishery and population.

“When those storms come, there’s so much rain until it just pours and pours, and it kills the oysters. I remember after Hazel there was a lot of oysters died because of the fresh, so much fresh water. And oysters don’t like too much fresh, but they’ve got to have some. And that’s why the oyster grows - is whenever it’s getting the freshwater and the saltwater, and there has to be probably an equal amount. I don’t know.” -- Shellfish dealer

“But I don’t know. I think what happened in oysters, a lot of it, when it first started there were oyster rocks everywheres. I’ve heard some of the older people talk about it. It used to be solid oyster rocks. And when the ’33 hurricane come, it destroyed it. Well, see, that’s something the hurricanes do that they don’t ever figure in, like clamming. Well, this covered up a lot of shells that the larvae caught in. And until it gets right, until nature decides it’s time for it to come back, and things get conducive, it’s not going to come back.” -- Fisherman/Fish dealer

The pulses of freshwater created by these events are heightened by coastal development and altered hydrology, which allow sediments and pollutants to wash into rivers and bays with surface runoff. While declines in water quality resulting from stormwater runoff may not kill oysters, they do result in harvest closures.

“It's probably been about - probably in the '80s, late '70s and '80s, because they started checking the rivers and closing it. And that's what woke people up to realize that something was going on, because there was people in our community that did not believe the state's reports onto it. And they ... started going down and getting samples and sending them to a laboratory in Raleigh. And then the state invited them to go right along with them. And they would get their samples at the same place where the state would get their samples, send them off, and come back the same thing, the same report. And they realized that there was things draining into the river
that was causing pollution. And so, this group got together and started scouting the river out to find places that was causing trouble. ... So, they started working with the state, helping them to spot places to show, you know, for them to check out. ... So, they come to find out that it was a lot to do with any time any kind of construction, big construction, was going on. And the biggest mistakes that they realized that we had made over the years, the people that lived along the rivers, was not having those buffer zones. And the state, the counties, all of them - everybody was at fault.” -- Shellfish dealer

In response to the combination of weather patterns and diminished water quality, fish dealers are supportive of enhancing efforts to plant shell and other cultch material. They deem such efforts critical to the oyster fishery because more cultch material, under the appropriate circumstances, can translate into more oysters and, because oysters are filter feeders, larger oyster populations can lead to water quality improvements.

“Oysters filter the water. That's what they do. So, basically, the more of them you've got, the cleaner your water's going to be, unless you just keep over-polluting and over-polluting, which I think there's a tendency in this country to go the other way on the pollution deal. So, that's got to help. More oysters would help, more oysters in more key places. ... But if you had some oysters up these rivers that was cleaning on them, and in the middle section, and in the mouth of it, by the time this water got out of these rivers, is our biggest pollution base, because that's where all the populations are. By the time you got the water out, you know, in those areas, I think we'd have a better shot for the oysters in the places they generally live, where we generally have oysters, to have oysters year-in and year-out, and have good-quality oysters.

Now, I think some years that the oysters up in these rivers would die completely out. I think they would get stuff to come through there that would completely kill them, and you'd have to go back and start again. Now, I do believe that. But I believe that same year that that does that, these oysters have filtered and worked as best they could, and these oysters out here would be in a lot better shape. You know, it may kill the first two batches of those oysters, and the next batch might be half-dead, and the next batch might not be but a fourth dead from it, where if you didn't have this up here filtering, all these down here would be dead. And maybe that's the best way to describe it.

But that's the best thing I see right now for water quality is try to get oysters in these rivers, some kind of oyster, if it's got to be that foreign oyster. ... But if it will work in these rivers - I mean, we need to clean our water up, not just for oysters, for all of us, everything. For all of us, you and me, I mean, the people in Raleigh and everybody else, the water needs to be cleaned up some.” -- Fish dealer

The establishment of larger oyster populations in strategic locations, as suggested here, is a critical component of the state's oyster rehabilitation program. Identifying strategic locations has been complicated by limited information regarding larval movement patterns and reef
connectivity. Adding cultch material to historical reef footprints or establishing new cultch planting sites in upstream, shallow water locations are hampered by access issues. NCDMF does not have the shallow-draft barge necessary for accessing these locations and ferrying small amount of cultch material on smaller vessels is not cost or time efficient. This is a recognized need within NCDMF, but recent budgetary constraints cut funding for a shallow-draft vessel.

5.5.2.2. Regulations: Gears and Limits

If budgets and access were not constraints, one informant described a combination of shell planting, rotating closures, and addition of hatchery-raised seed oysters as a means of improving oyster populations:

“If they would go up there and [plant] this huge area - and don't even let you work them! Don't work them. Don't do nothing until they've been there eight or ten years, if they've really come along, go in there and work them a yearlong, just, you know, for a week or two, just turn it up a little bit, you know. They can work it a week or ten days and close it, work it a week or ten days and close it, just enough to basically spread it out a little bit and turn it over where it will catch a little bit and do a little better.” -- Fish dealer

The key to the plan outlined above is that these areas must be worked with dredges periodically. Like fishermen, dealers in areas where the mechanical dredge is the primary method of harvest view dredging as a means of cleaning and tending to oyster bottoms that maintains bottom productivity and does not promote devastating overharvest. Some dealers point to lowered daily bushel limits as the damaging factor because lower bushel limits encourage poor harvest behavior and reward those fishermen with limited oystering knowledge and experience. They claim that with a higher limit, less knowledgeable fishermen would not remain in the fishery. These are the individuals who tend to dredge improperly and revisit the same reef, two behaviors that can lead to habitat destruction.
"It's the natural order of everything that's ever been: the survival of the fittest, the strongest. The ones that's good and can do, do; the ones that can't find something else to do." And the fifteen-bushel limit - my argument is there'd be half as many oystermen, catching twice as many oysters. And the oysters would be better off, because a man that knows what he's doing doesn't hurt oysters. It's a man that doesn't that does, as far as dredging, as far as with a dredge." -- Fish dealer

In the past, fishing was a challenge won by those who could catch the most fish. Input controls that created a relatively low daily limit in the North Carolina oyster fishery changed the landscape of the fishery giving more people a piece of the resource. More fisherman can catch the limit when the limit is low. One fisherman explained that the current daily limit does not do much to restore the oyster population, but rather, contributes to the extinction of the oyster industry:

"When we used to have oysters, these bays would get worked two or three weeks out of the year, and that was it. And we'd go in the sound and we'd find more oysters. If that started playing out, we might go to West Bay, we might go to Neuse River, we might go down to Bluff, we might go to Stumpy Point, and find more oysters, or not. But we could catch enough oysters if we found some oysters to make it worth going after them. With the bushel limits like they are, you can't do that. You can't afford to run six hours one way for fifteen. You can't do it. It's just not feasible. You're better off to stay here and catch five that you know you're going to get and do it every day. And that's what happens: the places get worked down too low with a bushel limit." -- Fish dealer

Due to the impacts of fuel prices and bad winter weather, informants in this group suggest a weekly limit instead of a daily limit, as exists for other species, through allotments to boats not licenses.

While some may view a weekly bushel law more favorably than a daily limit, all agree that regulations are required to protect fisheries resources. While more oysters in key places might contribute to water quality improvements, many agree that the state has done a good job protecting consumers from consuming oysters growing in potentially dangerous or injurious water.

"I know that the state is doing what they can to monitor the rivers and making sure that we get clean oysters, and that's what I appreciate about the state the most is that they do check our rivers after a rain and that they don't let us get oysters out of waters that would cause people to get sick. And so they do that, and they work with
trying to keep oysters in the river. All these years they've put - they went and put the shells into our rivers to bring forth even to new beds and transferred oysters, even though sometimes they didn't work out as good as they did other years, whenever they transferred those oysters. And so, I think the state is working." -- Shellfish dealer

5.5.2.3. The Oyster Business is a Business

In the current economic climate, fisher dealers and oyster shuckers have to focus on the financial aspects of their oyster businesses. A theme that emerged among informants in this group is that management is not doing enough to support local oyster businesses. A key issue for shucking houses is sourcing oysters. Processing plants primarily utilize oysters shipped from the Gulf of Mexico because they are available year-round. The majority of oysters grown in the Gulf is grown on leased bottoms and can be harvested all year. The role of oysters from the Gulf in the North Carolina oyster market expanded when local production crashed due to high Dermo mortalities in the late 1980s and early 1990s.

"And we were out of the marketplace for years. Well, the Gulf oyster and the oyster from the West Coast infiltrated these markets and now you're not going to get them out. People that know would rather have these local oysters, and they get a premium for them at times. There are some places that don't mess with them. They don't like messing with them. The shucker doesn't like to shuck them. Stuff in the Gulf are real thick-shelled oysters; it gets real big, real fat, real pretty, but it tastes like nothing. It tastes terrible." -- Fish dealer

Consistency is the main reason why oysters from the Gulf are so widespread in North Carolina shucking houses and oyster bars. The following informant explains the business side of importing oysters from the Gulf:

"And because of us being a shucking operation year-round, we need to have a source of supply year-round, and that's why ninety-eight percent of what we do is out of the Gulf of Mexico. We cannot depend on the state of North Carolina to keep us in business, because everybody that we sell to sells seafood year-round, and they need a year-round supply. And as long as you're dealing with North Carolina, that's not going to happen. We buy from the Gulf in the winter months also from public beds, open to the public, from different dealers in Texas, Louisiana, Mississippi. When the public bottoms close, then these companies switch to private leases that they lease from these different states. And it's such a big industry; Louisiana has tens of thousands of acres of leased bottom down there. And it's very politically oriented. It's a very strong happening in Louisiana. So, that's how we're able to source product in the other months, you know, when most people are out of the oyster business. We
go to these private leases and we buy tractor-and-trailer loads of oysters every week from them.

That ninety-eight percent is the year-round average. And we do as much as we can with North Carolina oysters when they're running. But as a rule, the North Carolina oysters, number one, are poorer than the oysters in the Gulf. And we don't get as good a yield when we buy them. We're lucky to get a full bushel. And they cost more. So, those three things are against you. So, it's really a disadvantage to handle the North Carolina oyster, because I'm competing with oysters coming out of the Gulf that are fatter and cheaper and are delivered right to the door from shucking houses in the Gulf, you know, bypassing us and our procedure. But, I mean, you know, I don't like having to buy all these oysters from the Gulf of Mexico. I mean, I'd much rather keep it in the community. I mean, that's a lot of money. Even if we're not making money, it's a lot of money to expend trying to keep it going. And it would just be better for everybody in the state if we could keep it in the state.” -- *Plant operator*

Consistency is also a critical issue for restaurants and raw bars. According to the following fish dealer, few North Carolina restaurants serve North Carolina oysters.

“See, we had an oyster bar over here. … Well, for a few years, all he used were southern oysters coming out of Texas and Louisiana. And I know the man real well that owns it. And I told him one day, I said, "Look, why don't you use these locals?" He said, "Well, I can't get them all the time," and we hemmed and hawed. And he finally said, "The real reason is," he says, "I don't want people to get on these local oysters during oyster season, and then me have to take them off of them when our oyster season is out." He doesn't want to have some really good product and then not. And he said, "That's the real reason." And I said, "Well, you do know that if, for some reason, somebody else decides to use these local oysters around you, you're going to be in trouble." He laughed and he said, "Who would do that?" And I said, "I don't know, but I wish I owned the building beside of him." And he laughed, and he thought about it a few minutes. And I saw him about a month later. He said, "You know," - and he don't buy them from me, but he buys them from somebody else - he said, "I've started using local oysters in my place." I said, "Well, you probably needed to." [Laughs] But it's the truth. There's no comparison.” -- *Fish dealer*

Even though North Carolina may produce better flavored, saltier oysters, the realities of the modern-day marketplace preclude these businesses from utilizing local oysters because of inconsistent supplies.

*Cultch Support*

Informants believe that the state could do more to support local oyster businesses by expanding its support of oyster fishery production. For this next informant, cultch material is a critical issue that needs to be addressed in order for production to expand. He goes on to
explain that while he would prefer to buy North Carolina oysters, but using North Carolina oysters in the plant puts him at a competitive disadvantage. The supply of North Carolina oysters is not steady nor is the yield (the volume of the shucked meat) as great as from oysters from the Gulf of Mexico.

“You know, North Carolina will never be what any of the Gulf States are, as far as the oyster industry goes. But I think the state of North Carolina is not nearly doing enough to promote its oyster industry. There's a shortage of cultch material. ... We're in the survival mode (here) ... . We're maintaining, but we're not getting ahead. ... But there's only a handful of us left, and the state of North Carolina, as far as I'm concerned, could pay more money for these shells to put them back overboard, and keep these businesses going, and build a better oyster industry, and put more emphasis on it. ... I mean, as long as businesses like Rose Bay Oyster Company are at a disadvantage by the North Carolina oyster, the industry isn't going to change. I mean, for us to be competitive and to exist and to try to make a profit, we've got to do what we've got to do to stay in business, and that's to buy oysters from the Gulf. And every year, when our North Carolina season comes in, we are buying less and less North Carolina oysters, because of us having to compete with the oyster out of the Gulf. And that's not good for the industry. ... So, I mean, it's definitely to our advantage for North Carolina to come onboard, as far as, you know, the resources in the state. I mean, we'd all be better off if we could do it. But until such time comes that it's improved to the point where we can compete for us to stay in business, we're going to still do business in the Gulf.” -- Plant operator

According to this informant, one way to help these local businesses and expand cultch planting to grow the industry would be to spend more money to buy shells from shucking houses. Money from the sale of shells is critical to the business so they are sold for the highest possible price. The State of North Carolina does not currently offer the highest price.

**Consulting with Traditional Knowledge**

Another important business-relate theme among members of this stakeholder group involves consultation and communication between NCDMF and dealers regarding when to open and close the oyster harvest season. In addition to being concerned that enough resources are left at the end of the season to support the fishery the following year, informants are concerned about coordinating supply with demand and other market forces.
They claim that while NCDMF has landings data, managers are not at the docks or on water to see the actual quality of the product being caught. As a result they may not have the same information for decision-making that dealers could contribute.

“I would like to see, personally, a little more input from the people that are selling the oysters. Otherwise, when they get ready to open a season or close a season, the market situation - I'll give you a good example. They closed it real early one year, closed it in January about three years ago. I used to have a big business the month of February in oysters. That's generally when it gets cold in North Carolina. And so, I lost all that business. It took me two years. I finally started getting it back last year. I had to have them oysters for two years before I could ever get any of them talked back into coming back with me. Now, if they close it in January another year, I'm out. Boom! The door will be shut on me! Then they can leave it open until July if they want to, because you won't sell them. It won't matter.

I would like to see the markets - we're going to catch a limited amount of stuff anyway. It looks to be that they're going to keep us on these bushel limits and keep us at a limited amount. And at that way, we should try to maximize what we get for them. In other words, a man's not going to catch but a thousand bushels a year or five hundred bushels a year. It makes more sense to me to catch them when we can get twenty-five or thirty dollars for them than when we can get fifteen or twenty. ... I'm saying don't open it in October. Don't close it in January, you know. I think we need a kind of a set season, and if there are areas that need to be closed, close those areas.” -- Fish dealer

Another informant seemed torn discussing the end of the season. Extending the season might help some harvesters, but it is hard to sell the oysters during March because the market is so limited.

“But when people are used to a season closing on the fifteenth, and then it's extended two weeks, they don't know that, and so it kind of closes you down, which I'd have been just as ready for them to have just closed it, and I told them that. Whenever they asked me, I told them, I said, "I'd just as soon close it down." But if it would help the boys be able to go and get a few more oysters, especially the way it is now, because even to the clam market is not good, so it would help them. And I think that bothers me more than anything, is knowing that when the season is closed, they're out of work. They ain't got nothing to do, especially if the clam market ain't no good.

No, I really think that they should close it down on the fifteenth of March, that they shouldn't go no further than the fifteenth of March ... because I hate the idea of knowing that there's people going down there gathering oysters, wanting to sell them, and trying to go somewhere to sell them to anybody and everybody, and can't sell them, and then there are these oysters that's ruined. And I know that's going on right now, because people are calling me and telling me they can't find nobody to sell them to.” -- Shellfish dealer
Beyond increased consultation with industry people, the group also discussed an expanded role for experienced fishermen. They believe the people who have fished for their livelihoods possess both greater knowledge of the systems in question and greater appreciation for them.

“It would be nice to see them use that money for more planting or more - I'd like to see them work with the fishermen a little better, is what I'm trying to say. If they would take, maybe, and spend that money and hire one of these boys in the summertime, one of the fishermen that really likes to oyster and does a good job. And hire them and let them go find places for them to plant and let them go there and check places and see what the stuff looks like and all that. I would like to see them do a little more of that stuff and get some people that know a little bit about oystering a voice in what's going on. ... They could possibly take some of these older oystermen that really know something and talk to them and try to work with them. If they work with them and talk to them, and people could see some fruit in what they're doing, I think they would. I mean, I don't think they could hire somebody seven days a week, but a day here and a day there. Pay them good. And actually listen to what they have to say and work with them and take the data down. I think certainly they could find somebody to do that. If the people, like I say, if they could see some good coming from what they were doing. If it was futile, they wouldn't want to do it. That's the reason most people - you talked to ( ) an hour over there the other day. ( ) will go to one of these meetings - he don't even go to them no more. And he loves to talk about oysters, thoroughly loves to talk about oysters. He won't go to them. And when he goes to one, he says a little bit and leaves, because it's just futile. He's been to enough of them. He's tried to talk to them enough. He gets up and walks out. And I've seen it numerous times, numerous times.” -- Fish dealer

While members in other stakeholder groups understand that oysters are an industry that supports a variety of businesses, this group, by virtue of their direct involvement in running these businesses, stressed the financial aspects of the fishery. Informants stressed that regulations are necessary, but they are concerned about the economics of supporting local projects and local people in eastern North Carolina.

“Some of them is getting kind of elderly because they've been with us quite a few years. [Laughs] Some of them is getting to where that there's days that they can't go. They're having health problems. But they love to be in that river. ... I have tried to keep seventeen going this year. Last year I had about ten. That many more came needing to sell, and so I took on that many more. Of course, the first part of the season you can sell about all you can get. But after Christmas, whenever you can't, they've not been going over two to three days a week. And then I'd have to cut them off, because I'll get too many. ... You can't just buy everything that comes in. Because so many people - I've had more people calling me this year and wanting to
sell me oysters than I've ever had. And with the economy like it is, you hate to tell them no, but you can't buy them if you can't sell them.

I don't want to stop, because so many people that's always depended on us would be without a way to sell their oysters. ... And when oyster season is out next week, what are they going to do? Where are they going to go, the ones that's always kept on clamming after we got through with the oyster, because there's really not no prospect out there for the clams right now. So, it just keeps me awake a few hours some time of a night, [laughs] thinking on it." -- Shellfish dealer

5.5.3. Management Group

Fisheries management and conservation regimes typically rely on harvest limitations to manage and restore fish populations. These regimes also include efforts to protect, supply, or restore those habitats that are critical to the completion of managed species’ life histories. In North Carolina, the Division of Marine Fisheries (NCDMF) utilizes primary and secondary nursery area designations to restrict fishing activities in order to protect juvenile populations. Harvest limitations and habitat-based initiatives are also utilized to manage and restore the oyster fishery. Harvest levels are restricted through the regulation of daily catch limits, and habitat is built by returning shell material to the water. However, since the oyster fishery is also oyster habitat, the habitat provision and harvest restriction aspects of management are linked in ways they are not in other fisheries. A NCDMF staff member described this linkage:

"We're trying to make sure that we have this viable, healthy population. If, you know - you can harvest them. Some people are saying now that you shouldn't harvest oysters, that they're more valuable as habitat than they are as a food source. I think they're probably right, but I still think there's room for harvest of oysters. But, you know, it's really difficult to wrap your mind around oysters, because they are habitat, and when you catch an oyster - you're taking habitat out of the water when you catch an oyster to get a food item. You know? So, I guess there may be some other things that are kind of like that, but it's a very unusual situation." -- Manager

It is likely that the value of the spectrum of ecosystem services provided by healthy oyster reefs greatly exceeds the value derived from oyster harvest (Grabowski and Peterson 2007). Oysters that are removed from the water as part of the fishery can, of course, no longer
provide other services. In spite of the fact that removing an oyster for the fishery is equivalent to removing a piece of habitat and yet we maintain some form of a fishery. The reasons why and how we manage resources are not a careful itemizing of values, but rather a reflection of how we would prefer thing to be.

Conversations with NCDMF staff highlighted three types of factors that affect oyster populations and relate to oyster management and restoration. There are factors that cannot be addressed. There are factors could be addressed, but are not. There are factors that are addressed.

5.5.3.1. “The Cannots”: Factors that cannot be addressed

Factors that cannot be addressed are beyond human control, and they cause fluctuations in oyster populations that managers recognize as inevitable. Managers cannot control or predict changes in weather patterns, the recurrence of high parasite loads and disease mortality, or the synergy between these two factors. Instead, they focus on enhancing population resiliency to future disease episodes.

“I mean, I think that over time and with constructing the right kinds - putting the habitat out in the right configurations - that the oysters will re-colonize it. I mean, there are - I mean, I've seen - I mean, oyster harvest - I mean, it's not a good measure, but it's the only measure we have. But, I mean, an oyster harvest was running around 100,000 and 120,000 bushels a year when we got - the dermo thing kept going up and up and up, and the landings dropped to 40,000 bushels a year, you know. And if you have that big of a swing just from primarily environmental conditions - some of it was habitat-caused - then, to me, the numbers are going to fluctuate. I mean, even more so, in a lot of cases, than fish, long-lived fish. They'll fluctuate even more widely.” --Manager

The prevalence of the oyster disease Dermo is related to weather and rainfall. Low rainfall or drought conditions raise salinity; high salinity combined with warm temperatures are prime conditions in which the Dermo-causing parasite, *Perkinsus marinus*, thrives and spreads quickly (Soniat 1996). Managers seem to dread the possible return of high disease
mortality as they describe the sense of powerlessness they experienced during the major outbreak in the 1990s. Gains in population abundance and landings achieved prior to this outbreak were quickly lost, and are only slowly being regained. During the recent period of drought, disease-related mortality remained low despite the increase in salinity. Two informants from NCDMF explained:

“Just talking about the last few years, it's been a decrease in the loss of oysters because of Dermo mortality. And last year the salinity was as high as it's been, and Dermo likes warm, salty water to grow in, so I can't really explain, especially this past year, why it's (the oyster fishery) better.” -- Manager

“I keep looking at the events in the late 80's and the droughts and the high salinities and kind of look at the trends that we're having now, and I'm very fearful that we'll have a relapse of the same thing. But so far we've seen fairly low Dermo levels, which is really comforting because I don't want to lose what we have gained and what we've built.” -- Manager

Disease, which followed on the heels of a red tide event in the late 1980s, is the main reason why population and catch levels declined so precipitously in the Pamlico Sound region, and it remains an important determinant of oyster abundance. As important as it is, disease is something that management can address in only limited ways.

“It just didn't seem like whatever you did really made any difference. I guess the realization of that came to me that it was gong to be almost impossible to manage around it when my supervisor wanted me to look at disease incidence as far as location and that kind of stuff and see if there was any kind of real patterns. And I started looking around at hundreds of cultch planting sites and recruitment levels and survival levels and Demo levels. And I would have a site that was planted the same year a couple hundred yards apart and one would be very high incidence of Dermo and the other would be negligible. And it's like a shotgun. There's no way to draw any type of conclusions. And I came to him and I said, "I spent a week on this. I can't see anything. When you've got that kind of proximity and everything seems to be the same and one's decimated by Dermo and the other one seems to be very low intensity of any kind of infection, how do you deal with that? And it's all over like that. There's no method to the madness." And I guess at the point I kind of figured the best you can do is try to make your enhancements the best that you can. And let Mother Nature kind of take care of things. There are limits to what we can actually do as far as that. That was a difficult time.” -- Manager

In the aftermath of this disease event, sanctuaries became an expanded part of the management program to offer some protection to oysters that could live through future epidemics.
5.5.3.2. “The Coulds”: Factors that could be addressed

Additional uncertainties for managing and restoring oysters are the results of changes in the surrounding landscape. Current conditions in the estuary are affected by development and alterations in watershed and land use patterns, and they, in turn, affect the health and survival of oysters in both known and unknown ways complicating management outcomes. In a sense, factors that diminish water quality, including runoff, point source pollution, and sedimentation, diminish the capacity of management and restoration efforts to improve oyster populations.

“So yeah, to me restoration is trying to put back in as responsible a manner, maybe not the way things were because conditions are so much different. I think in North Carolina there was a lot of mid-level and low-level oyster rocks scattered throughout the lower rivers and sounds, which they didn't have to worry about low dissolved oxygen and hypoxic situations back then. It didn't occur. Those low relief oyster rocks now don't survive. When that low dissolved oxygen comes down, they're wiped out and so they basically all you have left is just the shell. ... And so it's that kind of thing that I guess restoration you need to take that kind of stuff in account and try to evolve with current conditions.” -- Manager

Declining water quality could be arrested by changing patterns of land use and development. However, these are not factors that NCDMF, as a fisheries management agency, can overcome or affect directly. NCDMF is involved in the Coastal Habitat Protection Plan (CHPP), a coordinated effort among the state’s four rule-making commissions: Environmental Management Commission (EMC), Coastal Resources Commission (CRC), Marine Fisheries Commission (MFC), and Wildlife Resources Commission (WRC) to develop, adopt, and implement plans to protect and restore fisheries habitats, but as with other forms of governmental coordination, progress has been slow. In a sense, the work of restoring oysters is supplicant to decision-making regarding watershed development. Management informants refer to construction and development as “progress”: not something they envision can be halted and especially critical to the growth of the tourism economy in the coastal region, but something they believe could be done with less impact on the
estuarine ecosystem. They also point to the diffuse set of contributors to water quality problems at the coast. One informant highlighted that perspective:

“I mean, it's, you know, it's everything. If it was so easy to put your finger on the problem, it would have been fixed by now. But I guess if you could put your finger on the problem, it would be too many people. That's pretty much what it is. It's just too many people. Everybody flocks to the coastline, and it's the people. And then people generate all these water quality issues. That's pretty much - I mean, if you had - I mean that's not really ethical to say, you know. "Oh, it's a people problem." But that's what it is. I mean when you have lots of people, that's where the problems start. I mean, all the waste and the runoff and you know, everybody, you know, farmers, there's no one person. It's everything. You know? All the stuff that people spray in the fields, and flush down your toilet, and wash your car, and spray on your lawns to kill the moles or whatever, you know. It's all non-natural stuff. And it all ends up on the coast. How do you control it? You put in laws and this and that, but I mean, you can't - I mean, you've got to be good stewards of every little aspect of the problem. Like, you have to put in rules for wastewater and for runoff. You know, you need to be good stewards and try to manage that as best you can, but you can't - it's hard. I think that's the main problem. And it's the hardest one to fix. Everybody wants to fix it, but nobody wants to fix it. [Laughter] Because if you wanted to fix it, you would do a lot more than we do.” -- Manager

5.5.3.3. “The Ares”: Factors that are being addressed

While disease, weather, and water quality cannot be changed or addressed directly by NCDMF, harvest is one factor that the agency can address as part of the management and restoration plan for oysters. An output control, in the form of a per capita daily catch limit, regulates harvest by controlling what is harvested. Hand harvesters are permitted to take five bushels per day or 10 bushels per day in a combined fishing operation. Harvesters using a mechanical dredge can take fifteen bushels per day per fishing operation. In addition to the bushel limit, monitoring during the oyster fishery season tracks population status in order to close selected bays or the entire season when catches decline.

*Transitioning the Fishery*

In addition to restrictions of what fishermen harvest, some management actions are attempts to promote transitions to alternative fishing behaviors and practices. In the Pamlico
Sound region, where the vast majority of the oyster fishery is harvested by mechanical dredging, management activities promote the alternative use of hand methods. These activities include expanding Mechanical Methods Prohibited Areas and preferentially planting cultch material within those areas.

“What I would like to see is the industry transition from having to depend on dredging to hand harvesting. We’ve tried to support that through increasing the amount of cultch plantings that we do in hand harvest only areas as opposed to areas that are harvested by dredges. And I think that’s perhaps a sound way to help people to transition. I don’t like regulating people out of fisheries as a way of management. I like to do it more through providing them the means to be able to transition by really adding a lot more cultch material, building new oyster rocks in those hand harvest areas. Hopefully they will find it an attractive way to harvest.” -- Manager

Managers also believe that greater participation in growing shellfish on bottom leases would reduce the harvest pressure on natural oyster reefs and cultch plantings. The number of bottom leases has fluctuated relatively minimally over the few decades. In 2005, there were 277 leases totaling 1,972 acres from which 10,767 bushels of oysters were harvested. Most harvest from private bottom occurs in Topsail Sound, Stump Sound, and Newport River. Most leaseholders utilize cultivation methods that have not changed in over 100 years. They rely on cultch planting and relaying techniques while use of modern aquaculture techniques, hatchery-raised seed, and water column leasing remains minimal. From 1994 through 2005, 14% (1994-2005 combined estimate) of the total commercial oyster harvest in the state came from privately leased bottoms. Higher production requirements were instituted in 2004 resulting in slightly higher private harvest. Shellfish cultivation in North Carolina remains limited compared to other states. Managers recognize several limiting factors.

“It's difficult to say, well, you know, I'm going to get a lease and I'm going to make a go of it and try to do this instead of just doing what I've always done. And part of that is it's a lot of work, but it's also some capital investment into something that historically in a lot of areas hasn't been real productive and real successful. And whether that's been a function of the environment or a function of effort or what, some of the leases haven't been viable. And so it's very difficult to have the initiative and spend the capital and the time because, basically, if these guys aren't fishing,
Managers attribute the limitation to several factors. They understand that leasing requires relatively high investment of money, time, and effort, and there is uncertain return for those investments. Oysters on private bottoms are vulnerable to the same factors that affect public bottoms, including disease and storms, but there is also potential for theft.

When the commercial oyster fishery began in earnest in the late 1800s, dredging of undisturbed deep-water reefs occurred intensively. High harvest levels without concomitant habitat replenishment essentially mined the state’s oyster resources: the population fell to critically low levels and without attention to habitat, remained low. The population may have remained at a level that is lower than some critical population threshold such that, once weakened further by declining water quality, mortalities due to oyster disease began to rise, eventually rising to high enough levels in Pamlico Sound to largely shut down the fishery in that part of the state. As a result of this experience, current management practices are largely focused on protecting habitat by restraining impacts to habitat to an acceptable level. NCDMF refers to this acceptable level or critical cut off point as significant deterioration of
habitat and population. If a level of significant deterioration is reached, then changes in
regulation of the fishery must be implemented.

“The way things normally work around here is we keep reducing the effort down to a
level that we think is sufficient to protect the resource. And sometimes that keeps
going. We say, "Well, we didn't go quite far enough, and so we need to go again." And we seldom say, "You're not going to dredge anymore." We let them make the
decision. I mean, "This is the level that you're going to have to dredge at in order to
have an acceptable impact on habitat."” -- Manager

Reducing effort may include shortening the duration of the dredging season or reducing the
number of days per week that fishermen can dredge.

“We don't have the data to do a population estimate like they do for fish. So, we don't
have quotas on oysters, or caps. So, what we're trying to do is trying to look at -
when the oystermen are fishing, when should we stop them from fishing? At what
level, or what population, or what catch-level are they getting that they're doing more
damage than good harvesting? And they're receptive to that, and I'm surprised. We
were looking at some numbers and we were saying, "Well, if you're out there fishing,
and it looks like to us like about 20 percent of the oysters coming up on your culling
tray are legal - that's all that it is - then, you know, we should probably be looking at
closing the season." You talk to some of the fishermen, and they say, "Well, I think it
ought to be 25 percent or 30 percent." You know? So, their attitudes - a lot of them -
have changed, and that's the biggest thing.” -- Manager

Despite citing the possibility of further restrictions on harvest, management’s
perception is that the modern-day population is not controlled by harvest nor is harvest
resulting in continued habitat loss. Management informants stressed that though harvest
may be the least detrimental of all factors that affect oyster abundance and population
sustainability, it is also one of the few factors that they can exert any control over. This
control is exerted through restricting what fishermen are allowed to harvest.

**Importance of Habitat**

The other factor they can exert some control over is habitat. Since management
cannot really prevent disease or directly improve water quality, their focus is on providing
habitat. Instead of losing habitat due to harvest, managers are concerned about continuing
to expand the extent of oyster bottom habitat. They agree that more habitat in key locations
is critical to oyster population sustainability. This is not so because habitat losses are currently great, but because the increases in habitat have not been large enough. Managers maintain that reproduction and recruitment levels are high because the cultch material they deploy gets covered with oysters. Yet the oyster population cannot grow beyond a certain point because there is insufficient habitat for it to do so.

“I think one of the problems with our fishery is that, and I haven't done any kind of studies to prove this or not, but if you've got to put out stuff, you've got all this spat on this material, it tells you that it's substrate limited. Good land, I mean! If you'd put out a lot more material, then maybe you would have had less spat on your material, but when you put out material and it's just knotted up with spat, it's pretty obvious that those pieces of larvae, those things swimming around in the water, they all attract to that shell and there's nothing else for them to attract to. I mean, you see them on crab pots. Crab pots are loaded with spat. I mean, it's substrate limited. There's not enough places for them to grow. I mean, that's pretty obvious in my opinion. So I think with the oyster population going down over the past fifty or sixty years, the amount of material that the oysters can grow on is less. So there's just not enough substrate out there for them. I mean, it's limited.” -- Manager

Managers view habitat provision as the main task of the oyster restoration program. That is, deploying shell and marl material for oysters to attach to and grow on in order to overcome the limiting factor to population growth.

Managers conceptualize habitat provision as two linked efforts: sanctuary building and cultch planting.

“And again the sanctuary program is just part of the total concept of trying to restore oysters. The other part of that is trying to look for areas that we can put our cultch planting sites where they're going to be most successful, where they're going to survive. We're having, currently, better luck on the shallow water areas than we are in the deeper water areas. Whether that has to do with anoxic events or low dissolved oxygen or mixing or disease or whatever. But our effort is to try to determine where the larvae from these sanctuaries will be going and to be able to put the cultch there to receive those larvae. So all of that is really tied together.” -- Manager

“Yeah. I'm a big supporter, like I've said, of the cultch planting and trying to recreate the oyster reefs. But the sanctuaries, to me, are just as important. I mean, well, I mean they're the same thing. It's just that on one you don't allow harvest, and on the other one you do. And I think that we need both. And the more sanctuaries that we can create, in a balance with the harvesting areas, I think the better off we're going to be.” -- Manager
Shifting the focus for managing and restoring oysters from production to habitat changed the way NCDMF goes about the work of managing oysters. This is reflected in the design of cultch plantings and sanctuaries that calls for building taller mounds instead of spreading thinner veneers of material over larger areas. Today’s focus also reflects more a of landscape approach to restoration. This approach prioritizes consideration of how planting sites and sanctuaries may be linked through larval transport.

Since a population assessment for oysters is not conducted in North Carolina, it is difficult to judge the restoration work based on oyster abundance beyond landings data.

“And, of course, one thing - I think one thing I can say. Let me see if I can get this statement right. There are definitely more oysters in North Carolina waters today because of the Division of Marine Fisheries than what there would be if Marine Fisheries hadn’t been so involved in oyster restoration. Now, that’s convoluted, isn’t it? [Laughs] That's not to say that there's more oysters today than there was ten years ago. But because of the protected habitats that are out there, I know that five years ago, there was a lot of bottom areas out in the Pamlico Sound which were nothing but sand or muddy bottom. And we have now put rocks out there and shut those off to any kind of harvesting, so there are now more oysters out there in those areas than what there were before. But, now, in the population in general, there may be less statewide because of harvesting efforts over the last couple of years. I don’t know. But I can definitely say that, you know.” -- Manager

Habitat provision is a critical outcome of management efforts though NCDMF has only limited capacity to measure oyster habitat. This capacity may be improving due to the bottom mapping initiative that is underway. Even though, the management program was instituted to promote oyster production and production sustainability remains critical to the program, today, the program is judged less on production and more so on efforts to supply and sustain high quality habitat.

5.5.4. Conservation Group

Conservation informants situate the restoration of oysters within two landscapes. One is the physical landscape of the North Carolina coastal plain and estuarine system, and the other is the theoretical landscape of large-scale environmental issues. These landscape
perspectives describe a view of oysters as linked to their physical surroundings and the overarching ecological concerns of the coastal region.

5.5.4.1. Oysters within the Estuarine Landscape

In interviews, conservation practitioners emphasized the effects of landscape-scale physical surroundings, pointing to the need to consider the connections between land-based activities and oyster survival. Current conditions in the estuary are affected by watershed development and changes in land use patterns, and they, in turn, affect the health and survival of oysters in both known and unknown ways. Current conditions may limit the possible outcomes of restoration initiatives or the locations where projects should be undertaken. This informant described some of the changed conditions for oysters:

“But we also have areas - you know, some of the historical records - up near Washington there used to be oysters in the Pamlico River, and the system is too fresh now. So, I mean, there have been major hydrologic changes. And we have so many areas that are polluted that, you know, if you could get a healthy, could get oysters back in those areas, you might not be able to harvest them, but they would definitely improve water quality. I mean, the sediment bottoms have changed. In North River Farms, when you canoe down some of those drainage ditches, you get into the natural marsh, and you can push your paddle down, and it goes through about three feet of silt. Then you start hitting shell on the bottom of the silt. But all that silt has come off through, you know, the drainage upstream. So, I mean, it's probably - I don't know that we'll ever recover some of those areas, you know. That may be unrealistic, but further downstream we'll get improvements.” -- Conservation practitioner

Another informant described the importance of considering the relationship between land and water while developing an oyster restoration plan:

“But, you know, these are the areas we're going to be concentrating on, trying to restore oysters, okay? When you look at these areas, what you see is that they are ditched and drained. The land in them is ditched and drained, unbelievably. Okay, so, we looked and we went, "You know, it's not going to do us any good to put oyster rock in these waters if they're polluted with the runoff from ag fields, you know, and carrying sediments."" -- Conservation practitioner

Sedimentation, a critical determinant of oyster survival, production, and recruitment, results largely from land use that leaves sediment unsecured and altered hydrology that shuttles it
to estuary. This informant and others stressed that outcomes of aquatic restoration efforts are predicated on hydrological restoration in order to reduce sedimentation and other forms of runoff that are so detrimental to oysters.

Connecting land and water-based restoration initiatives creates an ecosystem-based approach to oyster restoration.

“... but the idea is we put the whole ecosystem back together by helping farmers hold water for irrigation; treating the outflow, whatever outflow there is, through sheetflow rather than just straight-piping it right into the sound, giving it the added benefits of filtering, you know, through the water table; and then, once we have all that in place, see about establishing new oyster reefs offshore. So, it's this whole, you know, using all of the partners, you know, this whole ecosystem approach to restoration.” -- Conservation practitioner

Many informants across groups described the need for a more ecosystem-based approach to restoring oysters and managing resources generally. They also stressed the difficulties with such an approach. While the project described above is large in scope, scale, and approach, smaller projects are also vital to achieving restoration goals. Smaller projects can create a snowball type of effect: when people see successful small projects, they begin to support other such initiatives.

However, conservation organizations do not have legislative or regulatory power through which they can accomplish their goals, and their projects can stall when funding dries up. Achieving initiatives like oyster restoration requires them to partner with governmental agencies. Nearly all stressed a good working relationship with fisheries management:

“And Marine Fisheries, you know, had always been pretty good about, you know, being an advocate for the resource. And Shellfish Sanitation was another one. But they - you know, they weren't silent partners. And then, the Marine Fisheries Commission, you know, on all the storm water rule-making, they would attend and, you know, be as strong as we were, in terms of saying things that had to happen.” -- Conservation practitioner

“I think with the Division of Marine Fisheries, I mean, they're a mandated state organization, so they have a mandate. You know, they've got their Advisory Committee, ... and they have an Oyster Management Plan, which only the last few
editions have incorporated a more restoration aspect, which they have done, you know, on their own but with prodding and support from other people, from outside people.” -- Conservation practitioner

Conservation and management groups share many concerns for oysters. Awareness of the impacts of watershed-level changes on oyster survival and overall water quality is not unique to the conservation group. Informants in the management group also visited these themes. However, fisheries managers are not able to directly address them because their purview is focused on fisheries and aquatic habitat concerns. Fisheries management has a mandate to manage and restore the fishery, but they lend their support to landscape restoration considerations through the CHPP process.

5.5.4.2. Oysters as a Tool for Environmental Action

Conservation practitioners situate oyster restoration within a second landscape, the landscape of overarching ecological concerns of the coastal region. In this landscape, they consider a second type of linkage: oyster restoration as a tool for addressing general ecological concerns, such as regional water quality. One informant explained the “work” that oysters are able to do:

“And the oyster emerged as one of the good indicator species of the health of the system. It's sort of like the canary in the coalmine. If the oysters are healthy, and you can eat them, then the system is probably in pretty good shape. I mean, it came out as a - I think shellfish waters were very much - you know, having open and clean shellfish waters may have been the whole focus of the storm water work and other things. But, you know, all that was more on the protective side of not losing the waters. Those regulations don't do anything to reopen, you know, polluted waters. So, you know - but, I mean, the interest in shellfish and then realizing that, you know, in other places the oyster was getting a lot of attention, and it wasn't sort of that keystone species in North Carolina yet. So, you know, it seemed like a way to help advance, not just oysters, but the whole cause of coastal protection.” -- Conservation practitioner

Considered this way, what is good for oysters is also good for the larger estuarine system. In addition, more robust oyster populations can contribute to improving and maintaining the estuarine system of which they are a part.
Within this second landscape, conservation practitioners discuss another linkage: the relationship between oyster sanctuaries and harvest areas. They view both areas as critical to achieving oyster restoration. Sanctuaries cannot be considered apart from harvest:

“...you know, we were also very aware that we couldn’t do this in a totally separate way. You know, we had to be making the argument that having healthy oyster sanctuaries could lead to a more productive fishery. If you would leave these sanctuaries alone, you'd see better production outside. You know, and then that's led people into their work to try to get a better sense of what is happening in terms of larval transport from the sanctuaries to other sites and everything. ... So, I really - to this day, I think that, you know, several thousand acres of oyster habitat are probably entirely justified from a - probably from an ecological standpoint, as well as from a fisheries standpoint. You know, several thousand acres of oyster sanctuary would mean so much for the quality of life out there underneath those waters and for commercial fishermen ...” -- Conservation practitioner

Both areas are critical independently and as part of the estuarine whole. Sanctuaries likely export larvae that help sustain areas outside the sanctuaries while providing habitat to a suite of other species. Harvest areas maintain fisheries production in the state, an important component of why restoration efforts have been undertaken in North Carolina. However, there are some concerns about the put-and-take nature of some of the effort and resources that go into maintaining harvest areas.

“And then, the third thing is sort of the shell plantings for put-and-take fishery. And that's where you use shell, you go out, you put it into an area, let the oysters grow, and once they reach harvest size, they harvest everything off of them. And it just seems like, you know, with limited amounts of shell that we have, you know, is that the best way to use that shell? I understand, again, these are all fishery things, and the fishery is important. But are there better ways that we can manage that fishery? I think sometimes you're shooting yourself a little bit in the foot. It's very sort of day-to-day management, and I don't - it's not necessarily that those things are coupled with long-term management. I know there are long-term management measures, but those things tend to cut that short.” -- Conservation practitioner

This consideration of types of management areas, areas for protection and those for fisheries enhancement, underscores concerns about engaging in perceived short-term management at the expense of more long-term conservation and restoration. One informant went so far as to describe fisheries enhancements, planting shell in areas that will be open to harvest, as a government subsidy:
"The present DMF oyster restoration is pretty much divided in two types. One consists of making sanctuaries of oysters, only ten or so, where they put marl down. And it's been largely successful on a microscale. People can go in there and fish on those, but you can't take the oysters. The other part is the oyster recycling, which if you go to the Division of Marine Fisheries, they sort of muddle that together with the oyster sanctuaries. But in fact, the oyster recycling is primarily a government subsidy for the short-term economic benefit of oyster fishermen, commercial fishermen. Those, in fact, they decide where to put those by having public meetings and asking the oyster fishermen where do you want us to put these. I commented by saying that it was subsidizing. A huge amount of money. But what we ought to do is to think towards the long-term. And we should take those shells and we should put them into oyster sanctuaries. And I said at that time, at least 50%. Either supplement the sanctuaries we have or put additional ones. So that's what I thought we ought to do with those shells - use them for long-term rather than short-term." -- Conservation practitioner

5.5.4.3. Long-term Decision-making

Part of the concern expressed by conservation practitioners regarding the perceived short versus long-term focus of oyster management initiatives is a consideration of harvest gear. They question whether certain types of gear are detrimental to the long-term sustainability of both created and natural reefs. Sustainability here focuses on the life of the shell resources that are utilized in the creation of shell bottom and the maintenance of reef relief and height. Some conservation organizations choose not to get involved in fisheries management issues even when something like a gear issue overlaps with the habitat issues they typically work on, choosing to remain focused on other issues where there is agreement and support. Other organizations choose to wade directly into such issues. The following two informants demonstrate the range of opinions on the topic of gear.

"You know, it really to us seems pretty counterproductive to be putting rock in the water with the idea that it's going to be dredged up, you know. So, you know, we're walking a fine line on that. But, I mean, in terms of these organizations having any stance on fisheries issues, you know, like fisheries policy, that's out of our bailiwick, too. But, I mean, it's something the state's going to have to deal with, for sure. And, you know, what we all want is for oysters to come back so that there is a sustainable commercial fishery and clean waters. How do we do that? You know, it may be that there needs to be some restrictions put on dredging." -- Conservation practitioner

"These rocks take forever to get this three-dimensional structure and to get those oysters off of the bottom silt. And when you smash them, many of them that you don't take, that might be too small, die and you lose this great habitat. Well, right now, the
Army Corps is mapping, using LIDAR technology, and they found a whole bunch of, I won't call them virgin, but novel reefs that are essentially untouched, and I won't say where. Some of the guys I know put the Corps onto them, wanted them to map it. When those lat/long numbers become public knowledge, the dredgers are going to go there and smash the shit out of those reefs. And that was one of the reasons that I was trying to implement a phase-out of dredging. Over a 5-year period is what I proposed, a buy-out of the dredgers. The dredging is why we are in the state of oysters throughout the east coast, the overfishing. Additionally if we would just declare maybe half of these new novel reefs oyster sanctuaries, they would continue to seed the down current areas of the Pamlico. And these are in areas, by the way, that are open to dredging right now and where a lot of the restoration, the dumping of shells, occurs by the Division. So we are essentially subsidizing the commercial fishing, and we're actually encouraging this destructive practice of dredging by doing that.” -- Conservation practitioner

Transitioning the Fishery

While informants differ in terms of their willingness to get involved in management issues like dredging, most believe that dredges can be destructive.

“To me, the number one threat to the fishery, the commercial fishery and the viability of the commercial fishery is the continued use of dredges in North Carolina waters, because they wear down the rock. I mean, they actually destroy the habitat, you know, that the oyster grows on. ... You know, to me, if the fishermen are smart, they'll do away with it, just because, you know, they're destroying their own resource. But they're also out to make a buck, you know, and they want to try to pick oysters off as fast as they can.” -- Conservation practitioner

Conservation practitioners would prefer to see a reconsideration of management that helps the fishery transition to other modes of production. Preferable modes of production include use of tongs or other hand harvest methods and leasing. However, they recognize how difficult implementing such a transition will be:

“Yeah, I think probably a pretty - a really hard look at the way we're managing the fishery right now. You know, I think we're looking at it, we're managing it, but - you know, are there different ways that we can look to, for example, to get rid of oyster dredging? You know, we shouldn't be oyster dredging in North Carolina, and we're just not looking at how to do it. We're looking at ways to minimize the effects of that, looking at ways to control it, all those kinds of things. But we're not really having a good discussion about how to get rid of oyster dredging and, you know, making sure that we take care of the people who are engaged in that fishery through other avenues, whether it's getting them involved in oyster growing and things like that. But I think that's one big thing is a really hard look at the fishery.” -- Conservation practitioner
Members of the group seem to differ in their perspectives on how the transition could happen. One informant's description of leasing paints it as an ideal alternative to wild harvest, not only for the resource, but the harvester as well.

“I think we get 1 or 2 million a year from wild oyster harvest. And it can only be done during a short period of time, the dredging, right now. But the oyster leases have a year-round ability to harvest. And so fishermen don't have to go out in bad winter weather, in a gale, to fish. They could do it on calm days. They don't have to do it during the winter only - they can harvest year-round, waiting until the market is right. Or they can establish a weekly shipment and a stable market. Rather than only in the winter it could be a year-round. So oyster harvest from the wild is really unsustainable and there's really only one place it even comes close to that and that's in Florida, the river there, Apalachicola. But essentially everywhere else the sustainable oysters worldwide are cultured. And the quality of the cultured oysters is far superior. No barnacles and stuff all over, slimy stuff. So I'm all for seeing more oyster aquaculture.” -- Conservation practitioner

Unlike the management group’s discussion of leasing and aquaculture, this informant did not mention the challenges of leasing which center chiefly on the high capital investments with high threat of loss due to disease, storm damage, or theft. In addition, lease applications undergo often intense public scrutiny during the review process. The informant did describe a buy-out of dredgers that would perhaps mitigate some of the financial barriers to leasing. Another informant offered a more sympathetic yet firm description of a possible transition process.

“And I think a lot of it is, hopefully, offering both a carrot and a little bit of a stick. The different incentives - training, engagement in different aspects of the fishery, giving people the tools to move out of the fishery, giving them incentives, whether it's buyout programs or things like that - together with the very firm thing, like, "We're going to ban oyster dredging or we're going to do this with this fishery as of this year. We'll phase it out. It will be banned. Here are all these incentives to get you engaged in something else." And, you know, I think there will probably be people who will never want to get out of it. There may be people who are willing to jump out of it because they're not making any money the way gas costs are and everything else. But there will be people who want to stick with it and see it as losing a heritage. So, I think there will be issues associated with it that have to be tread very carefully. But, you know, I don't know if we have a choice. I don't know if you can, you know, have a good sustainable oyster population and fishery and still have the impacts of dredging that we're having. ... So, I think there will be resistance, but I think there are ways to reduce that resistance and support the people who are involved in the fishery. At the same time, you know, I think we also have to make that move. We don't have that luxury if we want to really restore our population.” -- Conservation practitioner
Transitioning the fishery from wild harvest to leasing seems to be an issue that presents a struggle for many in the conservation group. One informant expressed that struggle:

“And, you know, the idea of going out and gathering food from a wild source is - it's a beloved way of life, you know, and I think that it's something that should be sustained, you know, in this area. I mean, it is so much a part of our culture and heritage. To, you know, build a little fence and, you know, have a little farmed oyster area isn't going to do it, you know. However, having said that, maybe the only way to have oysters re-establish themselves is to go to something like that or depend on it for the short term until more oyster reefs can get out and get established, and in a while the fishery can be opened. I don't know. … It's - I'm very - I know that were I working on the water - you know, were I one of the guys out working on the water every day, you know, taking a wild resource, you know, and really priding myself on knowing where the wild resource is, getting them out of a farm isn't going to be the same at all, you know. And that's just - that's the same with like finfish and crabs, too, you know. I don't know. But maybe we need all of these solutions. I don't know.”

-- Conservation practitioner

Conservation practitioners believe that maintaining harvest and the oyster fishery matters critically to coastal way of life. However, they fear that the use of dredges may be creating an unsustainable imbalance between the harvest and ecology of oysters.

5.5.4.4. Habitat and Resilience

While there is a great deal of contention around the use of dredges to harvest oysters, there is widespread agreement among stakeholder groups that returning shell material to the water in high enough quantities is a high priority.

“I guess I'm a big proponent of the "if you build it they will come," you know. There's just not - I mean, you can spawn out there, spat out there out the yin-yang, and if there's no place for them to attach, it's no good. So, I mean, to me, putting the rock out is number one. … You know, re-establishing - you know, having an area that's closed until oysters can really become established, and then opening it only to tonging. And I think in order to do that we're going to have to put a ton of rock in the water. I mean, not "a ton" - like, lots of rock in the water, you know. And that's going to be - you know, that will be a challenge, certainly, you know, in terms of the resources allocated. One of the things that I think is going to make or break oyster reef restoration is the amount of money that the state will allocate toward putting rock in the water and, you know, hiring personnel to, you know, really help with it and carry out these projects.”

-- Conservation practitioner

This informant linked returning shell material to the water with temporary protective status and gear restrictions in order to allow populations to establish themselves and avoid...
perceived destruction by dredging. Such a restoration formula could be successful only
because recruitment levels are high enough for new populations to get established.

Recruitment is high in most areas; the limiting factor to population expansion is habitat.

“As far as other things that I've learned is I've noticed at least for this area up in the
northern part that when we put material out, we've had recruitment. We have very
few places where we've put shell and stuff out like that that we haven't gotten
recruitment on it. So in some places it looks like it's a lack of material, of hardened
substrate that holding some things back. And that's interesting. How that would affect
disease and density and things like that down the road, it's hard to say. But it has
changed my thought on just some things like that. And just trying to get more material
in certain places. I'm always amazed at initial recruitment on some spots.” --
Conservation practitioner

Still, conservation practitioners caution that population growth through recruitment to
cultch planting material may not translate to higher harvest. Oysters may still struggle to
survive to the state’s harvest size limit. Informants cite a number of potential causes
including disease, sedimentation, and poor water quality as well as the cumulative impact of
multiple factors.

Despite the many challenges facing the work to restore North Carolina's oyster
population, conservation practitioners remain impressed by the power of nature and its
resilience in the face of a seeming barrage of incursions and assaults.

“Of course, the other thing that the oyster reef, oyster work, did for me was probably
more than anything else I've ever done is to show me that, if people will just get out of
the way, life is such a powerful force that life will go on and will come back, you know,
if we just don't screw it up too much. You know? It'll go on, and I really felt that
strongly there.” -- Conservation practitioner

The resilience of natural systems, along with the need to moderate possible impacts from
human activities, was a common theme for many in this group. Ecosystems are resilient
within certain bounds; if conditions change radically enough to reach outside of those
bounds, then the system’s ability to rebound will be compromised. According to one
informant, if, perhaps by magic, the oyster population came back to historical levels, if we
did not change our behaviors in terms of watershed development practices, stormwater
control, sanctuary establishment, and other factors that affect oyster sustainability, then the population would likely decrease all over again. These informants lament that the power of nature is recognized less and less in today’s coastal society because of a growing disconnection from the water.

“I mean, seeing that property values went through the roof, you know, the people that traditionally lived here couldn’t afford to live here, so they're not going to be out doing, you know, the traditional types of industry. And so, to me, that's a huge challenge going forward, because I think we're getting more and more disconnected. Although some of that could - you know, when construction was booming, it was just a much easier way to make a living building houses. And now that those jobs have disappeared, you know, I think there could be a trend back to more reliance on the environment. But we'll see… You know, if the coast changes substantially in its character, you know, at some point you begin to wonder what it is you're trying to do to protect it. I mean, I think we're a long way from that still, but that's a trend that I'm not real happy with seeing. Although, you know, a lot of that in the last year or so has really changed. … Because we went through this highly speculative period that has, you know, radically changed in the last year. And it may be that we just get back to more a normal type of community development. You know, things are going to continue to change in the region, but it will be at a pace that you can deal with it, and, you know, it will be because people really want to live here.” -- Conservation practitioner

5.5.5. Aquaculture Group

Informants in other groups have discussed aquaculture and leases as possible release valve to the harvest pressure on natural oyster reefs and planted bottoms. If restoring oysters to estuarine systems restores beneficial functions of the systems, such as filtration and habitat, then to the extent that oyster aquaculture installations replicate these functions, aquaculture has potential to improve systems’ resilience to insults such as eutrophication and turbidity (NRC 2010). Aquaculturists and leaseholders began growing oysters for a variety of reasons, but all believe the impact of shellfish growing can and must increase.
5.5.5.1. Impacts of Altered Hydrology

Members of the aquaculture group were highly aware of the negative impacts of changes in land use patterns in the surrounding watershed on oyster survival and the success of leases.

“Yeah. And that, you know, two years ago, was all woods. And when it rains like this, the water seeps down through the trees and goes in the ground, and eventually, it ends up in the sound. But when you clear it all and put houses in there, it tch... yeah, it goes in - and they've got retention ponds and all kinds of things in there. They tried to engineer their way out of it, but you can't do it.” -- Aquaculturist

Leaseholders are tightly connected to place in a variety of ways. One obvious way is through their lease agreements. These agreements tie them to specific, designated locations where they are to work and harvest oysters. Wild harvesters may have preferred sites for harvesting oysters, but they can move to other sites as patterns of productivity and yield inevitably shift. Declining yields due to environmental impacts on a lease can be devastating to a leaseholder. The cumulative impacts of altered hydrology and coastal development add to the complexity of understanding why the oyster population has declined, but lease holders point principally to sedimentation, which can smother and kill oysters on bottom leases.

“Back in the early '70s, you could go back here behind the Villages and pick just about all you wanted. And it doesn't happen anymore. I don't know if the sedimentation is worse now. Or people - I don't think people are really going out and picking them. But there certainly has been a lot more development here, and runoff would be greater. And since everybody's got a septic system, there's nutrients being run off. So, I never have been able to quite put my finger on why the population has gone down.” -- Aquaculturist

Informants in this group charge that water quality changes and continuing changes in land use hinder oyster restoration because the pollution entering the sounds and bays in runoff reduces the spawning output of oysters.

“I don't think you can restore the wild population. I think a lot of it is gone forever, just because, you know, the area is so much more developed. Right next to this property, right over here, that adjoins our property, there's eleven hundred houses going in there. ... So, I think the water - what that does, it takes food away. So, that's the
issue. You're taking food away. And then, of course, the more boat traffic and stuff you have, the more pollutants you put in the water. And when you have polluted water, you won't get as good a spawn with the oysters. So, you have different degrees of that.” -- Aquaculturist

Lowered reproductive output reduces the populations’ capacities to grow in response to restoration efforts. Heavy metals, petroleum hydrocarbons, and chlorine pollution interfere in various ways in reproductive success, larval development, and spat settlement (Perry and Cirino 2000). Water pollution, especially *Escherichia coli* contamination, can render leases unfit and lead leaseholders to give up affected leases. None of these informants mentioned this as a specific issue.

**Bottom Conditions and Floating Leases**

Restoring the bottom fishery is also challenged by bottom conditions in deep water areas. Sediment build-up combined with reefs shortened by the removal of shell material during harvest leaves oysters in poor growing conditions.

“You know, larvae like to get in that upper part of the - it just likes to settle up in that upper part of the water column in shallower water and get up there. If it gets out in deeper water, especially if there's a lot of mud out there, and it just dies.” -- Aquaculturist

Aquaculturists believe that taller reefs and elevated aquaculture operations are critical to basin-wide enhanced larval attachment and recruit survival because water column leases seem more successful than bottom leases.

“So, one year I got some of my tomato cages from my garden, my land garden, and took them back there. I cut up some old crabpots, and I got the chicken wire, and I made walls around these conical shaped tomato cages. And so, I took those out there, and I stuck those into the bottom, and I would dump, you know, buckets of shell culch into these cones. And I tell you, the first time I did it, I was absolutely amazed, because I was getting thousands and thousands and thousands of new spat that way. And it appeared that these things, being held up off the bottom and up into the water column - they went almost up to the surface - and I don't know where eyed larvae swim mainly, if they're up top, or at the bottom, or in the middle, or what, but these - I call them my catcher's mitts - these things were catching the larvae like crazy.” -- Aquaculturist
Shellfish growers often demonstrate greater success growing oysters in floating bags compared to on-bottom leases. For bottom culture, oyster larvae are set on oyster shells in some kind of closed system, and then the shells are placed on the bottom. Floating oyster aquaculture sets larvae on microculch or a piece of shell the size of a sand grain. The spat are then placed in stiff mesh bags or cages, and the bags are tethered and allowed to float. As the oysters grow, the volume occupied in the bags increases part of the population of each bag has to be transferred to another bag periodically such that the number of bags grows over time. Floating culture may be more successful because recruits may disperse higher in the water column, but importantly there is more food and greater oxygenation higher in the water, which helps recruits grow faster and survive better.

“But, yeah, we're raising - doing floating, off-bottom culture after reading a lot of the material on your growth rates for off-bottom versus on-bottom and caged versus non-caged. There's a lot less cost involved if you do spat-on-shell culture, but there's also a lot of things that can go wrong in the meantime. When you have everything in floating cages, you're basically in control from the moment you get the spat or eyed larvae until you sell it. You know what that oyster has been through, what you've done to it, you eliminate a lot of the predators. You put it up in the upper reaches of the water column where you have higher temperature, higher oxygen and higher food levels. So, all three of those added together will allow your oysters to grow faster in a shorter amount of time.” -- Aquaculturist

**Lease Restrictions**

In light of the production benefits of growing oysters in the water column as opposed to on the bottom, one informant expressed concern over the restrictions in place for water column leases.

“But to encourage people to grow them, there would have to be a lot less stringent demands on production and water column leases and things to allow people to grow stuff on the surface. For a clam lease, a bottom lease, it's twenty-five bushels an acre a year. But for a water column, the state requires - I'm not exactly sure, but I think they calculate the total amount of square feet all the way to the surface, and they demand production whether it's a hundred or two hundred bushels. And that's really - it is true that you are taking away from riparian rights, as far as somebody using that area, but you're basically only using the surface to float the oysters. So, if you get the lease, and you're going to float the oysters on top, you shouldn't be required to produce so many animals for the whole column, because you're not using the whole
column. You’re only using the top, just like a bottom lease is using the bottom.” — *Aquaculturist*

According to the Fisheries Rulebook, shellfish bottom leases must produce and market 10 bushels of shellfish per acre per year. They must also plant 25 bushels of seed shellfish per acre per year or 50 bushels of cultch per acre per year, or some combination of cultch and seed shellfish where the percentage of required cultch planted and the percentage of required seed shellfish planted totals at least 100 percent. A water column lease must produce and market 40 bushels of shellfish per acre per year to meet the minimum commercial production requirement or plant 100 bushels of cultch or seed shellfish per acre per year to meet commercial production by planting effort. For these purposes, a bushel of oysters is equivalent to 300 oysters (15A NCAC 03O .0201). I do not point out the difference between this informant’s recollections and the rulebook to simply point to an error, but to illustrate the limited amount of information about leasing that gets disseminated, even among those individuals involved in aquaculture.

5.5.5.2. Natural Phenomena

Survival and production is not always better in a floating lease compared to a bottom lease.

“This last year - was it last year we had the bad drought? We had a bad drought, and it killed our seed and all the crop for that year that was off-bottom - killed everything. Salinity went up way high, you know, a lot of reasons. Salinity went up - back in these bays, you know, the water evaporates. Our salinity went up to 41. It's okay if it does that for a couple of days, but it stayed there. And that invites all kinds of other organisms to grow, you know, a lot of tunicates, sea squirts, and all kinds of other organisms and diseases. It just promotes everything that's bad for the oyster. And once they start getting sick, the other ones get sick, and it's like a, you know – [LINDA: LIKE A WAVE, ALMOST.] Yeah, and we lost everything. We still had some bottom crop that lived.” — *Aquaculturist*

Leases, whether floating or on the bottom, are subject to fluctuating estuarine conditions just like natural and planted reefs. During periods of low rainfall, salinity increases. In some
locations this increase can be dramatic – reaching higher than full seawater. This causes oyster mortality due to competition for space and other resources as well as parasite infections.

“One of the biggest problems that oysters have is drought. It runs the salinity up so high from evaporation that some of the more - diseases that attack the oysters thrive on high salinities. And that's why this sound doesn't have hardly any oysters. But just on the other side of the island here we have an abundance of oysters, because it's fresher over there, because the [river] feeds it fresh water and keeps it brackish. And so, we did see - when we do have high-salinity years from lack of rain, we see it … and that's just nature. I mean, you're not going to be successful at every little turn when you're dealing with Mother Nature. You're going to have to take your lumps.” -- Aquaculturist

According to this informant, the unpredictable nature of weather and other ecological factors mediates high expectations for outcomes of aquaculture initiatives. Changing patterns of natural phenomena can interact with anthropogenic alterations in the watershed to further detract from lease success. While low rainfall raises salinity to potentially disastrous levels, high rainfall may be associated with algal growth, another destructive agent for oyster gardens and leases. In addition to causing human health-related harvest closures, runoff from high rainfall events washes additional nutrients, which can support high algal growth, into waterbodies.

“And I did notice, particularly in the summertime when the water would heat up, that there were some really big issues with trying to keep these oysters alive, particularly algae growing over them. And my first batch out there, they just got covered up, and I went back there one time, thinking, you know, I was going to find a bunch of nice big oysters, and they were all dead. … One thing I have here near by bed is a storm drain from the road. It's within a hundred feet of where I'm growing these things. And I suspect that has a lot to do with my algae blooms in the summertime. I'm not 100 percent sure, but - and I did do some volunteer testing for the Coastal Federation, and after significant rainfall events, we documented coliform bacteria coming out of a storm drain. … I did notice that, in the algae part, summer before last, we didn't have much rain, and I didn't have much - I didn't have any algae problem that summer. So that made me think that it's directly attributable to the runoff.” -- Aquaculturist

5.5.5.3. The Right Habitat

Despite the recent drought conditions, official disease mortality remained low.
Without proper testing it is difficult to say precisely what kills oysters during these events. In the face of the various natural, anthropogenic, and cumulative effects on oyster growth and survival, aquaculture informants are convinced that a critical determinant of oyster population expansion is deployment of cultch material. In general, reproduction is high, but recruitment can only be as high as the amount of area appropriate for colonization. One informant described the connection between the extent of good habitat and oyster population status:

“They used to be "overfished." And people said, "Well, it's not over-fished. If you just leave it alone for a year, it'll come back." And it does. But the concern is that they don't leave it alone. And it's dwindling at such a small degree every year. But over a twenty-year period, you know, if you look at the numbers of acres of bottom, of shellfish bottom, the bottom that actually has shellfish on them, you know, that dwindles a little every year. … Once you take it all, it won't come back. You have to have the habitat. If you take it all, it won't come back. If you take most of it and leave a few and leave it alone, it'll come back, if you have the habitat. But you've got to have the right habitat. Now, the habitat is impacted by all those other things - the people and the storm water runoff and the disease and whatever - all those things. So, you know, habitat is a big, big issue. Got to maintain it somehow or build more habitat.” -- Aquaculturist

The right habitat is critical to all other aspects of maintaining, managing, and restoring oysters. The right habitat refers to both location and architecture. Habitat must be located near areas that supply colonizing larvae, and it must have height to lift oysters away from the stress of growing on the bottom. Amid concerns that there is not enough shell material to expand the cultch planting program, one informant, citing the importance of creating habitat, suggested utilizing alternative materials.

“I went to an oyster festival up in Urbana, Virginia. It's been going on a long time. We've been several times. But one of the exhibitors up there was an aquaculture company. And I don't know how they got this exhibit there, but they had this big tank of water, and they must have had a crane to bring this piece of concrete in, because it was something that they had designed, basically, kind of square in shape, hollow in the center. But it was, like, kind of a selection of concrete beams put together in one mold, and that was, you know, that was how they were growing oyster reefs up there. And they brought this thing in, and you could look into this tank and see it right there. It was fantastic. And I don't know why North Carolina doesn't get into some kind of artificial substrate like that, you know. But they seem to be trying to just grow them on shell only, and I guess they may use marl, too, at times. But there seems to be a shortage of shell cultch, too, is another problem, because people are not returning
the shell to the water like they should. Locally, here - we have a recycling center. It's not working up there. I mean, I go up there and I check these - it's just a couple of trashcans, says, "Oyster Shell Recycling," and I never see shell in those cans. And it doesn't seem to be maintained by anybody. Sometimes I'll go by, and the lids are off, and the cans are full of water. … But I think, yeah, the answer for bringing them back would be, yeah, to get that substrate out there.” -- Aquaculturist

To build the taller mounds used in the oyster sanctuary, the state does use materials other than shell. The state piles up limestone marl and then covers it with smaller pieces of marl and a layer of shell. In some cases the shell is seeded with hatchery-raised larvae, but not all cases.

Like other stakeholders, aquaculture informants focus on returning habitat to the water in order to improve the oyster population. However, they seem less convinced that building habitat should help the oyster fishery. While a variety of factors combined to damage oyster habitat, this group sees harvest with dredges as a part of the oyster’s problematic status and questions the continued use of dredges in areas where cultch material has been planted by the state.

“You know, I personally think if their intent is to bring back oyster reefs, enhance the population, then they should always be off-limits for commercial fishing. I mean, let them be their true intent as a true oyster reef. And I know they do some like that. I don't know if there's a percentage or not, but I know they do make some reefs and they're always sanctuaries. But they do make some reefs and, "Okay, two years from now we'll open it up, and you can oyster on it." So, I don't know. To me, it's just throwing good money after bad when you're doing that and allowing people to fish on it. Because it's - you know, it's not like you have an oyster reef here, and people are just, you know, dredging around it and getting the oysters that have settled off to the edge, you know. You know some people are going to be dragging across it and down it and knocking it over. So, now you're just flattening it out again, and now you've just defeated the purpose of doing it.” -- Aquaculturist

The current approach to oyster restoration involves coordinating sanctuary creation with cultch plantings in areas that are open to harvest. This coordination is viewed by many as critical to success. The sanctuaries export larvae that settle on planted cultch material and recruit into the adult population and, ultimately, the fishery. However, they seem troubled by the use of shell resources in those areas that will be harvested.
“And we're talking - right now the state has about thirty acres of oyster reefs. It's not even thirty acres. They have oyster reefs on thirty acres of plotted-out area. Okay? … And the only way you can have it is to build them a little bit at a time and put them off limits, because if you let people go on there and dredge or tong or whatever, it'll be gone. … So, that's kind of the goal, I think: to build them. Pamlico Sound.” -- Aquaculturist

5.5.5.4. Contributions of Sanctuaries and Aquaculture

Informants in this group believe that the solutions to the state’s oyster problem are sanctuaries and aquaculture. Both sanctuaries and leases can result in a “more permanent” oyster population. Oysters on sanctuaries are permanent in terms of harvest protection, and the height of sanctuary mounds should help oysters escape other mortality factors like sedimentation and disease. Well-maintained and productive leases can become permanent fixtures because they will always contain oysters at various developmental stages. Shellfish growers see a similar relationship between oyster mariculture infrastructure and harvest areas. The reproductive output of leases, like sanctuaries, can seed neighboring areas promoting expansion of the oyster population.

“Now, if you go out on my lease, you can find all kinds of them. But, see, that's the glory about leases. See? And then, my oysters, which are mature, are spawning. And one of the reasons we have so many oysters in this area is because of our hundred acres of leases. We put out billions and billions of larvae every year. Yeah. And I've had a lot of people tell me, "Boy, don't ever give up those leases, because we won't have any oysters." And they're right. They won't. I think most of the fishermen around here really respect the fact that we've got leases.” -- Aquaculturist

To avoid state-planted cultch sites becoming unproductive, aquaculture informants imagine a system of closed reefs that allows harvest for only a limited time.

“And as you get into aquaculture, you get more acres of leases going, and you get more oysters out there, you know. I've got a hundred acres of oysters out there. The state couldn't do the same thing. They just can't do it. They put a hundred acres of oysters out there, they'd give it two years, and everybody would take them all. Then, they'd just have to go back there and put them in again. And you just spend a lot of money, you know. So, what we need to do is build oyster reefs, either that people can't get to - they're too deep - or that they're just off limits. You put them off limits. And let them grow. And maybe even some of them, maybe after a few years, after they get so clogged up with oysters, then you say for a year or two, you say, "All right, go in there and get what you can." And then, shut them off again. I don't know.
We could have a management program like that. But we can't even talk about that until we get the reefs going, you know." -- Aquaculturist

A system of rotating closures would allow areas to produce many large oysters, and then undergo harvest for only a limited time. Before such a system could be instituted, more reefs must be created.

Informants suggest this proposed system is a contrast to the current approach in which cultch material is planted and then harvested by dredges until it is unproductive and requires planting all over again.

“Personally, I think if they're going to spend the money to plant cultch, I don't think it should be open at all. I don't think it should be put-and-take by the state. I personally don't think that's the state's job to make a place for people to fish. Now, I think, and that's probably one reason why I don't agree with the whole system, that if the intent is to make an oyster reef and make your pile so the oysters can live, but then two years down the road, you go open it up to oyster dredging, and they knock it all down flat again. Okay, now you've got to go rebuild the reef, so you're either smothering the oysters that you're dropping your new cultch back on, or you're starting all over again. It just doesn't make sense to me. And I don't think it's the state's job to ensure somebody can fish and give them something to fish on … because they don't plant clams for other people that make a living hand clamming to go get, or they don't stock many, if any, saltwater fish for people to catch in gill nets or rod and reel or whatever. … In a way, it's a type of subsidy program. I guess it's more of a program if they're doing the actual spat-on-shell and putting that in a reef, and then two years later letting people get in, as opposed to, "All right, we're just dumping marl out, and then if any wild ones come and set on it, then you can go catch them." I guess that would be, "Well, we'll give you the base, but if anything happens, it's up to nature," as opposed to, "Okay, we're putting oysters here and two years later we'll let you come in and get them," which I don't know enough about it now since they've just started that if that's the intent, or if those reefs are actually just going to be reserved in sanctuaries." -- Aquaculturist

Informants refer to the yearly cultch planting program as a put-and-take program. While it does seem to be benefiting wild harvesters because landings are increasing, some in this group equate this program with a subsidy for wild harvesters. If the state can provide that type of subsidy it seems reasonable to these informants that the state could provide subsidies for wild harvesters to initiate private aquaculture and leasing operations.
Overcoming Limitation to Mariculture

Since leases, like sanctuaries, are larval sources for public bottom, shellfish growers believe that the state is not doing enough to encourage, facilitate, and incentivize mariculture. They point to other states as proof that leases and mariculture could be more significant here in North Carolina.

“We’re about twenty years behind everybody else. I mean, Virginia - I’ve gone to one of their aquaculture/ mariculture conferences up in Virginia and had their Marine Fisheries people and Wildlife people come up. And they said, right out front, "We are trying to make it easier for people. We are streamlining our forms so you fill out one page, you know. We supply the surveyor to go get bottom leases. We have opened up thousands of acres of bottom to the public to come in and lease. We are encouraging people to do this." North Carolina is just the opposite.” -- Aquaculturist

9.8 million aquacultured market oysters were sold in 2008 in Virginia, a state where approximately 95,000 acres of oyster bottom are in private leases. As of 2005, North Carolina had just 1,972 acres in private leases.

Several factors could inhibit an individual from establishing a new lease, including regulatory restrictions, public hearings, and legal challenges. The upfront costs of leasing, especially water column leases, are high, and those costs could also be preventing those who are interested in getting involved from doing so.

“We've got tonging and dredging in the state, and most of the money is spent on the putting in of oyster shells and rocks on the bottom. And that's a good program, and that works good, and a lot of people are making - it's helping the economy, and they're making money at it. And it's a good program. But also, along with that, it would be good if people would grow the oysters, you know. I think there's some interest, but I just don't think a lot of the people that have an interest into it have the money to get started. Because the bags that float on the surface, the best ones, are five dollars a piece. And the floats are six dollars a piece that go on each side. So, you've got five and six dollars is eleven, and then you've got - you've got almost twenty dollars a bag. And you can get about a bushel out of a bag, about three hundred sellable oysters out of a bag. But still, that's twenty dollars each bag. If you need five hundred bags, you know, you're talking some serious money, plus you've got to buy the animals to go in them.” -- Aquaculturist

High investment costs and risk of loss due to factors beyond the grower's control likely combine to limit the number of leases and lease holders in the state. In addition, maintaining
a lease is more time consuming than wild harvesting.

“And, actually, this is - it's not as hard physically, but it's more tedious. Because when you have to grade and sort 50,000 oysters, it's not a lot of heavy lifting or anything, but you've got to almost handle each one of those 50,000 oysters, to pick it up, look at it, or at least look over it while you're scooping it by or picking it up and throwing it in a basket. So, there's a lot of tedious work that goes on with it. So, you know, some people don't want to do that. But I see that - this isn't for everybody anyway. It's no different than any other fishery. You know, certain people are going to gravitate towards certain things that they identify with or like to do.” -- Aquaculturist

Time is also required to develop markets and outlets for the lease-grown product. Shellfish growers have to do their own marketing to restaurants and other markets in the region.

Shellfish growers believe that greater incentives from the state, perhaps instead of some of the cultch plantings on public bottom, could help overcome these challenges. This could be a prime time to offer incentives for aquaculture since so many fishermen are having to get out of commercial fishing for financial reasons. These individuals might be willing to switch to aquaculture and leasing if there was more state-funded assistance to do so.

5.5.5.5. Aquaculture as Connection to Tradition

Informants in this group advocate for new approaches to oyster restoration, such as expanded leases and sanctuaries, while maintaining fishing traditions and traditional fishing grounds and bottoms.

“You know, it's hard to go in there and take over a fishing bed that they've had for years and years and years. I don't think that should be done. I don't think that's fair. You know, they've been doing it for years and years. Let them have it, but don't plant it for them! And we do that, you know. And we've been doing that for years and years and years, and spending hundreds of thousands of dollars. I mean hundreds of thousands of dollars. Up until this year, we spent at least two hundred or two hundred and fifty thousand dollars on shells. Now, we've got two million dollars a year to spend on this stuff. And I don't think we ought to spend it and put it out there in the water and let people just go get it, because if you do it, they'll go get it, and it'll be gone. But if they have an area, like they do around here - there are a lot of areas around here where the people who shellfish for the wild go, you know, and they're traditional places, and that's fine. They need to have that. That's part of their living. So, we have to protect that.” -- Aquaculturist
Successful restoration will require the balancing of traditions, such as historical reefs for wild harvesting, with new methods for expanding production and offering relief to natural reefs, such as sanctuaries, aquaculture, leases, and hatcheries. Another limitation on leasing is fear of the unknown: fishermen may be unwilling to give up something they know for something that they do not know. While aquaculture may entail new methods previously unused along the North Carolina coast, they offer an important connection to place and sustainability of a heritage.

“Well, it's not just the sustainability of the product, but the sustainability of the people, because I'm looking at it as not only a way to produce oysters in an environmentally sustainable way, but also to sustain a way of life for coastal North Carolina that has been here for hundreds of years, and at least giving some people a way to maintain that and keep their coastal heritage and coastal roots. And so it's not - I don't want just to make it about the oysters. That's part of it, but it's also about the people. I'm from here and I enjoy the coastal heritage. And, you know, it's just something that I think - and I've seen over my lifetime getting pushed out more and more and more. And oysters have been tied to the heritage of the area as long as there have been fishermen, ever since the English landed, you know, and said there were oysters as big as your hands and their ships were running aground on the oyster reefs. And now you can barely scrape together enough to eat. And so, it's a heritage issue that goes back and is tied to the people, the place, the organism, everything.” -- Aquaculturist

Aquaculture and leases may provide continuity with place, that commercial fishing cannot, by allowing participants to maintain their connection to the water and their communities through a new means. Instead of having to go to work on tugboats or dredge boats, aquaculture can provide a way for coastal fishermen to stay on the water, but in a different capacity.

“Well, it's sort of like cars. You know, it started out with Model A, Model T Fords. All right, I've got a truck parked out back. It's still a truck, but it's nowheres near what that Model T was originally. You know? We still have the same connection and same line, but it's a new thing that's evolved. And this mariculture process is an avenue for people to stay where they've grown up all their lives, and make a decent living to support their family, and continue a waterman's heritage. Now, granted, you're not doing the same things you may have been doing twenty years ago, or your father was doing, or your grandfather. But the bottom line is you're still going out on the water, you're harvesting a product to sell to support your family. Now, before you were going out with oyster tongs or a rake hoping you could find wild oysters. Now, you're going out to a place that you have leased, you have put every oyster in there, if you're doing it that way.” -- Aquaculturist
Connection to land and water is very real for commercial fishermen. The work of a fisherman takes him out into the landscape. Shellfish growers believe that aquaculture can help preserve that connection.

5.5.6. Science Group

Researchers in the science group conceptualize oyster restoration within the limitations and opportunities provided by the current environmental conditions of the estuarine landscape. They value an experimental approach to restoration as part of a comprehensive plan for oyster management and restoration.

5.5.6.1. A Fishery that Fits Current Conditions

There is a strong interest among researchers to restore oysters as a wild fishery. This interest is tempered by the recognition that the current state of our coastal waters is so dramatically different than during the heyday of the fishery that it is impractical to try to return to an historical status.

“But I think oysters have been with us for years. It's only in the last hundred years or so that they've declined to insignificance. So, I mean, we're talking more broadly than oysters, I guess, because you asked me about restoration, but I see restoration as trying to go back to a more pristine ecosystem. The issues are, though, from a practical sense, there are things that have occurred that will never be reversed and that make it impossible to go fully back and may constrain how you might take components of it back, because the way it was then may not be attainable. In other words, there are fifteen parts that are very important. Three parts can't be restored. It's possible that the other twelve don't stably coexist without those three, so that you can't actually achieve a sustainable system with the remaining parts that could be restored, in which case I would define restoration as an achievable subset of those, with a new status that doesn't actually look like the old one.” -- Scientist

In altered systems, only restoration of selected aspects of the former system may still be achievable as opposed to a full historical baseline. In terms of the oyster fishery, it may only
be possible to regain the fishery in a changed form. Instead of going back to a previous status, the oyster fishery must evolve to current conditions.

“But I don't see, except for aquaculture, I don't see a fishery coming back. And people don't like to hear that. Basnight, you know, wants to see us restore everything to the way it was in the past. But, man, that's 1900, pre-1900, we're talking about, frankly, and that was because we hadn't fished them so heavily. We're never going to see that, where we can have a wild stock. I mean, we can maybe get more shell and get some more hard-bottom habitat, and I think we can expand them a lot. Maybe we'll have a modest fishery. But the writing is on the wall, if we look at shellfishing and declining wild stock and booming aquaculture, and that's, I think, projectible into the future as well. So, if you buy my arguments that we're not likely to regain the oysters of 1883, or anything like it, you know, we're never going to get back the oysters under the conditions that North Carolina promoted the fishery. The new conditions of promoting aquaculture require a mind readjustment that may occur.” -- Scientist

Supplementation of wild harvest of shellfish with aquaculture is critical to the survival of the fisheries and fishermen. Informants in this group believe this for several reasons. First, changes in environmental conditions, especially reductions in water quality, are affecting the future of the fishery. Oysters grown in polluted waters cannot be harvested for the fishery, but they can serve other eco-service functions. In addition, the organisms itself may have changed due to the influences of more than a century of exploitation and disease pressure.

“I think we've changed the environment enough in our coastal ecosystems that the carrying capacity of those ecosystems is different. And that's just a gut feeling; there's no - I have no data. [Laughs] And the other one is one that I'm interested in, but I don't know quite how to attack is: Have we changed the animal, with this huge selective pressure that the diseases have placed on the animal? And killing everybody at two years of age, how has that changed oysters? So, even if we could all make it go away tomorrow, the diseases disappear and everything like that, would oysters still live ten years? Or have they become more scallop-like? Shorter life span, a weeder species. … I think that the kind of easy answer is disease, but I'm not entirely convinced that it is the acute influence of disease that is keeping oysters small. I don't think we're having catastrophic episodes of MSX or dermo. The thing that I don't know goes back to something I mentioned earlier is that I don't know what the aftereffect of thirty years of MSX and dermo is, and whether that's really what's, again, keeping - has kind of made oysters a weedy, scrawny species instead of a big, fat, happy species.” -- Scientist

Finally, economic conditions have changed. The costs of fishing have climbed while the return on wild caught products have not always kept pace.
“You also have to take into account issues such as profitability at a time of rising gas prices and other effects that tend to work against the fishery in terms of being a viable business. So, I think the oyster fishery will continue, the wild fishery. I'm not sure how large it will become even with restoration, simply because, you know, unless we move people away from the coast, we're going to continue to have pollution problems. Unless we find quickly some great alternatives for gas, gas is going to go up. Cost of boats will go up. People aren't going to pay - some people pay a lot for oysters, but not the average person. So, oysters can become a luxury item, but you can only support so much fishery off of a luxury item. And probably mariculture is where you're going to get the cheaper oysters.” -- Scientist

5.5.6.2. Impediments to Aquaculture

Despite the shift in ecological, organismal, and economic conditions that researchers describe as justification for the expansion of aquaculture in the state, they also discuss a number of impediments to aquaculture. Aquaculture with oysters is challenged by disease, slower growth on bottom leases, and the lack of an in-state seed source. The state hatchery under development at UNC-W will address some of the seed source issues, but other issues will persist:

“The biggest factors limiting mariculture here are economic. And, to a lesser extent, just getting appropriate - well, that's probably economic - appropriate leases. Number one, land is very expensive. And just having - you know, most mariculture operations have shoreline areas that are involved. How do you tie up shoreline areas for what is a low-profit business no matter how you look at it, given the price of shoreline areas now? It doesn't make a lot of economic sense. The people who are doing it are doing it in spite of the fact they could sell their land for huge amounts of money. So, that's part of the economics. There's also just the economics of running the operations. You know, you have to put out the floats and those sorts of things. Locations. Where to do your operations? Water quality eliminates a lot of areas that would be great for culture operations in the Pamlico.” -- Scientist

Limitations to aquaculture and leasing including economic costs, poor water quality, and competition from imported oysters. Another critical issue is the way North Carolina interprets the issues of public trust waters. The waters and lands of the state belong to the people of the state and are held in public trust by the state, which retains the responsibility to preserve and develop them in the best interest of all state citizens. The public trust extends to the marine, estuarine, and wildlife resources of the state. One informant explained how the
state’s interpretation of the public trust doctrine impacts restoration of the oyster fishery through its relationship to aquaculture:

“I don't know that we'll have, in that timeframe yet, a great renaissance of oyster fisheries, but we will where we have aquaculture. But, restricted to North Carolina, I'm concerned about our resistance to aquaculture. And it's not just the people who claim that "my grandfather used to go there and fish," so now, even though there are no fish left, nobody else should be able to go there and do anything, which is the argument. It's not just that. It's people in our legal department in DNR who are so strong on this issue of public trust and maintaining open access, even if there's nothing that anybody is doing in it. And you get to sell, or rent actually - I don't know that we allow selling the public trust - and we do that to aquaculture businesses and, I can assure you, we're about to do it, or be prepared to do it, if anybody wants to, to wind power facilities, where they have to rent not only the bottom, lease the bottom, but also the water and the air above. So, they've got a trifecta of public trust resources that they will preempt with a good windmill on water. And so, why the hell not to aquaculturists and be more supportive?” --Scientist

In this informants view, the tight interpretation of the public trust does not extend equally to all potential uses of the public trust resources. Extending a different interpretation to possible aquaculturists could make a big impact on the success of the oyster fishery and those who participate in it. The kind of transition of the industry that this group describes has happened in other states that now enjoy a larger, more stable oyster production.

Research informants agree that aquaculture should be an integral part of the future oyster fishery. However, leases may not be successful in all locations, nor are water quality conditions sufficient for them to be established in all parts of the state. Informants are careful to point out that it should not be the only aspect of future landings. Wild harvest remains important, and management efforts that support wild harvest are critical. These should include efforts that could be labeled as part of the put-and-take fishery.

“No, I consider that a put-and-take fishery that makes sense to the degree that it provides economic and social benefits. So, I'm not opposed to it. I think it's a process whereby science can inform on effectiveness, and it has a lot of tendrils that run into the community of fishermen that are important to keep fishermen engaged and interacting with the state, and having the state Marine Fisheries serve a community who gives them feedback, although not a lot of people go to those hearings, you'll find, if you interview Mike Marshall about attendance and participation anymore. And that's in part because we just don't have any oystermen left. They're all now working at Cherry Point.” -- Scientist
5.5.6.3. The Benefits of Sanctuaries

Beyond aquaculture and a put-and-take fishery, members also favor the use of no-harvest sanctuaries. Sanctuaries provide multi-layered benefits.

“However, there's a perception, untested, that spawning-stock biomass of oysters is inadequate to provide enough recruitment onto areas that could serve as oyster habitat. And in that regard, creating these sanctuaries serves the goal of restoring the oysters. In addition, oysters that persist a long time do so in the face of disease by living out their natural lifetime instead of being eaten. We, then, are not selecting against disease-resistant oysters, but rather the selection is for it, because they continue to live. And so, it has the capacity to speed up the natural evolutionary resistance to disease that may evolve. So, in that sense, it can lead to a restored fishery.” -- Scientist

By restraining disturbance associated with harvest, these sites can produce ecological benefits by providing habitat and water filtration. In addition, by harboring longer lived oysters that have survived the threat of disease, sanctuaries can help the fishery when these disease-resistant survivors reproduce and their larvae settle outside the boundaries of the sanctuary.

Sanctuaries and harvest areas are intrinsically linked as possible larval sources and sinks through water currents and dispersal patterns. However, informants caution that it is not as straightforward as it would appear:

“Now, I think that - I admit to the possibility that you could do this. You could protect your sanctuaries and leave some areas open for exploitation. But, to me, from a standpoint of - with that sort of system persisting, we would have to understand a whole lot better the connections between these sanctuaries and, you know, the sources and sinks, and set it up so that we had sanctuaries where oysters were born and we fished areas where oysters go to die. ... and while I think that would be super, because it would be really interesting to figure it all out for once - you know, we've been trying to figure it out for a long time, and we still don't have a really good idea about that. And so, I see designing a system like that particularly challenging, if you're trying to balance these sorts of uses.” -- Scientist

Since dispersal patterns are not fully known, selecting sanctuary and cultch planting sites to take advantage of larval overflow is challenging.
Taken together, the concepts of aquaculture, put-and-take fishery, and sanctuaries with larval overflow could comprise a comprehensive notion of oyster restoration and fishery management. One informant described it this way:

“Clearly, people recognize you can develop reefs that are - you know, that fit multiple purposes that really are not at all at odds. For example, water quality reefs, reefs you want to do for improving water quality, obviously don't have an impact on fisheries because they're generally in areas where you don't have a fishery. More importantly, they might even provide brood stock to areas nearby that are open. Oysters used for erosion control, there you're establishing them in an eroded environment. You're establishing a reef where you wouldn't otherwise have it. And, yes, you're going to limit harvesting on those reefs, but it's an area where you never had a reef, nor would you ever have a culture operation. Preserving reefs for habitat, once again, if you establish reefs and develop sanctuaries that can provide habitat, nearby areas can be seeded by those areas, and in many ways you get a benefit to the surrounding cultured areas by potentially having these protected areas providing seed. So, the idea of having those mixed-type uses, all of which are different types of beds, different locations, different landscapes, often different structures, different ways in which to create them, there's no problem having that mixed use.” -- Scientist

This description of restoration stresses that multiple uses and intentions are fully justified and can be considered complementary parts of a complex whole.

5.5.6.4. Mixed Uses, Coordinated Planning

The desired outcomes of each of the measures described above are different, but they can be mutually supporting and each can contribute to enhanced fishery production. However, informants cite a perceived lack of a comprehensive plan that attempts to take overview of all of variously purposed reefs and restoration initiatives. Of course, all of the various oyster restoration projects go through a permitting process with the state, but there is no mandate for comprehensive restoration plan for oysters or centralized coordination of mixed usage. NCDMF has an extensive restoration and enhancement program that undertakes a variety of efforts including planting reefs for fishing and creating sanctuaries that will seed harvest areas, but their mandate is oyster productivity.

“In terms of other restoration efforts, the state has huge shell planting programs and remote set programs. Those are a tremendous effort. They need to be continued.
Those need to be continued, and it'd be great if they could be enhanced. … We need more targeted restoration efforts for habitat for some of those other types of restoration where you pay particular attention to the exact reason you're doing it and put out restored reefs in areas that have high probability of success, regardless of just productivity. That's probably where we're weakest. The state doesn't fund that, although it's very supportive, as we talked about. They do a little bit of that in the sanctuaries, but most of that has been done by private groups. That would be a great area if we could enhance those kinds of restoration activities: shoreline restoration, restoration for key habitat areas, restoration in nursery areas.” -- Scientist

NCDMF’s efforts focus on furthering its mission is to enhance productivity of the oyster fishery. Still, NCDMF is supportive of initiatives that restore reefs for other reasons.

5.5.6.5. Experimental Approaches to Restoration

Researchers in the science groups emphasize the need for experimental approaches to restoration. These approaches have contributed to our understanding of the changes to the estuarine landscape and oyster beds that led to the stark declines in landings. One such change concerns the structure and height of the reefs that oysters inhabit.

“And it became quite clear to me that one of the major changes that had occurred over the last hundred years or more in our estuaries was the tremendous depletion of oysters. … And then I, sitting around one day, … had an idea. And the idea was that oyster reefs, by being tall, create interactions with the physical, geological, and chemical environment that are likely to promote oysters. And because oyster fishing tends to mine the reef and reduce its height, I had the hypothesis that that was one of the major reasons why oyster restorations had not been successful. And they (North Carolina General Assembly) had tremendous interest in bringing back oysters, and liked my idea of doing manipulative experiments to test that means of restoring oysters. … And that was about 1991, or thereabouts, that I got three years worth of funding to do a field project to see whether, working with the Division of Marine Fisheries, who had already for years been doing some oyster restoration, but typically by just spreading shell flat on the bottom, rather than trying to reconstruct the habitat, which means reconstruct the physical, chemical, geological environment as well, in which oysters naturally live and have evolved.” -- Scientist

This and subsequent work has shown that where reefs maintain their structure and elevation, reef ecosystems maintain functionality even in the face of disease. These approaches have been variously received outside of scientific circles, and there is a perception that there is not much funding or interest in experimental restoration work.

“I don't think that there's a lot of money for experimental restoration work. I mean, it's gotten better. Certainly up until the current crisis there was a lot more restoration
money around, and they were oftentimes interested in new strategies or trying to figure out a better way. But I think in the long - one thing that has contributed to this is that the assessment of restoration is not very direct or very quantitative. It's always been sort of, "Well, it looks like we have more." And setting up, you know, the appropriate compares and controls so that you could actually ask those questions. I think most of the emphasis has been on getting it out there and getting out as much as you can. And then there's very - there's rarely money for monitoring. That is just considered to be so boring. [Laughing] We might find out something we don't want to know. … So, that's the - I think that's the sticky part of restoration, or the sort of dirty little secret, maybe, is that while we do a lot of restoration, we do considerably less assessment of that and even less long term monitoring.” --Scientist

Another initiative that can be considered an experimental approach to restoration is the state hatchery. The hatchery will allow researchers, managers, aquaculturists, and other stakeholders to learn more about oysters while contributing to better management of the oyster resource and industry. As with any kind of research, the hatchery can only provide information, it cannot control how that information is used or if it is used.

“Yes, and I think it points to something that also causes me some concern, is that it will be seen that the hatchery is responsible for the success of restoration, and really it's not. It only provides us with information that can better direct our restoration efforts. But the actual putting oysters on the bottom, putting shell on the bottom, that's not the hatchery doing that. That's the agencies, that's the nonprofits, that's totally separate things. And so, I'm a little concerned that, you know, if restoration doesn't work, or is perceived not to work, that they're going to say, "Well, it's the hatchery's fault." And it's like - it's not. And so, this is something that we've been trying to emphasize is that the hatchery is only a tool that might, that we think will increase the possibility that we can do successful restoration. But in no way is it (the sole responsibility of the hatchery to have successful) restoration. And the same thing with aquaculture is that the research hatchery can provide information, opportunities, training - we could train people to run hatcheries commercially that could then produce larvae to sell to growers. So, somebody could become a hatchery person. There are commercial hatcheries in lots of places. But it, too, is not responsible for whether or not we suddenly see an upswing in oyster aquaculture in the state. We can only provided the information, the technologies, the encouragement, the support.” --Scientist

An experimental approach to restoration is not a panacea for all of the challenges in the restoration process. It is any important tool and a critical component of advancing the results of the process.
5.5.7. Cultural Models

Restoration practitioners regard ecological restoration as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. If there were no impediments to doing so, degraded ecosystems would recover. The role of restoration provides a process through which humans facilitate that recovery. Based on the knowledge, values, and beliefs identified by coding interview transcripts, I constructed a cultural model for each stakeholder group called, “restoring oysters.” These cultural models express how stakeholders regard ecological restoration. The models are comprised of a series of propositions and sub-propositions. Figures 5.2-5.7 offer simplified illustrations of the six cultural models. Each group’s model structures the members’ understanding of the oyster population and efforts to restore it.

5.5.7.1. Fishing Group

The fishing group’s model shows that restoring oysters is determined by three main propositions, each attended by more specific propositions, which are more detailed descriptions of fishermen’s perceptions about oysters. Their main propositions about oysters are: 1) “nature controls oysters,” 2) “humans can harm oysters,” and 3) “humans can try to save oysters.” (Fig. 5.2).

The strongest of the three main propositions is the first one, “nature controls oysters.” More specifically, “oysters have cycles.” Oysters cycle through periods of high and low recruitment and survival that support high and low landings respectively. The propositions “cycles are powered by key variables” and “cycles are not predictable” are based on fishermen’s observations of the effects of weather patterns and predator pressure, neither of which can be forecast on oyster reproduction, recruitment, and survival. These factors are mechanisms through which nature controls and restores oysters.
"Environmental changes threaten oysters" and "regulations concentrate effort" are important propositions about how "humans can harm oysters." Fishermen are concerned about the intensification of human-related environmental changes because even though they believe that nature controls the abundance of oysters, they are concerned that cumulative impacts are undermining the cycles. If the cycle is degraded and remains in a downcycle, their livelihoods will be disrupted. The most critical of these environmental changes is declining water quality. Fishermen believe that runoff and pollution are critically imperiling oysters. Another source of harm to oysters are some of the regulations intended to improve the fishery. Specifically, fishermen believe that a lower daily limit makes it economically unsound for them to seek widely scattered oyster beds and forces them to revisit the same

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**Figure 5.2.** "Restoring oysters" cultural model for the fishing stakeholder group.
ones. This concentration of effort damages oyster beds beyond the point at which the cycle can restore them. Regulation of other fisheries also concentrate effort by redirecting effort to the oyster fishery.

A third set of propositions describes how “humans can try to save oysters.” “Humans can supply clean shell” encompasses two means through which fishermen believe humans can contribute to the restoration of oysters. Cultch planting provides new sources of shell while dredging cleans the shell already on oyster beds. “Limits sustain the fishery,” proposes that certain kinds of regulations can help restore oysters by promoting the natural cycles of oysters. These regulations include a weekly bushel limit, which they believe would improve oyster population sustainability and the economic strength of the fishery.

5.5.7.2. Industry Group

The industry (fish dealers and processors) group’s model of restoring oysters consists of the same main propositions as the fishing group: 1) “nature controls oysters,” 2) “humans can harm oysters,” and 3) “humans can try to save oysters” (Fig. 5.3). The first two propositions of the groups’ cultural models have the same supporting sub-propositions, but a different set of sub-propositions describes how “humans can try to save oysters.” “Humans can supply clean shell” encompasses cultch planting or providing new sources of shell and dredging, which cleans the shell already on oyster beds and turn up the bottom to tend to the beds. “Regulation is needed,” proposes that certain types of limits can help restore oysters by promoting the natural cycles of oysters. These regulations include weekly bushel limits and rotating area closures, which informants believe would allow areas to rebuild, be harvested, undergo cleaning during dredging, and then catch new oysters thereby mimicking the natural cycle. Seeding of key upstream areas would install a natural filter that would reduce the impact of pollution on downstream beds in traditional harvest regions. “Oysters
are business,” describes the group’s view that more industry considerations, such as buying back more shell and wider consultation and communication with dealers and fishermen, will help to grow the state’s oyster industry and restore oysters.

5.5.7.3. Management Group

The main propositions in the fisheries management cultural model are: 1) “prevent significant deterioration,” 2) “overcome substrate limitation,” and 3) “there are limits” (Fig. 5.4). Specifically, preventing significant deterioration to oyster habitat and stock encompasses “transition to tongs,” in areas where tonging can be a useful method of harvest and improve water quality through reduction of runoff and sedimentation from coastal development. NCDMF seeks a transition to tonging by concentrating culch planting in
MMPAs, but the agency cannot really affect runoff and sedimentation rates. Instead, creating tall mounds in deeper water oyster sanctuaries attempts to physically lift oyster above poorer water quality associated with the bottom layer of the water column.

For managers a major component of restoring oysters is overcoming the impacts of limited substrate on population growth. “Creating habitat” provides clean shell bottom for oyster recruitment. The population is not recruitment limited because managers find that the shell material they deploy is colonized by oysters. Unfortunately, these recruits struggle to survive to the minimum harvest size. The proposition “there are limits,” relates to these mortality factors, like disease, sedimentation, and poor water quality, that continue to affect the population even in areas where substrate limitation are being overcome.

Figure 5.4. "Restoring oysters" cultural model for the management stakeholder group.
5.5.7.4. Conservation Group

The cultural model for restoring oysters utilized by conservation practitioners has three propositions: 1) “humans are disconnected from the estuary,” 2) “land-based restoration is also needed,” and 3) “increased oyster habitat is needed” (Fig. 5.4).

Conservation informants perceive many coastal resident living lives that are disconnected from the estuarine ecosystem. In the coastal development boom of the past decade, many new residents arrived at the coast, and long-time coastal residents moved from traditional livelihoods into construction jobs. When livelihoods are no longer directly dependent on the health of the estuary, ecological challenges, like water quality decline and habitat loss, are considered less pressing. “People depend on oysters” proposes that by increasing the number of people who depend on oysters for a livelihood will increase local awareness of these ecological issues and more willing to support restoration and conservation initiatives.

“Altered watershed hydrology destroy restoration installations” is a proposition about “land-based restoration is also needed.” Where land use related to coastal development and agriculture has changed watershed hydrology, runoff from paved surfaces and agricultural fields can have damaging impacts on near-shore restored oyster reefs. Sediment and pollution in runoff can smoother oyster habitat and kill oysters and other reef inhabitants. For conservation practitioners, the success of oyster restoration depends on addressing land-based impacts. Oyster restoration must be connected to terrestrial initiatives. This proposition conceptualizes oysters as part of a larger initiative to improve coastal water quality and ecosystem integrity.

The third proposition is composed of the two sub-propositions “build oyster reefs” and “phase out mechanical harvest.” In the conservation group model, creating reefs in critical locations and the discontinuing dredging will increase the extent oyster habitat. Creating reefs in sanctuaries or closed areas and allowing little or no harvest will allow them
to mature undisturbed. Conservation practitioners are concerned by the impacts of dredging and believe that it should be abandoned in favor or tonging or aquaculture. However, most recognize that it will not be an easy transition, but it is necessary to really restoring the oyster population. They advocate finding incentives to reduce resistance and support the people involved in the fishery.

![Figure 5.5. "Restoring oysters" cultural model for the conservation stakeholder group.](image)

5.5.7.5. *Aquaculture Group*

Shellfish growers structure their model of restoring oysters around three propositions:

1) “sustain community connections to the water,” 2) “control stormwater runoff,” and 3) “support oyster populations through sanctuaries and leases” (Fig. 5.6). These propositions
outline a model in which oyster restoration is achieved by taking pressure off of the wild stock and providing additional larval sources in the form of aquacultured populations. First, shellfish growers believe community sustainability is critical to the sustainability of oysters. Continuing traditional coastal livelihoods like commercial fishing is becoming more and more difficult. The state’s commercial fishing fleet is constricting due to a variety of factors such as imported seafood, increased harvest restrictions, and fuel costs. Shellfish growers express a strong appreciation for the places where they live and maintaining traditional connections to the water. “Diversify fishing practices” will maintain connections to the water by lending new methods to a traditional occupation. Aquaculture can keep people working on the water and sustain coastal communities. Sustainable communities are critical to resource restoration.

Figure 5.6. "Restoring oysters" cultural model for the aquaculture stakeholder group.
Water quality is critical to shellfish survival. Shellfish growers are keenly aware of this; stormwater runoff introduces pollutants, sediment, and freshwater to aquaculture installations. These water quality impairments are especially detrimental to oyster bottom with low relief and limited structure. The third proposition, “support oyster populations through sanctuaries and leases,” addresses oyster bottoms that are thin veneers of shell. The height of the mounds in sanctuaries and water column leases that float aquaculture bags at the surface tend to support more robust oyster populations with successful reproduction and recruitment. “Larval spillover can sustain harvest areas,” describes dispersal of larvae from populations in sanctuaries and leases to unprotected areas where reef and oyster population growth may be limited. Shellfish growers favor this kind of restoration support compared to the expense involved in enhancement efforts they describe as contributing to a put-and-take scenario.

5.5.7.6. Science Group

The cultural model of researchers revolves around three propositions: 1) “oyster restoration benefits from an experimental approach,” 2) “oysters can survive in good habitat,” and 3) “an ecosystem-scale approach is required.” Important aspects of oyster restoration have been demonstrated through experimentation. This includes the primacy of tall mounds for oyster survival in the midst of disease and water quality insults. Future discoveries, including insights related to the usefulness of seeding restored reefs with hatchery-raised spat, will also benefit from experimentation with a long-term monitoring component.

Scientist propose that “oysters can survive in good habitat.” Good habitat denotes tall reefs that are permitted to develop without fishery disturbance. Height is maintained on reefs that are protected from perceived destructive harvest methods. Oyster survival despite
disease and poor water quality is enhanced higher on reefs compared to at the bases of reefs.

Above all, “an ecosystem-scale approach is required.” Oyster restoration will succeed best as a component of an ecosystem-based approach to estuarine management. Such as approach would bring a landscape perspective that includes terrestrially-based initiatives to oyster restoration.

5.5.8. How Oysters Matter to Stakeholders

In interviews, informants mention a variety of values or reasons why oysters matter. Not surprisingly, all of the values they discuss could be categorized into three general types:

Figure 5.7. "Restoring oysters" cultural model for the science stakeholder group.
Informants describe economic, ecological, and heritage values for oysters.

Oysters matter economically. North Carolina’s oyster harvest provides wintertime livelihood to wild harvesters, and oysters also provide income to shellfish growers and fish dealers, but no harvester or grower relies on oysters for their full-time income. Commercially landed oysters were valued at over $2 million in 2008.

“But, you know, we now have a fifteen bushel limit per day, which is essentially enough to make three or four hundred dollars, you know, net, and then you've got to pay for fuel and ice and the boat and gear and all that kind of stuff beyond that. So, you know, when it comes down to it, you may make a hundred or two hundred dollars a day, you know, oyster. Plus you've got to pay your help. So, you know, it's a much different fishery today.” -- Scientist

For those commercial fishermen who do harvest oysters, they consider the oyster fishery a small, yet still important fishery. Its economic importance may be growing as the high-money fisheries constrict due to greater restrictions and smaller catches.

“They're taking the big ones away, and if you take the little ones away - I mean, we can't afford to take nothing away is what I'm trying to say. There's not enough now of the puzzle. Too many pieces are missing now. But you can still fill in little blanks here and there, and make that check, and go through until the next little thing you do, you know, where you can make a little bit comes along. So, every little piece is very important, yes. Don't get me wrong. I'm not saying it's not important. I'm just saying it's a small piece of the puzzle.” -- Fisherman

Oysters provide livelihoods to NCDMF staff members who work within the oyster enhancement and management program. An unknown proportion of the oysters harvested in the state are taken from oyster beds created and managed by the state’s cultch planting program. There is anecdotal information that some fishermen harvest a large percentage of their individual landings from planted sites. Other fishermen, primarily dredgers, claim that they harvest little of their total individual landings from planted sites, instead spending more time outside of the bays and MMPAs where the majority of management activities are concentrated.

“I went to a planting meeting there this year, and a commercial fisherman got up and said during the planting meeting that 75% of his income, or 90%, I forget what it was, anyway it was in the paper, that big percentage of his income for oyster ing in the
wintertime came from DMF planting sites. So, he was one of the highliners in the oyster fishing in Hyde County. So he's a big player, and for him to say that makes you feel like you're actually making a difference...where there's a fellow in Hyde County that a big part of the money that he makes to feed his family comes from our work.” -- Manager

They are also sources of livelihood for participants in the shellfish industry, those who buy, sell, and shuck oysters. Sometimes those livelihoods seem tenuous, and their success is judged on a year-to-year basis.

“But with all the industrial growth ongoing, there’s not too much change taking place. That's why my husband persuaded my son to go to college and make a career, because he didn’t see any future, even back then, which was probably fifteen years ago. He didn’t see any future for my son to take this business and go on with it, even though my grandson that just come in here is trying to go on with it. And we've done a right good year this year.” -- Shellfish dealer

Economic benefits are not the only services that oysters provide.

“Oysters is one of the few things that I can see a - in other words, selling them is not the only use for an oyster. And that's the truth. A lot of people say, "Well, if you can't eat it or can't sell it, it ain't no good to you." ... But oysters, they filter the bottom, they clean up, they provide habitat and all that for fish and the other stuff that we use.” — Fish dealer

Oysters matter ecologically. Long-underestimated ecological and societal benefits, including amelioration of environmental conditions and habitat provision, flow from the direct and indirect ecosystem services that oyster reefs provide. The physical structure of oyster reefs alters water flow patterns leading to enhanced oyster growth at reef crests and increased sedimentation and greater aggregation of fish larvae at reef bases. The hard substrate and vertical relief supplied by oyster reefs in typically sediment-dominated systems provide foraging, spawning, nursery, and refuge habitat for a diverse assemblage of species and enhance biodiversity and secondary productivity (Kennedy 1996, Coen et al. 1999).

“You know, they create habitat for small fish. They create habitat for worms. There's a whole benthic community. There's a whole sub-benthic community. There's a whole - you know, fish gather around them. They eat the smaller fish, you know. So, absolutely, oysters are - you know, they've been termed as a keystone organism, you know, as an eco-tool, you know. ... You set up cameras or even just set gill net or some kind of traps on these oyster rocks and you see how many different types of fish are using these, versus, you know, you put your unit on top of a oyster rock, and then put another one to the left or right of it, and you catch more fish, or more of this
particular type of fish or species on top of that rock, which kind of tells you, hey, they are utilizing this for something. And then you’ve got to figure out what. Are they using it for food? Are they using it for shelter? So, I mean, you know, there's a whole ecology there of what that - the function of that reef. You know, it's a structure building - the organism itself builds structure, and that creates so much more for other species.” -- Manager

As filter feeders, oysters have important roles in estuarine energy processing as nutrient recyclers, nutrient retainers, and carbon sinks (Dame et al. 1984, Dame et al. 1992, Dame and Libes 1993, Newell et al. 2002). Oysters suppress the accumulation of organic matter and turbidity in the water column of shallow estuaries by consuming phytoplankton and other organic particulate matter (Coen et al. 1999, Newell et al. 2005).

“… they have value ecologically as a filter feeder and as a nitrogen fixer in the estuary. They clear the water. They allow light to reach the bottom, which allows levels of submerged aquatic vegetation to grow and to be nursery habitat for, you know, other estuarine organisms.” -- Scientist

Sediments containing oyster biodeposits support enhanced denitrification reducing the level of active nitrogen in the system (Dame et al. 1984, Newell et al. 2002, Nelson et al. 2004). In areas prone to strong episodic wave energy, oyster reefs reduce erosion and stabilize sediment in adjacent shoreline habitats (Meyer et al. 1997).

“They themselves, as a reef structure, you know, provide structural habitat for estuarine organisms and are very sentinel in their place in estuarine ecology. No one will debate that, unless they just don't have an understanding of basic estuarine ecology in this region.” -- Scientist

The ecological importance of oysters is not debatable. Yet oysters matter culturally as well.

“So, they're important from a heritage standpoint. You know, I'd love for my children to grow up with oysters, to understand their significance, not just oysters, but all of the estuarine mollusks. Yeah. But oysters are different.” -- Scientist

For all human groups who have inhabited the Pamlico Sound region throughout history, oysters have played a prominent role in daily life, local diets and special occasions. Oysters were important to poor coastal residents because they were an easily obtained, flexible
good: they could be eaten, traded for other foodstuffs, and used for home construction, kiln making, and fertilizer.

“All our forefathers and the Indians before, that's what they ate. Why not? Why would you - just in my little humble opinion - why would you not want to do that? You know? … But, you know, the oyster part of it is, I think, it was a way of life. It was a way of living and supporting people from time to time. People might have been fishing for fish, and so, while they were at the bank or the river, say, "Well, while we're here, we'll go and get us a bushel of oysters to carry back with us." So, to me, that's just another way of providing for a family in one sense, you know.” -- Manager

Oysters have also long been instrumental in maintaining social networks as part of the roasts and festivals that marked the beginning of the winter fishing and oyster harvesting season. For many informants, ecological restoration is linked to the integrity of the region’s social structure.

“You know, it's much more focused on establishing the resource at this point than it is establishing a social structure. But, to me, that's the end result, you know. I do not think that it's possible to have - to do ecological, you know, like environmental work without also, you know, having - you can't have environmental justice without having social justice. You know, the two are really hand-in-hand. One feeds off the other. So that when you have a natural resource being completely trashed by some outside corporation, it affects the natural resource, yes, but down the line, if not immediately, it's also going to affect the social structure of a community.” -- Conservation practitioner

Informants stress the importance of maintaining oyster harvest as a component of North Carolina’s fishing tradition and culture. A continuing wild fishery, both as a cultural way of life and for the individual who pursues it, is at the heart of so many of the restoration efforts that have been undertaken.

“I mean, there are guys - you know, fishing is a way of life. It's a time-honored, cherished way of life. And, you know, the idea of going out and gathering food from a wild source is - it's a beloved way of life, you know, and I think that it's something that should be sustained, you know, in this area. I mean, it is so much a part of our culture and heritage.” -- Conservation practitioner

“But, yeah, I rather do that than anything I know of. Because once you can get to culling and working - you know, there's nothing you can do about hot weather anyway. But it's steady work. You're steady working, you know. You're steady digging at what you're doing. But, yeah, I'd rather do that than anything I know of. And then, if you get where you're really catching oysters, it's fun. It's fun. Then it ain't just - it ain't work. It's fun.” -- Fisherman
5.5.9. Multiple Values, Multiple Goals

Stakeholders perceive ecological, economic, and heritage values of oysters and for restoring North Carolina’s oyster populations. These values have both been demonstrated in published reports and become well known among individuals and groups involved in the oyster fishery and oyster management and restoration efforts. Therefore, it is not surprising that these values were discussed in interviews. More importantly, informants move seamlessly from one value to the others and back again. Each of three values or benefits is considered integral to the other two and to the overall entity they conceptualize to as oyster restoration.

Research has documented the transcendence of the economic value of the ecological benefits of oysters over their economic value as a commercial fishery. Despite missing quantitative information for several ecosystem services provided by intact oyster reefs, the values of those services that can be estimated, such as augmented landings for commercial fisheries, show that the entire array of oyster reef ecosystem services probably greatly exceeds the value derived from oyster harvests (Grabowski and Peterson 2007). It has been demonstrated in other states that aquacultured oysters produced through private bottom and water column leasing can increase oyster production. 9.8 million aquacultured market oysters were produced in Virginia in 2008 (Murray and Oesterling 2009). In spite of the ability to increase oyster production through aquaculture and the ecological contributions intact oyster reefs can make to estuarine ecosystems, these factors do not define successful oyster restoration. The way stakeholders conceptualize and define oyster restoration, it should encompass ecological, economic, and heritage benefits.

Defining successful oyster restoration outlines what stakeholders want the world they live in to look like. It is linked to wider issues of concern. Stakeholders value traditional cultural and community connections to the water. These connections include a wild fishery
for oysters. For many informants cultural benefits are implicitly included in the economic benefits of oyster restoration. It is not simply that wild harvesters have jobs, but they have jobs harvesting oysters.

The outcomes of oyster restoration efforts are inextricably intertwined partially because there are only limited means for measuring the outcomes of restoration. There are few accessible metrics with which to assess the ecological outcomes of the state’s restoration efforts, nor is there a method to measure their contribution to the oyster fishery. Recent work in North Carolina by Powers et al. (2009) utilized three metrics for defining successful oyster restoration: 1) presence of vertical structure above the bottom (at least 20 cm); 2) presence of live oysters (oyster density greater than 10/m²); and 3) evidence of recruitment (for at least one of the two years of the survey). The state does not collect data regarding whether oysters are harvested from planted sites as part of the current trip ticket program. In fact, it is difficult for stakeholders to define and delineate the impacts of the state oyster management program. Instead, stakeholders choose to believe that the work is helping oyster populations because that belief makes sense to them. One NCDMF manager explained this conceptualization of the benefits of oyster restoration:

“Because I see both sides. I see the guys making money on it, and then I see how it filters the water and provides habitat. I see all this stuff that we catch on these reefs when we go pull a dredge on them. There's all kinds in them, you know. So I - yes, I see it both sides.

The biggest benefit is that we're creating habitat. That's the biggest benefit. We're taking bottom that has no oysters on it and we're putting substrate down and oysters are growing on it. So we are providing- we are enhancing the habitat. That's the biggest benefit of this program.

That's pretty much what we do is create habitat. Hopefully it spill over into, you know, people making money off of it because that's why the oyster program was put into play was to benefit the oyster harvest of the state. That's why it was done. It wasn't done to create habitat, it was done to make harvest higher.

Whether it ever gets harvested on or not, there is a certain value that has to be placed on an area that was just bare bottom and then that creating habitat, oysters growing on it. But when it's all said and done I think the biggest benefit is creating
habitat. What that value is, I don't know. Whether it's worth the money the state puts in the program, I don't know. But did I feel in Swan Quarter when that guy said 95% of his income come from oysters, it was probably a benefit to him. And all the people down at Hatteras and Ocracoke when I go sample those areas are tonging on them and thank me for putting stuff down there, they're making money and they're getting their limit everyday, everyday of the year. I mean, it's a benefit to them.” -- Manager

NCDMF is mandated to enhance oyster fishery production, but their practices have diversified over time, moving from strictly production activities to incorporate conservation activities. They hope that creating new and expanded oyster bottom will enhance state oyster landings. However, the main outcome of the work that NCDMF can point to is the creation of habitat that has important ecological values regardless of whether that area ever produces a harvest-sized oyster. Since NCDMF can conduct only limited monitoring of cultch planting sites, due to time constraints, it does not survey these ecological values. Estimates of the longevity and condition of planted bottoms also remain unexamined, further limiting our ability to define the benefits of the work.

Despite the inclusion of different propositions across the cultural models of the six stakeholder groups, underscoring the differences in how different stakeholders conceptualize oyster restoration, there are distinct overlaps among the models. Importantly, there is agreement that successful oyster restoration must include restoring the ecological, economic, and cultural benefits of oysters to the estuarine system. Equally important, how people interact with and construct oyster and other estuarine resources contributes to how they conceptualize and interpret nature and their relationship with it.
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Chapter 6

CONCLUSIONS

As opposed to a study of culture as objects in time and space to be studied and catalogued, I have examined culture as an adaptive system of knowledge, beliefs, and values for its effects on how a group of people utilizes, protects, manages, and restores natural resources. These beliefs and values create meanings, which provide members of the group with bases for action, telling them how to live in the world (Alasuutari 1995). Meanings and knowledge are codified in the cultural models or simplified representations of the world that people utilize to interpret observations, generate inferences, and solve problems (Kempton et al. 1995). Cultural models are widely shared, though not exclusively, by members of a group or society as taken for granted frameworks for conceptualizing the world around them and their behavior in it (Quinn and Holland 1987). Like scientific theories, cultural models make sense of most of what people observe (Kempton et al. 1995). Unlike expert theories, cultural models are only used when they are suitable and not applied in a consistent manner (Quinn and Holland 1987). As constructions or representations of shared information, cultural models provide a view of how members of a community can talk meaningfully in their own terms about their understandings and experiences (Blount and Kitner 2007).

A cultural model approach to the study of natural resource management and restoration conflicts can illustrate unarticulated reasoning that connects statements and positions made by one group in opposition to another group (Paolisso 2002). Differences in underlying worldviews among groups can result in differences in how they act toward nature
and in their goals for conservation or restoration (Medin et al. 2007). This dissertation elucidated cultural the models that North Carolina stakeholders use implicitly to structure their conceptualizations of managing and restoring the state’s native oyster population.

Oysters are known as ecological engineers: processing and modifying their environment with both their physical structure and filter feeding mechanism to the benefit of hundreds of other species (Jones et al. 1994). All stakeholders discussed the important benefits that accrue from the oysters’ engineering activities, describing them as a nexus that connects parts of the estuarine environment to each other. Beyond their capacity as benthic-pelagic couplers, oysters connect human actions to estuarine quality, human wellbeing and livelihood to the estuary and people to coastal protection. They are critical tools for addressing coastal water quality issues because a system with a healthy oyster fishery, safe for human consumption, is likely a healthy system overall. Oysters also couple fishermen to fish. Oyster reefs provide important habitat for species of invertebrates and fish, including commercially and recreationally important species, while their water filtration capacity improves overall estuarine quality for all species.

While the economic value of the ecological benefits and services of oysters likely far exceeds their economic value as a fishery, the study informants still desire some form of a wild fishery. Even though they cannot quantitatively evaluate the benefits arising from oyster restoration efforts, stakeholders still value the work. The strength of that value and the coupling capacities of oysters make important contributions to the cultural models that structure stakeholder conceptualizations of oyster restoration in the state.

By outlining the cultural models that different stakeholder groups utilize, I found both distinct overlaps and conflicts in how groups conceptualize oyster management and restoration. Both the fishing and industry groups emphasized the control of nature of oysters. Oysters have unpredictable cycles that are powered by variable factors like weather
patterns. Despite nature’s control, human actions still matter. There are means through which humans can affect oysters both positively and negatively. Humans can harm oysters through activities that degrade environmental conditions and by creating regulations that spatially concentrate harvesting effort. Humans can also try to save oysters, but they cannot really save them because oysters can only be saved for so long before the cycle changes or disease or poor water quality lead to oyster mortality. However, actions such as providing clean shell for larval attachment and restraining harvest through regulations such as weekly bushel limits can help.

Despite their differences with the fishing and industry groups, conservation practitioners model similar positive and negative human actions for oysters in their conceptualization of restoring oysters. Like the fishing and industry groups’ propositions that anthropogenic-caused environmental changes can harm oysters, conservation practitioners cite human disconnection from the estuary as part of the root cause of the runoff, poor land use, and other factors that produce anthropogenically-derived environmental changes. Because of this disconnection, according to the conservation practitioners, people do not seem to connect their land-based activities with the impoverishment of estuarine conditions. When reefs are restored in the water without attending to previous hydrologic alterations on adjacent lands, runoff can destroy the restored reefs. Conservation practitioners propose that greater human reliance on oysters, through an enhanced fishery and greater recognition of the ecological benefits of intact reef systems, would mean more oysters and lead to improved estuarine quality and function.

The main distinction between these groups centers on harvest. Conservation practitioners view phasing out dredging as a way that humans can increase oyster habitat. In addition to being an important component of their cultural model of restoring oysters, dredging is one of this group’s highest five concerns for oyster survival (Table 4.4). The
fishing and industry groups view dredging much differently. While they are convinced that
dredging can be conducted to devastating results, when done properly, they view dredging
work as critical to maintaining good oyster settlement surfaces. This view was most common
in the northern part of the Pamlico Sound where most fishermen harvest oysters with a
dredge. Their years of experience harvesting oysters tells them this is true despite the outcry
from conservation groups and NCDMF’s prioritization of cultch planting in hand-harvest only
areas in order to ultimately phase out the dredge-harvest of oysters in the state.

Conservation practitioners’ cultural model of restoring oysters has some of the same
overlapping propositions with the aquaculture group as it does with the fishing and industry
groups. The aquaculture group’s cultural model proposes that anthropogenically-derived
environmental changes can harm oysters such that land-based restoration initiatives are
needed to control stormwater runoff and correct hydrologic alterations. Like the conservation
group, a key component of restoring oysters for the aquaculture group is sustaining human
connection to the water and the larger estuarine system. This group views mariculture as a
way to diversify fishing practices in order to strengthen coastal communities and maintain a
traditional heritage, but in a new way. Critical to this group’s conceptualization of restoring
oysters are issues of large-scale connectivity. Aquaculturists focus on potential connections
between not only harvest and sanctuary populations, but between harvest and lease-based
populations as well. Located appropriately, sanctuary reefs and leases can serve as
broodstock, supplying larval recruits to wild harvest populations.

Like the conservation and aquaculture groups, scientists’ cultural model of restoring
oysters proposes a larger-scale approach to the problem. For all three of these stakeholder
groups, land-based restoration or an ecosystem-based approach to restoration is needed.
Part of restoring oysters is providing good quality habitat. For the science group, good
habitat has height, which lifts oysters away from the bottom and any associated anoxia or
sedimentation. In addition to an ecosystem-based approach, scientists also propose taking an experimental approach to restoration, i.e. doing the science needed to answer questions about the ecological processes that support oyster populations and the impacts of various restoration installations.

For the sixth and final stakeholder group, fisheries management, preventing significant deterioration is an important proposition in their cultural model of restoring oysters. However, in the view of the fisheries management group, not all deterioration arises from factors that they can address. They view harvest impact as a factor that they can address, and the agency is attempting to transition the fishery to tongs-use only. There are other factors upon which management has less or no impact. These include the detrimental effects of weather and poor water quality. Through the Marine Fisheries Commission (MFC), the North Carolina Division of Marine Fisheries (NCDMF) is actively involved in the Coastal Habitat Protection Plan (CHPP), the state’s effort to take a broad-scale approach to the assessment and management of crucial coastal habitats, including oyster reefs. The CHPP is an effort to develop options for management by assembling information from across expertise, research, and management programs to assess habitats, threats, and rules. The CHPP process is an important example of an ecosystem-based management program.

There are many commonalities among the cultural models of the six stakeholder groups that I included in this study. The issues where groups agree could provide an important foundation for addressing issues of discord. Each model of restoring oysters contained a proposition or sub-proposition related to degraded water quality or other negative environmental factors. These propositions demonstrate that each group is aware of the importance of the health and functioning of the larger system of which oysters are a part for the production and ecological health of the oysters themselves.
Collectively, stakeholders join the ecological, economic, and cultural aspects of oyster restoration in the goals they articulate for the process, believing in the benefits of restoration even if they are not calculable.

“We want clean water, a functioning ecosystem, and plenty of seafood out there for fishermen to catch, gorgeous waters for people to come and recreate in, so we can have lots of tourists here.” -- Conservation practitioner

All of these goals link to each other through one broader goal: a functioning ecosystem. Clean water and a sustainable fishery are not in tension with each when considered from this system-level perspective. Instead, they reinforce one another. Cleaner water supports more robust fisheries. More robust fisheries support more people creating more people dependent on clean water and thereby more support for cleaner water to sustain those fisheries. Such a system-level emphasis was a component of each group’s cultural model for restoring oysters.

“Well, as a whole, it's everybody that concerned with the three things: the fish habitat, the food, and cleaning the water, if there's enough of them, at enough level to do that. Really, everybody's concerned about all those things. It's just - in a way, it's not what - what do you think would be success? If they had a lot, and it was all fish habitat, not able to eat them, and was helping with the filter feeding, you know, with cleaning the water, but you couldn't eat them. You know, to try and do all three of those things at one time, that's hard. Because probably they are filtering a lot in the places where it's called polluted. So? So, we're making success! If they call it polluted, we're not making success! Because you can't eat them! So what do you want? [Laughter] Can't have everything! [Laughs] If success is all three at the same time, wow, you got a problem there.” -- Fisherman

Addressing oyster restoration at the systems level would require a comprehensive approach with targeted restoration of reefs for different reasons and goals. The complementary aspects of stakeholders’ cultural models indicate a shared willingness to follow such an approach with real opportunities for shared responsibility and initiative.

Shared responsibility could also foster opportunities to examine issues that are in contention among stakeholders. One obvious issue is the use of dredges to harvest oysters. Collaborative initiatives that bridge scientific and PEK methodologies and spatial scales of
investment are needed to address the impacts of the dredge. There is fundamentally different knowledge on the two sides of the dredge issue that must be addressed before this harvest conflict can be resolved.

Conflicts over dredging and other disagreements typically pit the fishing and industry groups against the science and conservation groups. An explanation often offered for the root of these conflicts is a greater reliance on religion or faith on the part of the fishing and industry groups than the science and conservation groups to explain phenomena or make decisions. While I did not discuss discrete religious views with any informants, some in the fishing and industry group may be quicker to invoke God’s plan or Mother Nature more in our discussions of management and restoration issues. Still, simply invoking religion or faith marginalizes the knowledge and experience of these groups. Their conceptualizations of restoring oysters, as revealed in their cultural models, are more complex than faith-based doctrine only. While fishermen believe that there is an unpredictable cyclical pattern to environmental change, they are not passive in the face of change. Instead they use generations of observations and experience to adapt their fishing practices to this uncertainty. As the level and intensity of environmental change itself appears to be changing in response to heightened insults from human activities, it remains unknown if their adaptations will be able to keep pace with the rate of change. Now more than ever, the evolution of collaborative research and management may be a critical adaptation for oysters and those who share a stake in the goods and services they continue to provide.
References


Appendix A

GENERAL INTERVIEW GUIDE

Personal history, fishing tradition, fishing practices, and involvement with oysters

• Where is your home? Could you describe that place a bit? What do you like about where you live?
  o [Follow-up: How long have you lived in this area?]
    ▪ [Follow-up: Where else have you lived? When did you come here? Why did you move here?]

• What kind of work do you do?
  o [Govt Follow-up: What program are you involved with at DMF? (or other agency)]
  o [Scientist/Cons. Follow-up: What projects are you involved in currently?]

• How long have you been (insert type of work)?

• Tell me about how you got into this work.
  o [Follow-up: How did you start working for (insert name of org.)? Did you always work with the same program? Can you tell me the story of how you started your business?]
  o [Prompts: education, earlier jobs, interests]
  o [Follow-up: Do any members of your family, including extended family, fish commercially? For how many generations back has your family been fishing?]

• [If not already mentioned explicitly] What about oysters? How does your work involve oysters?

• While I imagine that you probably do different things each day, are there some things that you do regularly, everyday or every week?
  o [Dealer Follow-up: After you buy the fish from the fishermen, who or what do you sell it to]
  o [Dealer Follow-up: How much of your business deals with oysters? How has that level changed over time? Is it usually the same fishermen coming in with oysters?]
  o [Retail Follow-up: Are oysters important to your business? Where do the oysters you sell come from? Do customers ask you that? Are you noticing interest in local foods?]
  o [Growers Follow-up: How many oysters do you have in the water currently? How many are harvestable each year? Where do your oysters go when you sell them?]
  o [Scientist/Govt/Cons. Follow-up: Do you spend time on the water?]
    ▪ [Follow-up: How much time? What does that involve?]
  o [Follow-up: How far from home do you work?]

• Are there things you do only every so often, but that are still important?
• Can you tell me about a really great day that stick out in your mind? A really challenging day?

• Do you do any (other) outdoor activities?
  o [Prompts: recreational fishing, hunting, hiking, birdwatching, gardening, etc.]

• What do you enjoy most about your job? What do you like least?

• Is this your only job? Have you done any other jobs in the past?
  o [Follow-up: What other jobs do you have/have you dad?]
  o [Follow-up: Have you ever done any commercial fishing?]
  o Follow-ups if s/he was a fisherman:
    o Dealer: What made you go from being a waterman to getting your dealer’s license? What was that like?
    o Tell me about how you got into fishing
      ▪ [Follow-up: How did you learn to be a fisherman? How did you start out in fishing? Who taught you to be a commercial fisherman?]
    o What kind of fishing did you do?
      ▪ [Follow-up: What kind of fish did you go after? What type of gear did you use to catch X? How many nets/pots/etc. did you use?]
      ▪ [Follow-up: Did you ever do any oystering? For how long? How did you get into that? About how much of the year did you put into it? Did you make much money from oystering?]

• Are oysters important to you? Why is that? Are there any other reasons why oysters important to you?
  o [Follow-up: When I say oysters, what do you think of?]

• Are there any holidays that you’d celebrate with your family or events in the community when you’d usually have oysters? Where would the oysters come from? How would people have them? Who would do the cooking? How do you like to eat oysters? How would you describe eating an oyster to someone who had never had one?

Oyster fishery
• How do you think the fishery is doing? What makes you say that – can you tell me about a situation that shows this?
  o [Prompts: going strong, dying out, status quo, too many regulations, too few oysters, too much pollution]
  o [Follow-up: Is there good money to be made oystering? Do you think that will change in the future? How much longer do you think there will be money in oystering?]

• How is today’s oyster fishery different than when you start your career?
  o [Prompts: What do you think about today that you never did when you started out?]
  o [Follow-up: Could you say how it’s different than times before you started working? Where do you get your information about those times?]
• What do you think are the biggest threats to oyster survival?
  o [Follow-up: What about threats to the environment around here in general – are they different or the same?]
  o [Follow-up: How could the environment be changed to benefit oysters?]

• What are the biggest challenges for this fishery?

• How well do you think most people who live here or visit the area understand what’s happening with oysters or with other fisheries?
  o [Follow-up: Should the public be more informed about these issues? What information do you think should be getting out to people? Can you suggest how to do this? Who should be doing this education?]

**Conservation, management, and restoration**
• What does conservation mean to you?
  o [Follow-up: Is conservation needed in this area? What should be conserved?]

• Do fish need protection? From what?

• What do you think would happen if there were no management or DMF?
  o [Prompts: to fish, to oysters, to fishermen]

• What does sustainability mean to you?
  o [Follow-up: Tell me about a fishing practice that you consider to be sustainable? And one that is not sustainable?]
    ▪ [Prompts: targeting or not certain species, gear, technologies, limits, territoriality]
  o [Follow-up: Do you think about sustainability in your life?]
    ▪ [Follow-up: How does this show up in your life or work?]
  o [Follow-up: Do you think fishermen would be willing to give up profits in the immediate future to assure long-term gains? In what kind circumstances]

**Oyster restoration and management**
• What does restoration mean to you?

  [This question may not be needed at this stage of the interview.] Are you aware of any oyster restoration activities going on in North Carolina?
  o [Follow-up: How do you think restoring oysters in NC is going?]
    ▪ [Prompt: Is it succeeding, failing, somewhere in between?]
  o [Follow-up: Tell me about a couple of activities that you are in favor of.
    ▪ [Follow-up: As far as you know, what are these activities trying to do?]
    ▪ [Follow-up: What about any restoration activities that you are not in favor of?]
    ▪ [Follow-up: Are there things you think should be done to restore oysters that are not being done?]
• [Prompts: planting, hatcheries, sanctuaries, non-natives, rotating MPAs]
  o [Follow-up: What benefits do you see coming out of oyster restoration?]
    ▪ [Prompts: ecological, economic, cultural]
    ▪ [Follow-up: Do you think a bigger oyster population will affect the health of the coast? How?]
    ▪ [Follow-up: Do you think there is a market for more oysters?]
  o [Follow-up: What would happen if restoration failed and there were no oysters?]

• Does managing for other fish affect oysters? How so?

• What role should scientific research have in oyster management and restoration?
  o [Follow-up: Do you think there is enough science to know how to manage oysters?]
  o [Follow-up: Should there be more funding for scientific research? Are there any issues that you can think of that you’d like to see researched more?]

• [If it didn’t come up earlier] Do you see a role for aquaculture or private leases in oyster restoration? Tell me how so.

• Do you think that recreational shellfish harvesters should have to get a license?
  o [Follow-up: How big do you think the recreational harvest is? What impact do you think it has on the commercial industry?]

Relations with other stakeholder groups
I’d like you to take a look at this list of groups of people that might have some relationship to or vested interest in oysters or oyster restoration.

• commercial fishermen
• fish dealers
• shellfish retailers
• shellfish growers/aquaculturists
• resource/fisheries managers
• scientists
• conservationists
• consumers

• Can you tell me about a time when you had a conversation or meeting or some other kind of interaction with (insert one of the other groups here) and you felt like it was positive or helpful? What about a time that was not so good?
  o [Follow-up: What about with someone associated with one of the other groups?]

• How do you think (insert same group as in previous question here) would describe their conversations or meetings with watermen?

• Is there anything that you would want other people who work with oysters or the general public to know about your work or what you do?
Demographic and socioeconomic information

• How old are you?

• What do you consider to be your ethnic background?

• How many years of school have you completed? What is the highest degree you received?

• What is your marital status? Are you now married, widowed, divorced, separated, never married? How many people live in your household?

• I’m going to read a series of numbers and when I reach a number about equal to or more than the total income from all sources earned by all members of your household last year (2007), tell me to stop.
  o 10,000
  o 15,000
  o 20,000
  o 30,000
  o 40,000
  o 60,000
  o 80,000
  o 100,000
  o 150,000
  o 200,000
Appendix B

GUIDE FOR INTERVIEWS WITH FISHERMEN

Personal history, fishing tradition, fishing practices, and involvement with oysters

- Where is your home? Could you describe that place a bit? What do you like about where you live? How long have you lived in this area?
  - [Follow-up: Where else have you lived? When did you come here? Why did you move here?]

- What kind of work do you do?
  - [Follow-up: What kind of fishing do you do?]
    - [Prompts: What kind of fish do you go after? What type of gear you use to catch X? How many nets/pots/etc. do you use?]

- How long have you been fishing? Where do you work mostly?

- Tell me about how you got into it.
  - [Follow-up: How did you learn to be a fisherman? How did you start out in fishing? Who taught you how to be a commercial fisherman?]
  - [Follow-up: Do any members of your family, including extended family, fish commercially? For how many generations back has your family been fishing?]

- While I imagine that you probably have to do different things on different days, are there some things that you do regularly, everyday or every week?
  - [Follow-up: For example, how do you choose a location to set your gear?]
    - [Follow-up: Who taught you this? What have you noticed about how good locations move over the years?]
    - [Follow-up: Do fishermen have set territories?]

- Are there things you do only every so often but that are still important?

- Can you tell me about a really great day that you had out on the water that sticks out in your mind? A really challenging day?

- Do you do any other outdoor activities?
  - [Prompts: recreational fishing, hunting, hiking, birdwatching, gardening, etc.]

- What do you enjoy most about your job? What do you like least?

- Is this your only job? Have you done any other jobs in the past?
  - [Follow-up: What other jobs do you have?]

- What about oystering? How did you get into that?
  - [Follow-up: How long have you been doing it? About how much of the year do you put into it? Is that more or less than you did in the past? Do you make much money from oystering?]
• What gear do you use for oystering? Why do you use that gear?
  o [Follow-up: How do you feel about your gear – are there good qualities and not-so-good aspects of using that gear?]
  o [Follow-up: If they dredge: Do you ever hand tong?]
  o [Follow-up: Did you always use the same gear?]
  o [Follow-up: How do you decide where to oyster?]
  o [Follow-up: Have you noticed DMF trying to encourage people to use hand tongs instead of dredging? (Explain this if necessary.) What do you think about this?]

• Have you noticed certain kinds of fish around oyster reefs? Or that a person can catch certain fish near oyster reefs? What do you think this means?
  o [Follow-up: Are there kinds that you never find around there? Have you noticed any patterns to this?]
  o [Follow-up: Have you noticed that there are certain conditions where reefs tend to have more oysters or bigger oysters?]
    ▪ [Prompts: bottom type, salinity, depth, flushing, other habitats nearby, traits of the reef: height, complexity, age, size]
    ▪ [Follow-up: Or where there are lots of fish on an oyster reef?]
    ▪ [Follow-up: What do you think this means?]}

• Is harvesting oysters important to you? Why is that? Are there any other reasons why oysters important to you?

• Are there any holidays that you’d celebrate with your family or events in the community when you’d usually have oysters? Where would the oysters come from? How would people have them? Who would do the cooking? How do you like to eat oysters? How would you describe eating an oyster to someone who had never had one?
  o [Follow-up: What about your customers – do the same folks come back each year? When? Do you look forward to seeing any particular folks?]

Oysters and the fishery
• How do you think the fishery is doing? What makes you say that – can you tell me about a situation that shows this?
  o [Prompts: going strong, dying out, status quo, too many regulations, too few oysters, too much pollution]
  o [Follow-up: Is there good money to be made oystering? Do you think that will change in the future? How much longer do you think there will be money in oystering? Do you want your children to rely on it?]

• How is today’s oyster fishery or the work different than when you started out?
  o [Prompts: What do you think about today that you never did when you started out? people, product, money, rules]
  o [Follow-up: Could you say how it’s different than times before you started working? Where do you get your information about those times?]
    ▪ [Prompts: anecdotal evidence, stories from old timers, literature, data sets]
• What do you think are the biggest threats to oyster survival?
  o [Follow-up: What about threats to the environment around here in general – are they different or the same?]
  o [Follow-up: How could the environment be changed to benefit oysters?]

• What are the biggest challenges for this fishery?

• How well do you think most people who live here or visit the area understand these threats and challenges?
  o [Follow-up: Should the public be more informed about these issues? What information do you think should be getting out to people? Can you suggest how to do this? Who should be doing this education?]

Conservation and management
• What does conservation mean to you?
  o [Follow-up: Is conservation needed in this area? What should be conserved?]

• Do fish need protection? From what?

• What do you think would happen if there were no management or DMF?
  o [Prompts: to fish, to oysters, to fishermen]

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Oyster restoration and management
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• Are you aware of any oyster restoration activities going on in North Carolina?
  o [Follow-up: How do you think restoring oysters in NC is going?]
    ▪ [Prompt: Is it succeeding, failing, somewhere in between?]
  o [Follow-up: Tell me about a couple of activities that you are in favor of.]
    ▪ [Follow-up: As far as you know, what are these activities trying to do?]
    ▪ [Follow-up: What about any restoration activities that you are not in favor of?]
    ▪ [Prompts: planting, hatcheries]
    ▪ [Prompt: Have you heard about the oyster sanctuaries that DMF has created?]
      ▪ [Follow-up: What do you think of this idea?]
        o [Prompt: Do they seem to be helping the oyster populations? Why or why not? Have you noticed any
benefits from them? Should more or less area be restored but closed to fishing? Where would you recommend they be located?

• [Follow-up: Are the fishing regulations for sanctuaries followed? How are unlawful activities in sanctuaries penalized?]
  ▪ [Follow-up: Are there things you think should be done to restore oysters that are not being done?]
    • [Prompt: non-native introduction, rotating MPAs]
      o [Follow-up: Have you noticed any benefits coming out of oyster restoration?]
        ▪ [Prompts: ecological, economic, cultural]
        ▪ [Follow-up: Do you think a bigger oyster population will affect the health of the coast? How?]
        ▪ [Follow-up: Do you think there is a market for more oysters?]
      o [Follow-up: What would happen if restoration failed and there were no oysters?]

• Do you know if any of the reefs where you harvest oysters were planted by DMF?
  o [Follow-up: Do you work any natural reefs? Where are they? (Supply map for this.) Have you noticed any differences between natural and planted reefs?]

• Does managing for other fish affect oysters? How so?

• What role should scientific research have in oyster management and restoration?
  o [Follow-up: Do you think there is enough science to know how to manage oysters?]
  o [Follow-up: Should there be more funding for scientific research? Are there any issues that you can think of that you’d like to see researched more?]

• Do you see a role for aquaculture or private leases in oyster restoration? Tell me how so.
  o [Follow-up: What do you make of efforts to encourage aquaculture and private leases?]

• Do you think that recreational shellfish harvesters should have to get a license?
  o [Follow-up: How big do you think the recreational harvest is? What impact do you think it has on the commercial industry?]

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  o [Follow-up: What about with someone associated with one of the other groups?]

• How do you think people working at DMF would describe their conversations or meetings with watermen?

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