POST-DISASTER COMMUNITY RECOVERY

LINKING ENVIRONMENTAL AND ECONOMIC RECOVERY

by

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Abstract

This study examines the linkages between environmental and economic post-disaster recovery for coastal communities using the effects of Hurricane Katrina on the Mississippi Gulf Coast as a case study. The disaster literature often neglects to discuss the recovery of the natural environment in urban areas and how this influences the economic recovery of a community. This is caused in part by the difficulty of measuring recovery. However, it is a very important part of the post-disaster recovery and this study explores such 'hidden losses' as a declined contribution of the local fishery industry to the community. It is also important to recognize that the perception of how the natural environment relates to human societies is influenced by a society's paradigm. This study first examines the influence of two contrasting paradigms on the assessment of the recovery of natural system: the anthropocentric and ecocentric paradigms. This provides insights into the influence of the contemporary anthropocentric paradigm and the contrast with an ecocentric approach. Secondly, this thesis research studies the linkages between environmental and economic recovery for coastal tourism and fishery industries, focusing on a case study of the Biloxi area of Mississippi following Hurricane Katrina in 2005. The empirical insights gained from the case study are used to refine a framework for linking post-disaster environmental and economic recovery. Fieldwork was conducted in October 2010 and included 13 expert judgment interviews with local stakeholders and authorities. Quantitative analysis was also conducted using statistical time series data on economic and environmental variables. Results indicate that the economic recovery of the environment-dependent fisheries sector lagged behind the recovery of the general economy. This is caused by several factors such as decreased demand for fisheries products due to perception of environmental damage. Findings are summarized in a diagram of linkages between environmental and economic recovery.

Preface

This thesis is part of an international collaborative research project on '*New Methods for Measuring, Monitoring and Evaluating Post-Disaster Recovery*' that is funded by the U.S. National Science Foundation (NSF)[1]. Collaborators include researchers at the University of British Columbia, the University of Memphis (USA), the University of Delaware (USA) and ImageCat, Inc. (UK).

This thesis adopts the analytical approach for measuring the post-disaster economic recovery of the tourism and fisheries sector from the Guidelines for Measuring Post-Disaster Economic Recovery (Chang and De Ruiter, 2011). The application to the Biloxi case is an original contribution of this thesis. The measure for economic diversity presented in chapter three is also an original contribution.

This thesis required the approval of UBC's Behavioral Research Ethics Board for Minimal Risk studies, which was granted on August 17th, 2010.

[1] NSF project number CMMI-0926142.

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Acknowledgments

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Special thanks are owed to my friends and family, who have supported me throughout my years of education, both emotionally and financially.

Dedication

Voor Oma (To my grandmother)

1 Introduction

Post-disaster recovery is one of the least studied topics within the research field of natural hazards and disasters (Berke, Kartez and Wenger, 1993; Chang, 2010; Comerio, 2005; Davis, 2006; Mileti, 1999; Olshanksy and Chang 2008; Rubin, 1985). At the time of this writing, there is little mention in the literature of a comprehensive measure for all different aspects of post-disaster recovery. In particular, research into the recovery of environmental systems as well as the linkages between the affected environment and local economic sectors has some major gaps. Some frameworks for environmental and economic recovery exist, but they have not been linked and empirically implemented.

This master's thesis will address these gaps by both studying the post-disaster recovery of a coastal community's environment and determining the linkages between the recovery of a local natural environment and recovery of a coastal community's economy. This study aims to provide empirical insights into the linkages between environmental and economic recovery and a framework for addressing these linkages. This research presents a case study of the city of Biloxi, Mississippi and the impacts of Hurricane Katrina on the community's environment and economy, using the tourism and fisheries sectors as the focus of the data analysis to exemplify a broader concept: that of linkages between environmental and economic recovery. The tourism sector of Biloxi, which is casinos-based and has little dependence on the environment, is used as a proxy for the general economic recovery of the community, and the fishery sector is used as an example of an environment-dependent economic sector. Impacts of the 2010 BP oil spill are also discussed.

Research in the field of natural hazards has a strong interdisciplinary character and often combines elements of natural and social sciences, as well as to a limited degree, humanities. This study in particular aims to address this interdisciplinary character by using different types of data, such as quantitative time series data and qualitative data derived from expert judgment interviews and stakeholder consultations.

The increased occurrence and severity of natural hazards as well as the increased vulnerability of disaster prone areas make the assessment of natural hazards and post-disaster recovery an urgent issue. The pressure of humans on their environment is growing and this underscores the importance of how we assess recovery and mitigation efforts with regards to these natural systems in the post-disaster period.

Van Aalst (2006) discusses the impacts of global climate change, as caused by humans, on the risks of weather-related natural disasters. More specifically, the predicted global warming will likely influence the severity and the number of weather related hazards such as heat waves, floods and hurricanes. The overall vulnerability of a community depends on its capability to deal with the changed situations in weather and climate, but the *likelihood* of these meteorological events happening is increasing (Van Aalst, 2006; Keller and Blodgett, 2009).

Munich Re (2007) writes in its annual report that the economic costs associated with the impacts of these natural hazards are increasing every year. Densely populated areas are often found near or are part of hazardous areas. Moreover, according to the Center for International Earth Science Information Network at Columbia University, 40% of the world's population lives in coastal areas, defined as the area within 100km of the coast (CIESIN, Retrieved March 21st, 2011). Secondly, the value of the built

environment as well as the intrinsic value of the natural systems is increasing. The increase in the economic costs is caused by humans' growing dependence on technology and the growth in the value of the built environment and the increasing appraisal of the intrinsic value of ecosystems is caused by the pressure of both climate change and the expanding human population on the natural environment (Burby, 1998; Keller and Blodgett, 2009 and Munich Re, 2007).

1.1 Problem Statement

The Heinz Centre (2000) and Pérez-Maqueo et al. (2007) discuss the importance of coastal ecosystems for many coastal communities. Mansfield et al. (2010) explain the dependency between environmental change and economic activity in terms of resource use, land cover, and the negative feedback of economic activity on environmental pollution and degradation. By affecting the natural environment, a natural disaster can impact these ecosystem services and economies that depend on them.

This study focuses on the first type of relationship between the two: the use of resources. Changes in the natural environment can have great implications for the local economy. The choice to focus on the two economic sectors, fisheries and tourism, has been made based on the tight connection the fisheries sector has with the local coastal environment and, in the Biloxi case study, the lack of such connection in the casinos-based tourism sector, which can serve as a for the general economy. Despite the recognition of the dependence between a coastal economy and its natural environment, the linkages have not been explicitly studied for the post-disaster recovery of the fishery industry and how this compares with a non-environmentally dependent sector.

1.2 Research Objectives and Questions

In order to address the ways in which a coastal community's post-disaster environmental and economic recovery are linked, this research will focus on the following two main research questions and associated sub-questions:

1. *What does environmental recovery mean after a natural disaster?*
    a. *How can this recovery be measured?*
    b. *What empirical insights can be gained from measuring this?*
2. *How does environmental recovery relate to economic recovery?*
    a. *How do coastal communities recover economically from natural disasters?*
    b. *What is the role of environmental recovery for resource dependent sectors of coastal communities?*

Dryzek (2005) explains that environmental issues are complex and with this complexity comes a large number of possible perspectives on these issues. This study will discuss two different paradigms for valuing environmental and ecosystem services' recovery -- anthropocentric versus ecosystem-centric (i.e., "ecocentric") approaches – but will take an anthropocentric approach in the analysis. The National Research Council (NRC, 2005) defines ecosystem services as both the marketable goods (e.g. fish) and

myriad functions (e.g. nutrient recycling and climate regulation) of an ecosystem that have value for human users. The concept is therefore one developed within an anthropocentric paradigm.

The ecocentric paradigm recognizes not only humans' needs but also those of nonhuman communities who depend on ecosystems. Ecocentrism is defined by Eckersley (1992, p. 46, c.f. Dryzek, 2005, 184) as recognizing 'the full range of human interests in the nonhuman world as well as the interests of the nonhuman community'.

The concept of anthropocentrism as used in this research is based on the Promethean discourse. Dryzek (2005) defines a discourse as 'a shared way of apprehending the world' and discourses 'are bound up with political power' (Dryzek, 2005, p.9). This discourse is described by Dryzek (2005) as the idea of humans having an unlimited confidence in their capability to overcome any problems by relying on our technologies. I will not further restrict the definition of anthropocentrism by including the idea of cornucopia (the idea that the environment is abundant). However, I do acknowledge capitalism and economic optimization as being the main driving force for this paradigm. According to the anthropocentric paradigm, these ecosystem services are subordinate to issues such as economics and land use planning (Dryzek, 2005).

This study will adopt the above-mentioned definitions for anthropocentric and ecocentric perspectives of ecosystem services. The approach taken in this thesis research for examining the post-disaster recovery of the tourism and the fishery industries will be the anthropocentric approach. This choice has been made based on the assumption that the case study region functions in a capitalistic framework. The aim is to determine how environmental recovery influences economic recovery from the point of view of the economic stakeholders and the anthropocentric approach will more closely capture the local views and values of the relationship between humans and the natural environment than the ecocentric paradigm. A conceptual framework to address the influence of environmental recovery on economic recovery doesn't exist yet and will be developed in this study. For this framework, a distinction will be made between economic aspects, physical aspects and environmental quality. The *economic aspect* represents an anthropocentric approach to environmental recovery (in the literature also referred to as the 'economic paradigm'; Roach et al, 2010), as the concepts measured are based on their provisioning role for the local community (in this case the local community's economy). The *physical aspect* can both be measured in terms of its anthropocentric as well as ecocentric values (also referred to as the 'ecological paradigm'). The *environmental quality aspect* represents an 'ecocentric' approach for measuring environmental recovery. This study focuses on this aspect (environmental quality) to establish a theoretical approach for determining long-term environmental recovery for coastal communities and will use the economic aspect to assess the linkages between environmental and economic recovery.

1.3 Research Design

1.3.1 Background

1.3.1.1 Collaborative Research

This master's thesis is part of a larger study, an international collaborative research project on '*New Methods for Measuring, Monitoring and Evaluating Post-Disaster Recovery*' that is funded by the U.S.

National Science Foundation (NSF)[2]. Collaborators include researchers at the University of British Columbia, the University of Memphis (USA), the University of Delaware (USA) and ImageCat, Inc. (UK). This larger study seeks to develop and test new methods for comprehensively and systematically measuring the multiple dimensions of post-disaster recovery at the community scale. The study takes a holistic approach, taking into account four dimensions of recovery: economics, environment, housing and social recovery. The study holds a place-based perspective, using the cities of Punta Gorda, Florida, and Biloxi, Mississippi, as case study areas. A complete description of this project and its participants is included in Appendix A. This thesis contributes to the broader study by examining the linkages between environmental and economic recovery in the Biloxi case as shown in Figure 1.1.

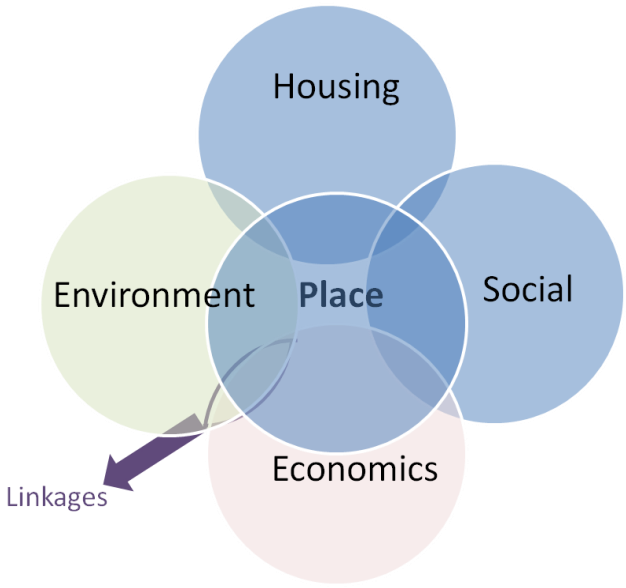

Figure 1.1 The NSF project's holistic scope and the place of this study within it.

1.3.1.2 Interdisciplinary Research

Research in the field of natural hazards and disasters requires an interdisciplinary approach in order to assess and fully comprehend the different aspects involved in a disaster. A disaster is likely to affect multiple aspects of a community and therefore this research will address different aspects of recovery and try to link those.

One of the issues that arises from interdisciplinary research is that of defining which questions to ask and how to approach the analysis of the problem (Öberg, 2010). As described by Chang (2010) the majority of the disaster literature focuses on the pre-disaster and disaster conditions rather than creating an overall post-disaster image. Of the various aspects of post-disaster recovery, economic aspects (e.g. business recovery) are the easiest to quantify and have therefore, together with social aspects that have become important because of the recent emphasis on understanding decision making processes, been studied the most (Mileti, 1999). The larger NSF project of which this research is a part

[2] NSF project number CMMI-0926142.

aims to provide a holistic approach measuring recovery by combining the economic, social, environmental and housing dimensions of a disaster-stricken community. This thesis research fits into the interdisciplinary character of this larger research by aiming to link environmental and economic recovery and discusses the different ways in which environmental assets can be valued. Reflecting its interdisciplinary character, this research also combines both quantitative, economic data and qualitative data derived from expert judgment interviews. These mixed methods are appropriate here because the different research questions can't be completely answered by only using one or the other. The expert judgment interviews are used in combination with quantitative research to (1) increase understanding and interpretation of the quantitative data, (2) overcome issues of scarce or non-existent data and (3) fill in gaps that can't be addressed through the quantitative data research.

1.3.2 Scope

This study will first look into the influence of the anthropocentric paradigm on approaches to assessing the recovery of natural systems and will then discuss an opposing perspective, the ecocentric paradigm. These paradigms have been chosen to keep the scope of this research manageable but at the same time provide insights into the influence of the prevailing, anthropocentric paradigm and a comparison with the contrasting, ecocentric paradigm.

This study then examines the influence of recovery of the natural environment on recovery of a community's economy in a case study of Biloxi in Harrison County, Mississippi, following Hurricane Katrina, focusing on the tourism and fisheries industries. The choice of these industries is justified by the importance of the tourism sector for the local economy and the dependence of the fisheries sector on the coastal environment.

The timeframe adopted in this study will be four years before and four years after Hurricane Katrina, or the period from 2001 to 2009. The spatial scope is Harrison County but the focus will be on the City of Biloxi. Another spatial scale often used in this study is that of the Biloxi-Gulfport Metropolitan Statistical Area (MSA) which includes Harrison County, Hancock County and Stone County. The MSA is a spatial unit regularly used by the US Census Bureau. This study adopts the definitions for coast and coastal county from the Center for International Earth Science Information. The Center defines the coast as the area within 100km of the coast (CIESIN, Retrieved March 21st, 2011). A coastal county is defined by the Heinz Center as 'having (1) at least 15 percent of its total land area within the nation's coastal watershed or (2) a portion of its land accounting for at least 15 percent of a coastal cataloguing unit' (Heinz Centre, 2002, pp. 115). According to NOAA, the US has 672 coastal counties in total and Harrison County is one of them (NOAA, 2011).

The main environmental system that is considered in this study is the coastal waters. The quality of the coastal water of the Gulf of Mexico and its capacity to support aquatic life are studied to determine the influence of Hurricane Katrina on the fishery industry. This study won't look into the biological aspects of the marine and terrestrial systems.

A full assessment of the environmental consequences of the BP Deepwater Horizon oil spill (April 2010) is impossible to pursue in the short time that has passed since the oil spill and closure of the leakage. Therefore, this study will discuss the impacts and the recovery of the tourism and fishery industry after the oil spill only through the expert judgment interviews.

Finally, the disaster literature distinguishes between three main definitions of post-disaster recovery. The definition that is used in this study assumes that recovery has been completed when a new, stable level has been reached (Alesch 2009; Chang 2010; Olshansky and Chang, 2008). For example, for the recovery of an economy that could mean that although not all business have returned, the ones that are in business are not affected any more by the disaster and are making normal revenues compared to the new level of population. This definition also incorporates retrofitting and other mitigation measures into the recovery process, which lower the vulnerability of a community (Alesch, 2009). The literature review in chapter two will expand on the different definitions of post-disaster recovery and the choice of this specific definition for this study.

1.3.3 Case Study Area Description

1.3.3.1 Characteristics of Biloxi's Demographics and Economy

This study uses the empirical data obtained from the case study done in the city of Biloxi and Harrison County in the state of Mississippi in October 2010 (Figure 1.2). The US Gulf Coast was hit by Hurricane Katrina in August 2005 and has also been affected by the recent oil spill of the BP Deepwater Horizon oil well in the Gulf of Mexico. The city of Biloxi, part of Harrison County, is located in the south of the State of Mississippi, along the coast of the Gulf of Mexico. According to Census city data, the city had a population of 50,644 in 2000 and 45,670 in July 2008. According to Mississippi Coast data Harrison County had a population of 189,601 in 2000 and 182,336 in 2009 as shown in table 1-1. As shown in Figure 1.3, the city is located 90 miles east of New Orleans and was strongly affected by Hurricane Katrina in 2005 as 90% of it was inundated by a 9 meter storm surge (FEMA, 2006). Figure 1.4 shows an example of the effects of the Hurricane on the beach area.

Figure 1.2Map of the South of Mississippi. Source: NOAA (used with permission).

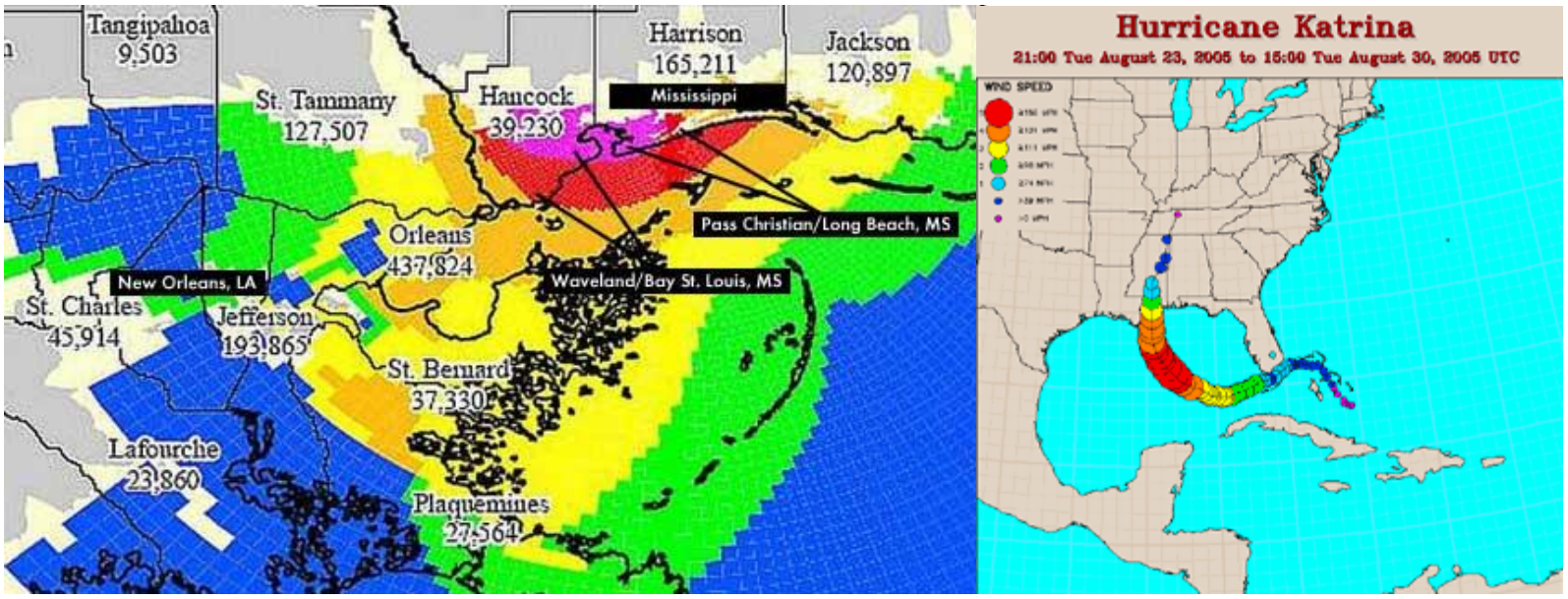

Figure 1.3 FEMA storm surge map. Source: http://lwf.ncdc.noaa.gov/special-reports/katrina.html (used with permission).

Table 1-1 Population by age Group for Harrison County in 2000 and 2009. Source: www.mscoast.org

Age group	2000 Census	2009 Estimate
0 -4	13,556 (7.2%)	11,072 (6.1%)
5 – 14	27,545 (14.5%)	25,318 (13.9%)
15 – 19	14,828 (7.8%)	16,126 (8.8%)
20 – 24	14,502 (7.6%)	13,012 (7.1%)
25 – 34	27,398 (14.5%)	19,776 (10.8%)
35 – 44	30,484 (16.1%)	25,594 (14.0%)
45 - 54	24,176 (12.8%)	26,723 (14.7%)
55 – 64	16,110 (8.5%)	21.981 (12.1%)
65 – 74	12,235 (6.5%)	13,338 (7.3%)
75 – 84	6,904 (3.6%)	6,910 (3.8%)
85+	1,863 (1.0%)	2,486 (1.4%)
Total	189,601 (100%)	160,377 (100%)

According to the Harrison County Development Office, the seafood, timber and tourism industries have historically been the major industries in Harrison County. Tourism comprises the largest industry, while the Kessler air force base is the principal employer. The Mississippi Department of Marine Resources (MDMR) describes the following major characteristics of the Biloxi Coastal Heritage area: the Biloxi Lighthouse, the Biloxi Schooners, maritime and aquatic museums, gateway to fishing, coastal and Island tours, art and seafood festival and fishing tournaments. Historically, Biloxi has been known for its shrimp cannery industry (late 1900's), export of raw oysters, and shipbuilding between 1870 and 1980 (22 shipbuilding companies settled in Biloxi) (Biloxi City Council Comprehensive Plan, 2009; City of Biloxi, Department of Finance and Administration, 2009 and MDMR, 2008). Biloxi's tourism sector is comprised of the casinos and is not highly beach, or environment, dependent.

The MDMR writes in its 2008 Environmental Assessment report that before Hurricane Katrina the economy of the Mississippi Gulf Coast counties (Hancock County, Harrison County and Jackson County) was characterized by commercial fishing marinas, docks and other fishing related businesses. After the Hurricane economic growth mostly resulted from newly developed high rise buildings, hotels and recreational marinas, instead of restoring the pre-disaster economic composition (Biloxi City Council Comprehensive Plan, 2009 and City of Biloxi, Department of Finance and Administration, 2009).

Figure 1.4 Biloxi, MS coast pre- and post-disaster. Source: USGS (used with permission).

1.3.3.2 Characteristics of Biloxi's Coastal Environment

The National Oceanic and Atmospheric Administration (NOAA) explains in a March 2009 report that the beach between Biloxi and the city of Pass Christian (west of Biloxi, also located in Harrison County) is one of the longest manmade-beaches in the US and is suffering heavily from erosion. The US Environmental Protection Agency (EPA) divides Biloxi's beach in 4 parts: Biloxi East Beach (length: 1.6km); Biloxi East Central Beach (length: 3.7km); Biloxi West Beach (length: 2.1km) and Biloxi West Central Beach (length: 2.9km). According to NOAA the Biloxi beach is a low-energy beach, which means that only 'sand movement occurs as a result of high-energy events (e.g. hurricanes, tropical storms)' (NOAA, March

2009, p.5). In order to accommodate tourism, the beaches are kept clear of vegetation and the profile of the beaches is being kept flat; both characteristics increase the erosion-proneness of the beaches.

1.3.3.3 Characteristics of Damage of Hurricane Katrina to the City of Biloxi

This section describes the overall damage of Hurricane Katrina to the city of Biloxi and on the tourism and fisheries sectors in specific. Of Mississippi's three coastal counties, Harrison County was hit the hardest and the cities of Biloxi and Gulfport in particular were severely affected (NY Times, August 30th 2005). The city of Biloxi had a reported death toll of 52 (The City of Biloxi, Katrina Statistics, retrieved April 11th 2011). With two bridges (the Biloxi-Ocean Springs) washed away and the main road, highway I-90, severely damaged the infrastructure was heavily impacted. Some 90% of the roads were rebuilt within a year after the Hurricane (Person G, personal communications, [October 18th, 2010]). The built environment was heavily impacted by Hurricane Katrina, with 6,000 buildings out of a stock of 25,575 houses and business destroyed (http://biloxi.ms.us/pdf/sotcpage4.pdf). These damages were mostly located in East Biloxi and along the coast line. The city of Biloxi issued over 5,000 building permits in the five months after Katrina. (http://biloxi.ms.us/pdf/sotcpage4.pdf). The City of Biloxi Condominium Report states that 14 buildings consisting of a total of 213 units were destroyed by Hurricane Katrina (http://biloxi.ms.us/PDF/condostatus.pdf, Retrieved April 11th, 2011). Many of the old heritage buildings which had been located near the coastline were washed away. The casinos that were located on the south side of highway US-90, such as the Grand Casino, the Beau Rivage and the Hard Rock Hotel were damaged by a 20-foot storm surge and most of them decided to move to the North side of the road after the Hurricane (NY Times, August 30th, 2005). There was no gaming revenue during the months of September until November 2005 and the revenue in December of that year was $11,494,157, compared to $61,730,555 the same month in the previous year (City of Biloxi Gaming Revenues, http://www.biloxi.ms.us/gamingrevenue/totals/, Retrieved April 11th, 2011). From the City of Biloxi Debris Removal Report (http://biloxi.ms.us/PDF/debris.pdf) it appeared that there was a total of 2,980,939 cubic yards of debris to be removed, of which 24% originated from private properties and 8% from commercial properties. The other 68% was made up by Right of Way[3] (The City of Biloxi Debris Removal Report, 2007). The vast majority of the Live Oaks in the area near the beach were killed (Person G, personal communications, [October 18th, 2010]). Lifelines such as water pipelines were damaged, and it took until August 2010 for city structures such as lifelines and other infrastructure to be restored. A large part of the fleet in the harbor of Biloxi near the Hard Rock Hotel had sunk and the commercial harbors and the facilities were heavily damaged, along with the piers of the recreational harbor located directly east of the main commercial harbor (Person F, personal communications, [October 20th, 2010]). The harbor on the North side of the peninsula was not damaged (Person F, personal communications, [October 20th, 2010]). The barrier islands in front of the Biloxi coast were damaged and some of them were cut in two (see figure 1.5 of Ship and Cat Islands) (Person F, personal communications, [October 20th, 2010][4]).

[3] Mississippi State roads and highways network (http://www.gomdot.com/Divisions/Highways/Preconstruction/RightOfWay/Home.aspx).

[4] Persons interviewed in this study are referred to by code letter rather than name, to ensure confidentiality.

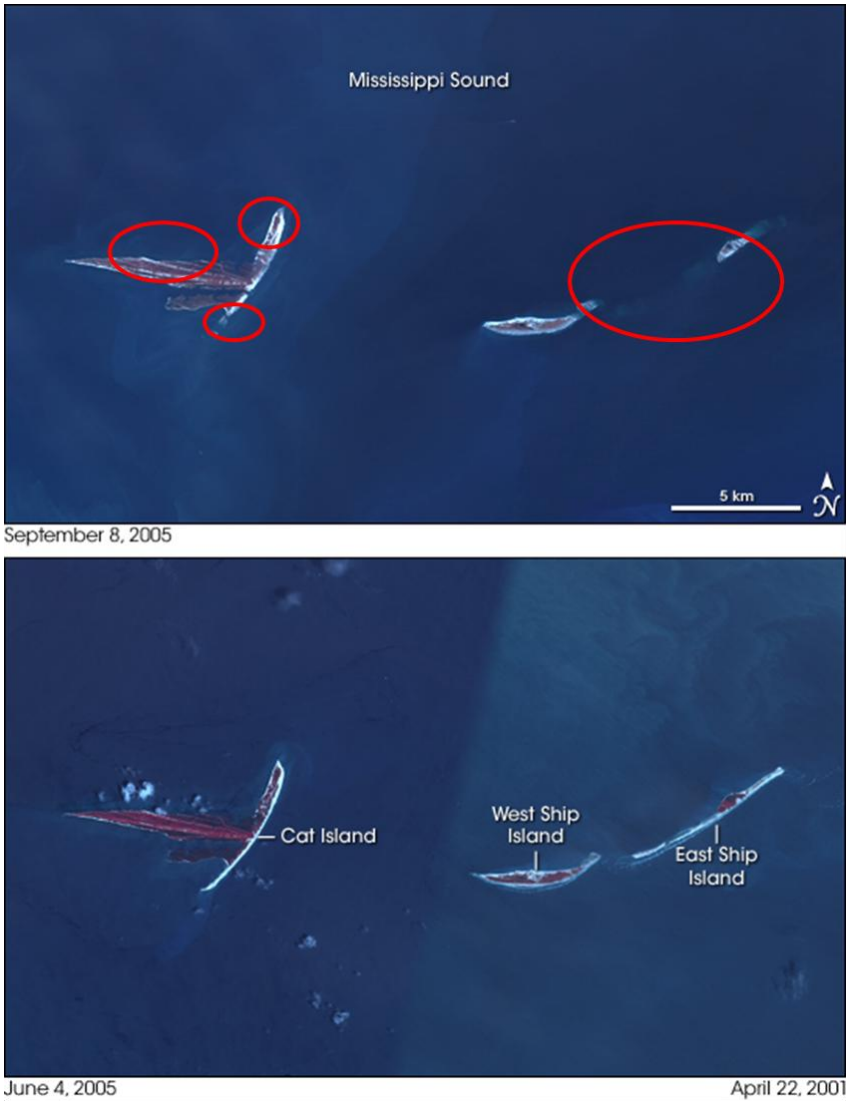

Figure 1.5 The Cat and Ship Islands that were affected by Hurricane Katrina, comparison of post-disaster September 2005 and pre-disaster (June 2005) situations. Source: USGS, http://soundwaves.usgs.gov/2009/03/. Retrieved, April 12th, 2010 (used with permission).

1.3.4 Methodology and Data Collection

Key in this research is how the long-term recovery of the economic and environmental sectors are linked for coastal communities; specifically, the impact of the recovery of the environment on the recovery of the fisheries sector and the recovery of the tourism sector. First, using a literature review, research questions 1a (how to measure post-environmental recovery) and 1b (how can this help gain insights into economic recovery) will be addressed. For this first part of the problem statement, a distinction will be made between an anthropocentric approach and an ecosystem-centric approach for measuring environmental recovery. This study will develop an initial framework to describe the linkages between post-disaster environmental and economic recovery based on the literature review. This framework will incorporate both anthropocentric and ecocentric metrics but will focus on the anthropocentric paradigm for both measuring long-term post-disaster coastal environmental recovery as well as the impacts of environmental damage on economic recovery.

For the second part of the problem statement and the main objective of this research, the post-disaster recovery of environmental systems and its linkages with the recovery of a coastal community's economy will be examined. This study uses the city of Biloxi and Harrison County as a case study. For the link between the environment and the economy, the focus will be on two important coastal economic industries: the tourism sector and local fisheries (including aquaculture). This justifies the use of the anthropocentric paradigm rather than the ecocentric paradigm for the assessment of the linkages. This part of the research will utilize both quantitative statistical data and qualitative data from expert interviews, and will refine the framework of the different ways in which environmental and economic recovery are linked to each other.

On the side, this research will also touch upon the recovery after the oil disaster using information obtained during the expert judgment interviews. As the oil disaster in Prince William Sound on the coast of Alaska has shown, impacts from an oil disaster of this scale are noticeable for a decade, and potentially longer, after the disaster has occurred (Piatt and Anderson, 1996). Nonetheless, there are some common threads to the BP oil spill and the Exxon Valdez oil spill. This research will only discuss how the oil spill has affected the area until a year after its occurrence and will try to capture ways in which the experts think the oil spill will affect them and what the overall environmental aspects will be.

1.3.5 Analytical Approach

For the second research question, addressing the relationship between environmental and economic recovery, a combination of quantitative time series analysis of economic developments from pre- to post-disaster situations and qualitative data provided by expert judgment interviews indicating their perspective on the timeframe and trajectory of the recovery and the linkages will be conducted. The analyses of the time series data and expert judgment interviews will be based on guidelines for measuring post-disaster community recovery developed as part of the larger NSF project (Chang et al, 2010). The economic recovery will be tracked in terms of three different aspects: the trajectory, the timeframe of recovery and the changes in the economy compared to pre-disaster levels. The expert judgment interviews will be used to supplement the time series data as well as to provide background information to interpret the time series data. On the side, the interviews will also briefly discuss the environmental recovery and the implications for the coastal-reliant industries after the recent oil spill in the Gulf of Mexico.

The analysis of the time series data and expert judgment interviews will provide a basis for the quantitative analysis of the linkages between environmental and economic recovery and how these two economic sectors compare. Statistical data such as income, employment and production in the tourism and fisheries sectors together with measures of post-disaster economic recovery, can provide an assessment of the extent to which the tourism and fisheries sectors are being affected by a natural disaster.

When comparing the overall economic recovery of Biloxi and Harrison County with the time series analysis of the tourism and fisheries sectors, the dependence of the local community on these sectors can be assessed. The main output will be a diagram of linkages between the economic and environmental recovery for tourism (as an example of general economic recovery) and the fisheries sector.

Figure 1.6 shows a preliminary schematic diagram of environment-economy linkages at four points in time: pre-disaster, at the time of the disaster, during the recovery period and finally, when a new stable state has been achieved. The diagram distinguishes between ecosystem (resources) and built environment (infrastructure facilities) dependent linkages and how they influence either or both the fisheries and tourism sectors, and shows the four different stages of the recovery (right before the disaster, at the time of the disaster, during the recovery process, and when recovery has been achieved). Each chapter of this thesis will provide input to adjust and refine the linkages diagram.

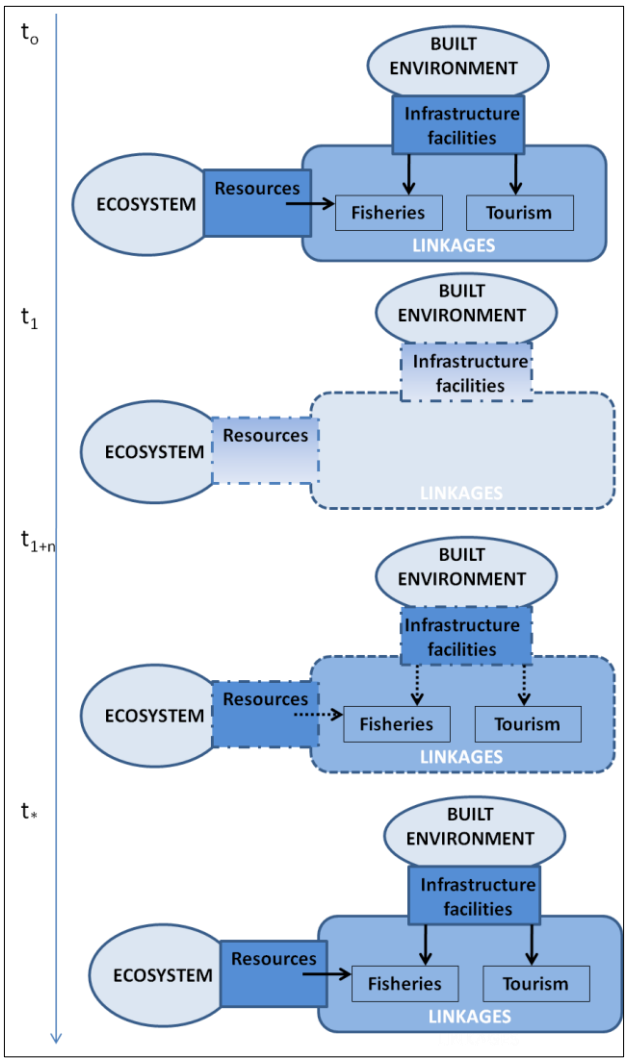

Figure 1.6 Diagram for the recovery of the linkages between economic and environmental factors shown for the different points in time, where t_0 denotes the situation before the hurricane, t_1 the situation immediately after, t_{1+n} denotes the recovery period and t_* when recovery has been reached.

1.4 Target Audience

My ambition is to conduct research that goes beyond the academic lab, that is, I hope that this thesis has a practical contribution to society and in particular for disaster prone coastal communities. Thus, I hope to have bridged the gap between the ivory tower of academia and the 'real world' in which natural

disasters occur. Research in the field of natural hazards combines natural and social sciences and humanities and I hope that to have reached this by emphasizing the interdisciplinary character in both the research methods chosen as well as the concept examined.

With my research, I hope to help managers and planners within the disaster community and give them a tool for analyzing post-disaster recovery, such as the guidelines developed for measuring post-disaster recovery in the Florida case study that is part of the larger NSF project, as well as the differences in recovery from natural hazards such as Hurricanes and human induced natural hazards such as the recent oil spill, to create a framework for environmental and economic recovery that may contribute to the improvement of mitigation measures.

The key stakeholder groups that may hopefully benefit from this study include:

- Decision-makers in disaster-prone communities
- Decision-makers in post-disaster recovery communities
- The natural hazards research community

I hope that this research will help managers and planners within the disaster community to gain insights and give them a tool for analyzing post-disaster recovery. Moreover, I hope that the creation of a framework for the linkages between environmental and economic recovery can support refining current mitigation measures and increase the general understanding of the post-disaster recovery process for community planners and aid workers.

1.5 Outline

This introductory chapter has introduced the research topic and design for this Master of Sciences thesis, including the context, scope, a brief introduction of the case study area, and the general methodological approach.

The second chapter will situate this research in the relevant literature. Post-disaster recovery is the least studied part of the disaster cycle (Mileti, 1999) and this literature review will address the three most common definitions of post-disaster recovery. Furthermore, the existing anthropocentric and ecocentric frameworks for addressing recovery will be discussed, including their ability to measure environmental recovery. The first of the main research questions, studying the measurability of environmental recovery, will be addressed in this chapter. Based on the literature review, a preliminary framework will be developed for linking environmental and economic recovery. This framework can be used to gain insights into economic community recovery and will be used in the case study analysis. Finally, background information will be provided on the case study area, including its demographic and geographical situation. This section will emphasize information on Biloxi's current and pre-disaster economic situation in order to provide background on the importance of both the tourism sector and the fisheries sector on its economy and how Hurricane Katrina, and to a lesser extent the BP oil spill, have influenced this.

Chapter three describes the methodology and data collection section of this research. First, the quantitative data selection and analysis will be discussed to provide the bigger picture. Next, the fieldwork in the city of Biloxi and the approach taken for the expert judgment interviews will be

discussed which will provide insights into the finer details of the quantitative analysis. Finally, a measure of economic composition changes will be developed[5].

Chapter four will present the analysis and results of this research. The aim is to combine the results of the quantitative and qualitative research to provide a holistic answer to the second main research question.

Finally, the main conclusions and a discussion will be presented in chapter five, in which the main outcomes of this research will be discussed. Furthermore, the need for further research and the transfer of knowledge gained from this study to make it applicable for practitioners will be stressed.

[5] Part of the analytical approach has been adopted from the Guidelines for Measuring Post-Disaster Economic Recovery (Chang and De Ruiter, 2011), however, the measure for economic diversity presented is an original contribution.

2 Literature Review and Conceptual Framework

This chapter will provide an overview of post-disaster recovery research and discuss two main issues. First, theories and frameworks of post-disaster recovery will be discussed. Secondly, literature employing different paradigms that influence thinking about environmental recovery will be reviewed to help answer the first research question: What does environmental recovery mean after a natural disaster and how can it be measured?

Hurricane Katrina did not only devastate the built environment in the south of Louisiana and Mississippi; it also left a trail of damaged natural environment behind. How we value these environmental damages and losses caused by a natural disaster, and how we consider the implications for communities with coastal-dependent economies, is subject to the paradigm used. The different paradigms influence the way in which recovery is measured as well as how the linkages between the environment and local economies are being assessed. Next, the literature on economic recovery of fisheries and coastal tourism industries after a natural disaster will be reviewed. This section will provide background for the second part of this research and explore some of the linkages and metrics indentified in the literature that will be used to adjust the environment-economy linkages diagram. Furthermore, literature on other coastal oil spills will be briefly reviewed. Finally, background for the case study of the City of Biloxi, MS, will be provided.

2.1 Theories and Framework

It is often recognized by the disaster-research community that post-disaster recovery is one of the least studied stages of the disaster cycle (e.g. Chang, 2008; Olshansky, 2008). Moreover, the disaster literature often neglects to discuss the recovery of the natural environment in urban areas. How the natural environment is seen as mattering to human societies is subject to the prevailing paradigm in these societies and, moreover, determines how we measure environmental losses and the recovery of natural systems after a natural disaster.

First, three prevailing definitions of post-disaster recovery are discussed and the choice of definition for this thesis will be explained. Furthermore, the different ways to measure and model post-disaster recovery as discussed in the literature are addressed.

2.1.1 Definition of Post-Disaster Recovery

Mileti (1999) explains that the disaster cycle is comprised of four stages: preparedness, response, recovery and mitigation. It has often been recognized in the recent recovery literature that the recovery phase is the least studied of these four stages for several reasons (Chang, 2010; Olshansky, 2008). The first issue that arises in post-disaster recovery research is the lack of an unequivocal definition of recovery. Early definitions of post-disaster recovery, dating from the early seventies, focus mostly on the reconstruction of the physical environment. Haas et al. (1977) define post-disaster recovery as ‘ordered, knowable and predictable’ and they assume that recovery can be modelled as a linear process. Nowadays, recovery research often assesses not only the physical aspect of recovery but also the social,

economic and political processes. The way researchers view the recovery process has also changed. The prevailing notion has shifted from perceiving recovery as a linear process to a probabilistic and recursive process (Mileti, 1999; Comerio, 1998).

There are three definitions of post-disaster recovery that are commonly used in post-disaster recovery research (Chang, 2010). The first definition suggests that recovery means a return to pre-disaster levels. This is a point of view often taken by residents of disaster struck communities; they aim for a re-building of their community as it was before the disaster (Alesch et al. 2009; Mileti, 1999). As Alesch (2008) explains, one might question whether this means recovery at all since it returns the community to the same vulnerable levels it was at when the disaster hit. The second definition describes recovery as reaching a level where the community would have been at that point in time had the disaster not taken place. The third definition assumes that recovery has been completed when a new, stable level - which may be different from the pre-disaster level - has been reached. This definition can incorporate retrofitting and other mitigation measures in the recovery process, which lower the vulnerability of a community (Alesch, 2009). The three definitions demonstrate the ongoing debate on whether to incorporate mitigation as a part of the definition of recovery. The International Strategy for Disaster Reduction (ISDR) defines post-disaster recovery as: “decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk”. This definition clearly encourages mitigation to be part of the recovery phase. This thesis research will use the third definition of post-disaster recovery, studying changes that have taken place by comparing the pre- and post-disaster situation. The National Disaster Recovery Framework NDRF (http://disasterrecoveryworkinggroup.gov/ndrf.pdf; retrieved Feb 2010) also describes recovery as a continuous process, supporting the idea that post-disaster recovery should not be defined as a return to a pre-disaster situation.

Another issue that arises when addressing post-disaster recovery is the constraint that is put on by the tension between speed and quality of recovery (Olshansky and Chang, 2008). As Alesch (2008) and Comerio (1998) point out, local residents often aim for a quick return to the pre-disaster situation, whereas the incorporation of mitigation efforts aims to increase the quality of recovery but simultaneously is highly likely to slow down the recovery process. This is the trade-off between the speed and quality of recovery.

Finally, post-disaster community recovery involves taking into account and understanding many different aspects and processes that are at play simultaneously, requiring a holistic approach. Up till recent years, the post-disaster recovery research has focused on the following sectors of recovery: residential (households and families), economic (organizations and commercial and industrial businesses) and community recovery (including the aspects mentioned above as well as politics and community life). Most studies focus only on one or two sectors at a time. However, especially when trying to measure recovery it becomes important to incorporate the different sectors.

This study will assume the third definition of recovery while acknowledging that this is constrained by the tension between speed and quality of recovery.

2.1.2 Measuring and Modeling Post-Disaster Recovery

There are only a few measures of post-disaster recovery in the literature, and they mostly focus on the degree of recovery of only one of the sectors of post-disaster recovery described in the previous section, rather than combining the different sectors of recovery.

The last few decades have yielded a handful of studies that examined post-disaster recovery and indicators that can be used to track recovery. The first North American, post-disaster recovery study was conducted by Haas et al. (1977). The authors regarded post-disaster recovery as a linear process with fixed phases and time-span. They argued that disaster recovery is ordered, knowable and predictable. According to their model of recovery activity, recovery consists of four, overlapping periods: emergency, restoration, reconstruction I and reconstruction II (see Figure 2.1) where each period is approximately ten times longer than its predecessor. Their model depicts the amount of activity per period against the amount of time that has passed after the disastrous event. Furthermore, the writers state that although trends of growth or decline may be slowed down or accelerated, the pre-disaster trends are likely to continue after the disaster. When talking about the third period, the writers refer to recovery as going back to pre-disaster levels or higher. The authors identify seven issues taking place after a disaster and that are intertwined: required decision to decide how, when and where to rebuild the city; land use changes; changes in building codes; changes in efficiency and attractiveness of the city; how to compensate private properties owners for their losses; how to deal with public participation; and how the increased local public expenditures should be financed (Haas et al. 1977).

Ever since the development of this first post-disaster recovery model, the way recovery is modeled and the role of time and (new) indicators of recovery have changed. The literature distinguishes several types of categories in which indicators of recovery can be classified. According to Haas et al. (1977) it is difficult to find a ‘standard set of measures that identify the *pace* of reconstruction in any society’. They identify the following indicators that influence the rate of recovery: the magnitude of the disaster, availability of resources for recovery, pre-disaster trends and leadership, planning and organization.

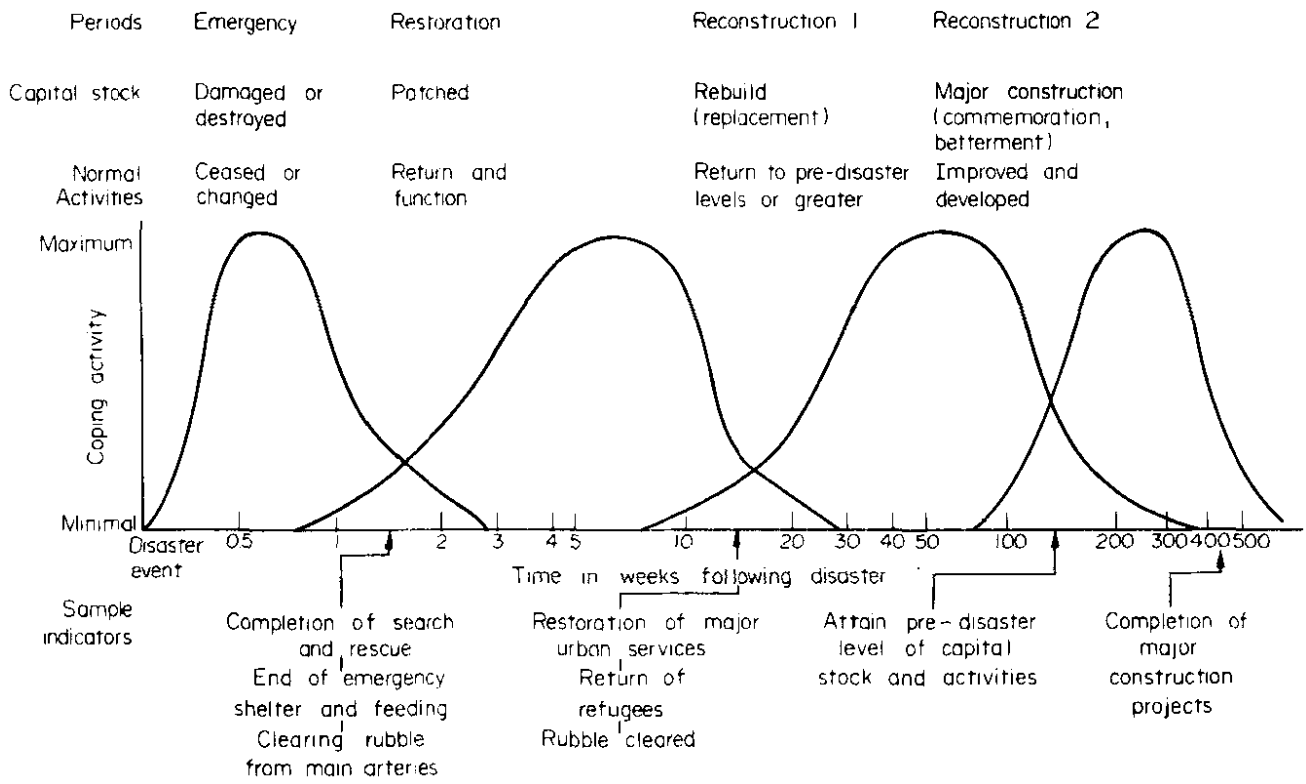

Figure 2.1 Model of recovery activity by Haas et al. (1977), MIT Press (used with permission).

In contrast to Haas et al. (1977), Rubin (1985) defines recovery as a dynamic and on-going process that is difficult to measure. In her study, Rubin (1985) focuses on the importance of intergovernmental relationships for a prosperous recovery. Rubin (1985) distinguishes five categories of recovery activities that measure post-disaster recovery: residential, business, public services and facilities, general population and mitigation, where the main restriction is based upon the fixed amount of available money for the recovery. Within each category she gives examples of indicators, most of which are focused on numbers of restored or reconstructed facilities, buildings etc. (Rubin, 1985). The (local) officials can influence the outcome of the recovery process by controlling the available resources.

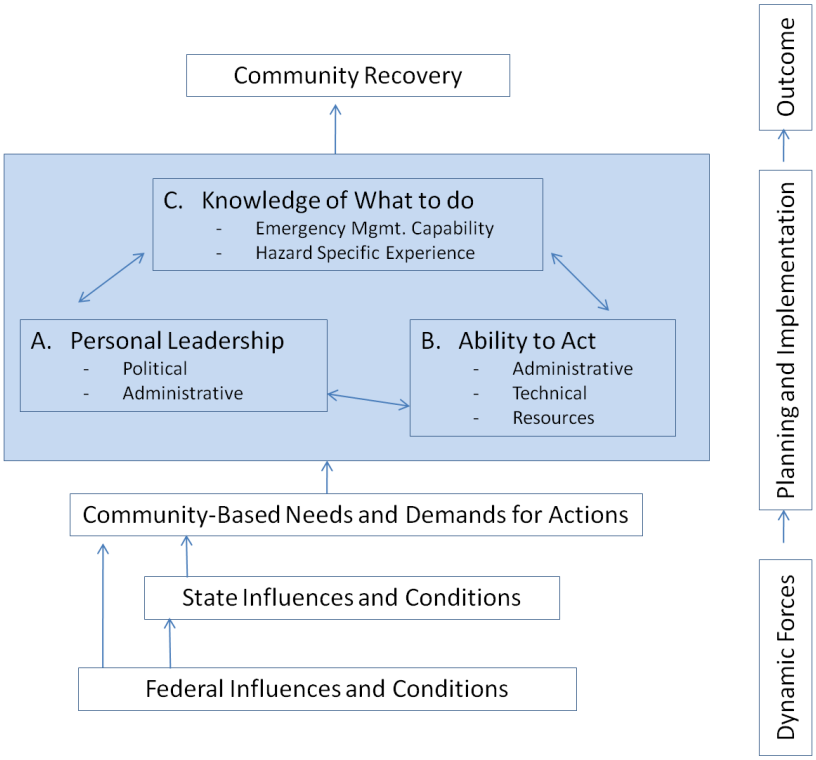

Figure 2.2 Organizing framework for elements of the recovery process (based on Rubin (1985)).

Figure 2-2 shows the framework for recovery and the most important elements of recovery, as constructed by Rubin (1985). She explains that the importance of intergovernmental cooperation increases as the number of governments that provide emergency and recovery assistance increases and therefore their interaction, defined by a certain number of key actors, has a major influence on the efficiency of local recovery (Rubin, 1985). On the level of community recovery, Rubin (1985) distinguishes three basic and necessary elements: 'leadership, ability to act and knowledge'. Rubin (1985) raises the question of how recovery should be defined, but does not answer it. Finally, she notes that this framework could provide a basis for further recovery research although she acknowledges that she is unsure how 'the model will fit into other societal settings' (Rubin, 1985).

West and Lenze (1994) noticed that there is a gap between the two main issues that arise after a natural disaster: the regional impact of the natural disaster and the economic implications of recovery and reconstruction. Therefore, the writers developed an econometric model to identify direct disaster impacts on exogenous variables, endogenous variables and model linkages. Estimations of direct impacts mentioned by them are, among others:

- Purchases made outside the region
- Temporary reassignment of outside labor to the disaster area
- Short-term overtime wage increases as a result of supply and demand imbalances
- A rise in temporary migrants for the construction industry labor market.
- Shifts in housing demand and supply imbalances
- Changes in the link from income to spending
- Shifts in regional purchasing patterns

- Changes in net-migration
- Changes in the resolution of labor supply and demand imbalances
- Reconstruction of spending flows
- The rise in external transfer payments and grants to the region

West and Lenze (1994) conclude that an economic impact analysis of a natural disaster lacks the analysis from engineering and natural science points of view and therefore new models of regional impact analysis of natural disasters that combine the three are necessary.

Tatsuki and Hayashi (2002) developed a seven-elements-model of life recovery based on survey data from the 1995 Kobe Earthquake. Tatsuki and Hayashi (2002) take a different approach in explaining recovery: the writers focus on the social, 'life', aspect of recovery and claim that their final model (incorporating housing damage, demographics and the seven critical elements: housing, social ties, townscape, mind and body, economic and financial situation, relation to the government and preparedness) accounts for almost 60% of the life recovery variance (Tatsuki and Hayashi, 2002). Another difference with the previously discussed literature is Tatsuki and Hayashi's focus on the recovery of individuals whereas Haas et al. (1977) and Rubin (1985) focus on community scale recovery. By taking the social and human aspect into account, they distinguish different kinds of indicators than most other researchers in this field have done; e.g. willingness to pay, sense of attachment to *locale*, optimistic expectations of the future and mental stress. In a more recent paper, Tastuki et al (2005) come to the conclusion that their earlier paper focused linearly on the outcome of life recovery and did not pay enough attention to the recovery process itself. Therefore Tatsuki et al. (2005) wanted to model psychosocial recovery and integrate that into the life recovery model. The writers define recovery as normalcy or a situation of stable reality that is not necessarily the same as the pre-disaster situation. They use this as a basis for their "normalcy-to-disaster-to-recovery" curve (see Figure 2.3).

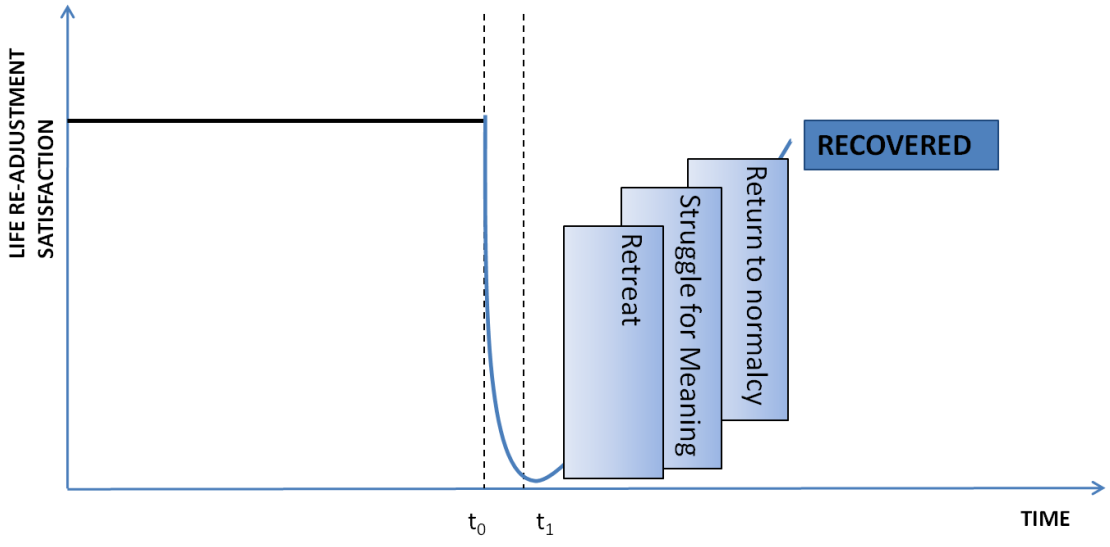

Figure 2.3 The "normalcy-to-disaster-to-recovery" curve after Tatsuki et al (2005).

Tatsuki et al (2005) constructed an appraisal scheme that considerd 5 factors of life change appraisal: return to normalcy, struggle for meaning, retreat, sense of life change and life change direction. The main outcome of their paper is that 'as life recovers, people feel less inclined to show communitarian attitude and pay less attention to preparedness and mitigation efforts' (p. 8).

Comerio (2005) points out that there are 'three critical elements in post-disaster recovery, jobs, housing and community services'. Next, she distinguishes two ways to define the concept of recovery. The conventional definition of post-disaster recovery defines recovery as a 'return to a pre-event status-quo'. However, Comerio (2005) notes that this definition doesn't make sense in cases where you want to upgrade the pre-event situation, for example by implementing mitigation measures. The second possible definition mentioned by Comerio (2005) regards recovery as community renewal, which takes into account that there are situations where the replacement of the losses is not a reasonable option. The writer mentions the following indicators of measuring recovery as indispensable: impacts on mainly low-income households, the number of housing units replaced, economic changes by new homeowners who take advantage of the post-disaster sales and new businesses that replace lost military and agricultural jobs. According to Comerio (2005) the degree of success of post-disaster recovery depends on three aspects: (1) the scale that recovery is measured, (2) the time frame in which recovery is measured and (3) the perspective of the evaluator.

The Federal Emergency Management Agency (FEMA) writes in its *Planning for Post-Disaster Recovery and Reconstruction* report (2005) that a society benefits from quick decisions made in the 'immediate post-disaster' period. The FEMA states that the factor time vs. extent is very important in the recovery of the public sector: how long does it take to clear a certain extent of mud and debris, the time it takes to replace a number of temporarily housing by permanent housing etc.

Olshansky et al. (2006) based their study on the rebuilding of communities after the 1995 Kobe and 1994 Los Angeles earthquake disasters. They point out that both the speed and the quality of recovery are 'measures of a successful recovery process'. Furthermore, they focus on the number of repair and reconstruction permits issued by the local government for resident housing and retail/offices.

The National Academy of Sciences held a 'recovery from disasters' roundtable in 2007. According to Olshansky et al. (2006) the first goals of recovery are: 'to at least return to a previous level of economic function and to replace lost housing units'. They identify the strength of continuing social and economic networks as a key to successful recovery. At the same roundtable debate, Barbera notes that there can't be an overall community recovery without the restoration of local medical and mental-health delivery systems. Barbera claims that failure to restore the healthcare system can be a major factor hindering the economic and social revival of the community. Laska notes that mixed signals of recovery process are often observed. Indicators mentioned by her include: improvements in the tourist industry; improvements in the health care sector; progress in curbing the crime rate and whether schools and universities can resume classes.

Gardoni and Murphy (2009) warn that in most post-disaster recovery studies, metrics are chosen too narrowly, taking only the easily quantifiable metrics into account, and lacking metrics that measure societal changes. Therefore Gardoni and Murphy (2008; 2009) propose a capabilities-based approach based on a theory introduced by Nussbaum and Sen (1998). Gardoni and Murphy (2008) state that a capabilities-based approach to recovery realizes the popular concept of sustainable recovery which implies that recovery efforts should aim to (re-)build, maintain, and enhance the quality of life of

the community members for both the short and long term. Capabilities are defined as the constructive elements of well-being and they measure the real opportunities individuals have. The capabilities-based approach to recovery aims to measure the level of well-being or the standard of living of individuals within the disaster-struck society. Risk is then defined as the possibility of a hazard to decrease individuals' capabilities. Next, the writers introduce the Damage Impact Index (DII) which measures 'the societal impact of a disaster by measuring the change in well-being' and the Damage Recovery Index (DRI) which 'measures the current level of individuals' capabilities'. Gardoni and Murphy (2008) state that the DRI can be used to measure recovery (the degree to which capabilities have been restored) by comparing the DRI with a benchmark value. The writers establish a five-step model to construct a given DRI and DII.

Alesch et al. (2009) state that while most residents regard recovery as going back to pre-disaster levels, that is not recovery since it's a past and unsustainable state.

In sum, post-disaster recovery can be measured in terms of the recovery of built environment; economics, businesses; social, health and safety, and natural resources and ecosystems. The way recovery is measured is subject to the definition of recovery. This research defines recovery as reaching a new stable state, and therefore focuses on measuring changes. In aiming to develop a measure that combines the different sectors, the NSF project and this study are taking a holistic approach addressing different sectors of recovery. Finally, the developed measure will study a set area looking at place recovery rather than people's individual recovery.

2.2 Environmental Recovery

The natural environment is the least studied aspect of post-disaster recovery. This is most likely due to the different interests in environmental recovery is subject to. The way the environmental recovery matters to the community, its utilitarian value, is central for this part of the research and is used to determine the diagram for the linkages between environmental and economic recovery used in this study. This section will first discuss two different paradigms for assessing environmental value, anthropocentrism and ecocentrism, and the choice of paradigm made for this research will be discussed. Next, the definition of environmental recovery will be discussed. Thirdly, the environmental and economic impacts of other oil spills will be discussed. Finally, different measures of environmental recovery and different framework for addressing environmental recovery and the linkages with economic recovery are discussed.

2.2.1 The Anthropocentric and Ecocentric Paradigms

Dryzek (2005) explains the lack of natural environment recovery related studies by explaining that environmental issues are complex as they are often intertwined and subject to other aspects of society. Because of this complexity, there are numerous ways to approach environmental recovery.

Therefore, an unequivocal definition of environmental recovery can't be provided. This study recognized the existence of different paradigms and their influence on how to address environmental recovery. The different approaches in the recovery process as well as measures of recovery are subject

to the prevailing paradigm. In this study, the anthropocentric paradigm is used to develop a diagram for assessing the linkages between the recovery of the natural environment and the economy.

2.2.1.1 Anthropocentrism

The anthropocentric paradigm in the natural hazards context is based on the idea that human-made hazard protection systems are better in terms of creating resilience and mitigation than natural systems (Burby, 1998; Dryzek, 2005). For example, humans tend to build dikes in floodplains although floodplains can serve as a tool to reduce the damage from flooding (Kousky and Zeckhauser, 2006). The concept of anthropocentrism is tightly linked to the post-Industrial Revolution changes in society and the development of capitalism: economic growth has become the main justification for making humans the centre of the world (Klein, 2007).

As Rousseau (1754) describes, the civilization of humans has a negative influence on their behavior. In the western world, the increased pressure on the natural environment is justified by the underlying assumption that this is acceptable when it is in the name of economic growth. Klein argues that 'an economic system that requires constant growth' is destined to make all attempts to regulate the natural environment impossible (Klein, 2007, p. 426). As long as our anthropocentric paradigm prevails, environmental solutions will never be sustainable and will lack a long-term perspective.

It can be argued that when speaking of the "recovery of natural systems," an anthropocentric paradigm is being used since it suggests that a disaster is not part of a natural cycle. The National Research Council (2004, p. 7) defines an ecosystem as 'an interacting system of biota and its associated physical environment'. Kousky and Zeckhauser (2006) define ecosystem services as 'the benefits people derive from ecosystems', which includes commodities as well as recreation. The writers explain that human actions can reduce the services provided by an ecosystem. Like the NRC, Kousky and Zeckhauser (2006) recognize that the economic approach of ecosystem services is growing. Kousky and Zeckhauser (2006) focus on ecosystem services as a reducer of vulnerability and impacts of natural hazards. They distinguish three advantages of using this type of ecosystem service. First, the improvement of policies to mitigate natural disasters can be cost-effective compared to other measures such as the development of a dike system in the floodplain. Secondly, the protection of an ecosystem can have benefits for the environment, for example increasing the biodiversity. Finally, the writers discuss that ecosystems are not subject to errors, unlike anthropocentric disaster-reducing systems. For example, they argue that the wetlands had provided better protection for New Orleans than the levees built in the wetlands. Another aspect raised by Monday (2009) is the contribution of ecosystems to the quality of life (as shown in Figure 2-4).

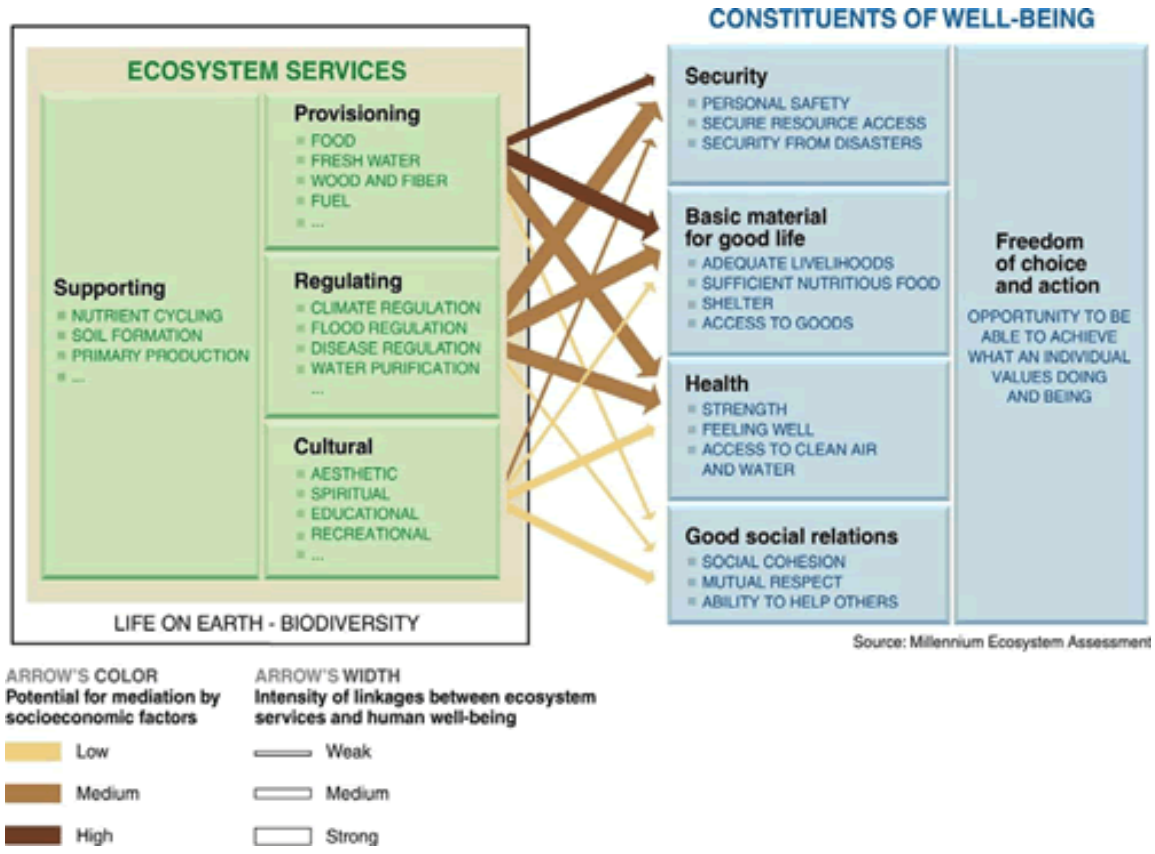

Figure 2.4 Ecosystem services and its contributions to constituents of well-being. Source: http://www.millenniumassessment.org/en/index.aspx (used with permission).

2.2.1.2 Ecocentrism

Burby (1998) argues in favor of bringing back or implementing ecosystem services instead of relying on anthropocentric disaster reduction tools. An important aspect of the recovery of natural systems in an ecocentric paradigm is the emphasis on valuing the intrinsic aspects of ecosystem services rather than anthropocentric aspects of ecosystem services which are defined as provisioning to humans.

Within ecocentrism, Minteer (2009) distinguishes between strong and weak ecocentrism; where weak ecocentrism is defined as "humans hold a higher moral significance than the other natural things that are taken to have moral standing" and explains this as human behaviour not necessarily being constrained by its effects on an ecosystem. Strong ecocentrism is defined as "equal or more than equal moral significance to other nonhuman, natural things which are taken to have moral standing" (Minteer, 2009, p. 84). In these definitions, moral standing relates to how the different paradigms define the intrinsic value of natural things (Minteer 2009).

Finally, sustainability can be another aspect of the ecocentric paradigm (Monday, 2009). It could also be argued that a sustainable approach provides a midway between both paradigms. Here, sustainability means that humans value an ecosystem not only for their economic value but also for their intrinsic value combined with taking a long-term approach.

2.2.2 Definition of Environmental Recovery

The Human Ecology School of thought came into being in the early 1900's at the University of Chicago, established by one of its protégés, Gilbert F. White (Mileti, 1999). It is often considered to be the foundation for all natural hazards and disaster research (in the social sciences) during the following century (Mileti, 1999). Sewell (1986) describes White`s approach as the first to combine a physical assessment, studying parameters such as geology, hydrology, vegetation and natural hazards, with socioeconomic assessments of parameters such as population, income and ecosystem services-based employment. The Human Ecology paradigm, also known as the Chicago-school of thought, defines natural resources as 'cultural appraisal of nature' and positions them where nature and society meet. One of the issues lies in the definition of natural resources. The Chicago-school describes it as follows: a resource is only defined as such when it links to both 'biophysical heterogeneity' and social institutions. (Bakker and Bridge, 2006).

Another complicating factor in defining environmental recovery is the issue of how to value environmental *costs* in terms of losses. The Heinz Center (2000) aims to address the hidden costs of coastal hazards at a community level. The writers aim to improve the framework for community risk and vulnerability. The Heinz Center studied the hidden costs of different aspects such as economic, social and environmental issues. It takes an anthropocentric approach in valuing the different types of costs associated with a coastal disaster. In line with this research is work done by the National Research Council's (NRC) Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems (2004). The NRC's Valuing Ecosystem Services study (2004) elaborates on what it calls the ecosystem services paradigm, exploring how human societies think about the meaning of the natural environment. They use the anthropocentric approach in valuing ecosystem services as where it an economic asset. This approach integrates the two fields of environmental and economic sciences and concludes that this is a not yet an established field. How the environment or ecosystem services are valued is subject to its paradigm. The next section will explore different paradigms and explain its implications for valuing the environment.

The following studies all discuss how the recovery of the natural environment is or is not addressed in the overall recovery process. Tatsuki (2007) describes the need to shift the conceptualization of recovery from linear and outcome-based to seeing it as an ongoing and long-term process. Often the environmental aspect is not addressed in the long-term community recovery literature. Alesch (2008), for example, described long-term community recovery as consisting of restoring or rebuilding the social, political and economic elements of the community that address its viability. As Comerio (1998) explains, funding is often a problem in recovery and when times are dire, it is not likely that money will be spent on reconstruction of the natural environment. In a weak ecocentric approach to post-disaster recovery, the environmental aspects are likely to get a more prominent role than they would have otherwise, and from a sustainability point of view should be weighed together with the social and economic aspects of a community (Natural Hazard Center, 2003 and 2005).

2.2.3 Environmental and Economic Impacts of Marine Oil Spills

On the side, this thesis discusses the impacts of the BP Deepwater Horizon oil spill on the recovery of Biloxi after Hurricane Katrina. This section discusses the environmental impacts of marine oil spills on

coastal communities to provide a context for the impacts the BP Horizon oil spill. First, a brief overview of the BP Deepwater Horizon Oil Spill will be provided. Next, the Exxon Valdez oil spill in 1989 that contaminated the coastal shore of Alaska near Prince William Sound will be used to provide a context for the oil spill that affected the Mississippi Gulf coast in April 2010 in terms of its economic and environmental impacts. This paragraph will look into the post-disaster recovery process of Prince William Sound and its local communities and will identify literature describing the environmental impacts and metrics used to study the post-disaster recovery.

2.2.3.1 The BP Deepwater Horizon Oil Spill

On April 20th, 2010, an explosion took place at a BP oil well one mile below surface in the Gulf of Mexico. It was the largest oil spill accident so far in human history (NY Times, April 21st, 2010). The National Commission on the Deepwater Horizon Oil Spill and Offshore Drilling (http://www.oilspillcommission.gov/) writes in its final report that the amount of oil released was 62,000 barrels per day until shortly before July 14th when the well was capped and the flow rate had declined to 53,000 barrels a day. Furthermore, they report that the estimated total release of oil is 5,174,887 barrels which is about 18 times as much as the oil spilled in the Exxon Valdez oil spill of 1989 (http://www.noaa.gov/). NOAA published Oil Trajectory Maps during the first weeks after the oil spill, depicting ´the surface location of spilled oil for several consecutives days´ together with predicted scenario for the next day as shown in Figure 2.5. In its ecosystem damage assessment on the first hundred days after the oil spill, NOAA explains that it has more than 40 teams on the ground to assess the damage by the oil spill and by May 2011 1,800 linear miles of shoreline have been assessed (http://www.noaa.gov/). US Economy explains that BP has put aside about $6 billion dollar to hire about 4,000 people for the cleanup of the spill (www.useconomy.com).

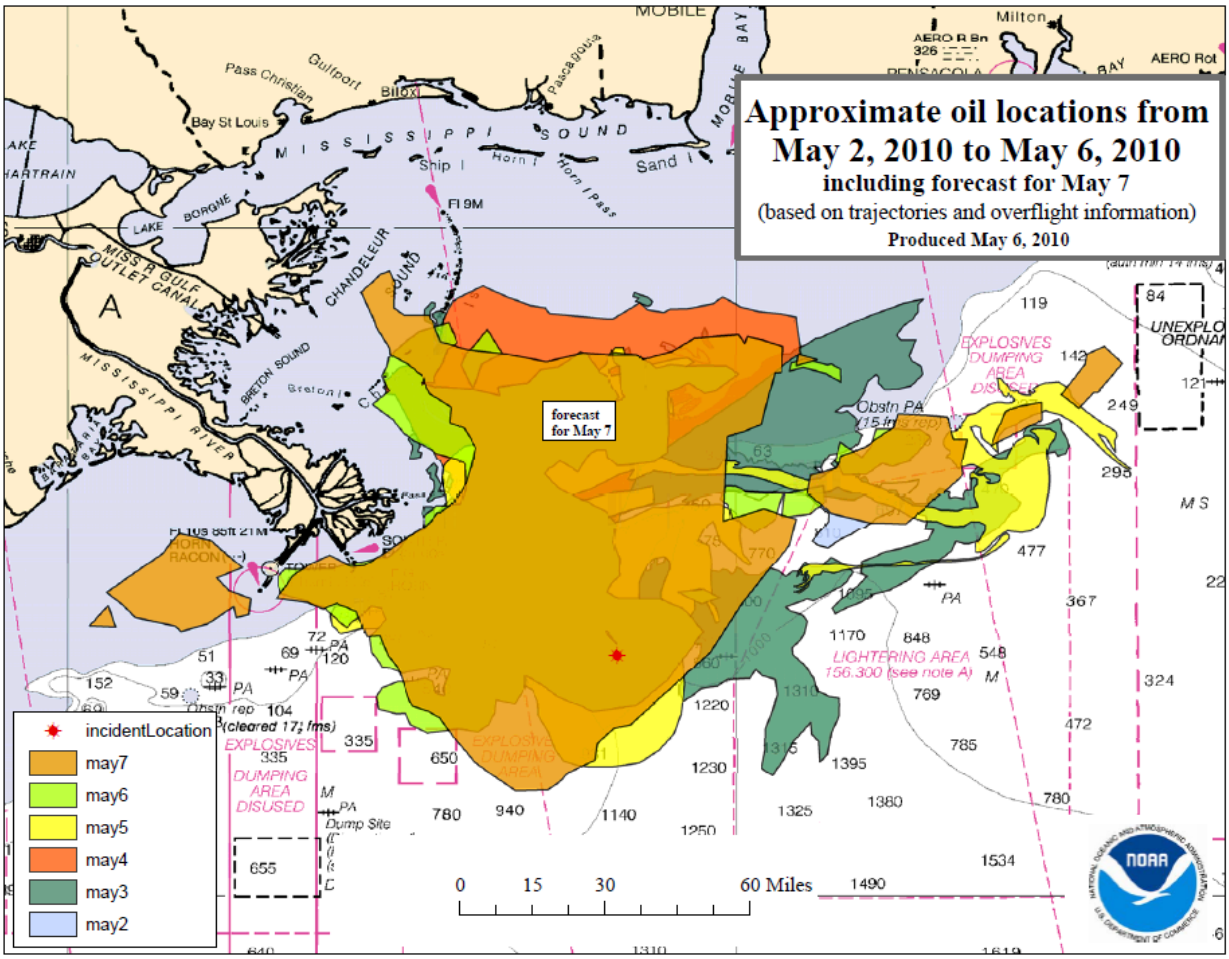

Figure 2.5 Approximate oil locations from May 2nd, 2010 to May 6th, 2010. Source: http://www.noaa.gov/deepwaterhorizon/maps/traj_maps.html, retrieved May 19th, 2011 (used with permission).

It took over 80 days to close the leakage, which caused fisheries and beaches in the area to close and caused widespread fear of environmental damage (NY Times, April 20th, 2011). The long-term impacts on the natural environment are still uncertain (NY Times, April 20th 2011). Bjorndal et al. (Science, February 2011) state that the marine ecosystems have been damaged and that populations of species used for commercial fishing have decreased. The writers argue that there is still a lack of scientific understanding to measure the effects of an oil spill of this size (Science, February 2011). Also, other impacts from the oil spill a year after the disaster are still uncertain. Fishermen and restaurant holders have seen their turnover decrease significantly and that hasn't changed yet a year after (NY Times, April 19th, 2011; The Guardian, February 3rd, 2011). In contradiction to this, other studies acknowledge the lower economic activities but simultaneously note that businesses are recovering (USA Today, April 20th, 2011). It appears that perception is still an important issue causing the tourism sector to recover slowly (USA Today, April 20th, 2011).

2.2.3.2 Exxon Valdez Oil Spill in Alaska

In March 1989, the Exxon Valdez oil tanker spilled approximately 42 million liters of oil in Prince William Sound and contaminated marine resources over 1990 kilometers of the Alaska coastline (Peterson et al.,

2003). Since then, there have been many studies covering the economic and social-environmental impacts of the disaster. Because of the severity of the event, the availability of data and the similarities with the impacts of the 2010 BP Deepwater Horizon oil spill on the fisheries sector (both communities have a shrimp fishing industry), the Exxon Valdez oil spill constitutes an appropriate case study to provide context for the BP Deepwater Horizon oil spill.

2.2.3.3 Environmental Losses from the Exxon Valdez Oil Spill

Peterson et al (2003) examined the long-term impacts of the Exxon Valdez Oil Spill on the ecosystems of the Prince William Sound in Alaska. They describe three metrics that describe the three major ways in which the oil has affected the ecosystem: (1) chronic persistence of the oil, (2) long-term population impacts and (3) indirect effects. The writers define the indirect effects as being 'delayed in operation because they are mediated through changes in an intermediary' and, moreover, they extend the recovery process (Peterson et al, 2003, p. 2084). Some of the indicators the writers used for these metrics are: (1) the oil decay rate, oil mass grounded on the beaches and oiled coarse sediments; (2) oil persistence measured by biomarkers in fish and other sea life, changes in mortality rates, acute toxicity, sea otter population recovery, sea otter prey abundance; and (3) the numbers of available prey influencing both the prey's food species as well as the number of predators and the capability of environment-creating creatures to do so, area of algal canopy cover and the loss of key individuals in a group of socially organized organisms (Peterson et al, 2003). Peterson et al. (2003) conclude that the recovery was more delayed than expected because of indirect effects. The persistence of the oil is described and the researchers found that after 3.5 years, about 2% of the oil mass remained on the beaches, reflecting a decay rate of -0.87year^{-1} and in the period of 1992 to 2001 a decay rate of -0.22 to -0.30 year^{-1} (Peterson et al, 2003, p. 2082).

2.2.3.4 Recovery of Recreation and Tourism Sector

The Exxon Valdez Oil Spill Trustee Committee (2010) studied the recovery of the recreation and tourism sector after the oil spill. (http://www.evostc.state.ak.us, retrieved April 20th, 2011). Their study suggests that the tourism sector has strongly declined after the 1989 oil spill for several reasons and is in 2010 still recovering. First, the access to areas that used to be open for fishing and hunting were severely limited because of the damage done by the oil spill to the natural resources. Secondly, local communities were (over)using the areas that were not affected by the oil spill because they were forced away from their primary areas that were directly affected by the oil spill. This caused the areas to be less available for recreational use. The researchers performed a qualitative study, conducting interviews in 1999 and 2002 with people who used the area for recreation before and after the oil spill. It appeared that they didn't decrease their recreational use of the area. However the respondents did notice a decline in wildlife in the area (http://www.evostc.state.ak.us, retrieved April 20th, 2011).

2.2.3.5 Linking Environmental and Economic Losses from the Exxon Valdez Oil Spill

Cohen (1995) claims that the economic aspects of natural disasters have been studied extensively, starting in the late sixties with key studies: Dacy and Kunreuther (1969), DeAllesi (1968) and Friesema et al (1979). Cohen (1995) aims to incorporate the social costs associated with a coastal oil spill, but acknowledges that an economic assessment has its limitations when trying to account for costs caused

by damaged ecosystems. Cohen (1995) argues that up till then none of the research had included social costs of an oil spill and she states that it is necessary to include social costs into the existing market model framework and to 'distinguish an oil spill's social costs from other sources of economic variability' (Cohen, 1995, p. 65). Garza et al (2008) define social costs of an oil spill as both private costs and collective or public damages, (Garza et al. 2008, p. 1) including for example cleaning and restoration (with a marketed value) and recreation (a non-marketed value). Some of the metrics proposed by Cohen (1995) that link economic and environmental impacts are: transaction values for fishery products from the region which measure the economic impacts on the local fisheries, loss of consumers' surplus caused by a reduction in supply and number and volume of harvest. To determine the social costs for the local fisheries Cohen (1995) applies the second definition of recovery by comparing the post-disaster situation with a hypothetical situation had the disaster not taken place. However, Cohen (1995) does not correct her data for normal, seasonal economic and biological fluctuations. Finally, Cohen (1995) acknowledges that it is very complicated to give very specific numbers of economic losses that are exclusively caused by the oil spill as other factors come into play as well.

Picou et al. (1992) use a control community for a comparative analysis to estimate the impacts of the oil spill on a fishing community in Alaska. The writers state that traditionally social studies of disasters emphasize either the general approach which deals with the common aspects of disasters or focus specifically on characteristics that are unique for a certain community and disaster. Therefore, Picou et al (1992) argue in favor of an "ecological-symbolic approach", which emphasizes 'the relationship between human communities and their physical environment and culturally-based, subjective responses to disasters' (Picou et al, 1992, p. 237). This approach aims to understand how a natural resource dependent community's economy and culture are vulnerable to a contamination such as a marine oil spill.

Palinkas et al (1993) aim to determine the linkages between the social (-economic), cultural and psychological impacts of the Exxon Valdez oil spill. The writers state that the main focus of the local public and government was on the environmental and economic impacts. According to Palinkas et al (1993), long-term social-cultural processes cause a paradigm shift in two ways: firstly, the environmental change forces the local community to change its ways of interaction with the natural environment. Secondly, the writers argue that it provides a case study of how social-cultural change and change in human well-being are linked. One of the changes that occurred was that more women joined the labor force. The communities along the coast have a historic based dependence on the ocean as a source of marine resources for commercial fishing, subsistence harvesting and recreation. The communities often indicated positive benefits economically and in terms of community bonding.

The Exxon Valdez Oil Spill Trustee Committee (2010) has published an overview of the natural and human services that were impacted by the oil spill (http://www.evostc.state.ak.us, retrieved April 20th, 2011). The committee recognizes that human services that are dependent on natural resources have been severely impacted by the Exxon Valdez Oil Spill and they state that recovery can only be completed when the recovery of both eco-resources and human-services are restored. The committee recognizes four human services that are dependent on natural ecosystems and that are impacted by the oil spill: commercial fishing, passive use, recreation and tourism, and subsistence.

First, the commercial fishing industry is still recovering according to the committee in 2010 (Exxon Valdez Oil Spill Trustee Committee, 2010). This is partly caused because not all fish species have

recovered yet and the industry had to close for over a year after the disaster. The committee states that full recovery can only be reached when the fishing species that are important for the commercial fishing industry have recovered and when the opportunities to catch these species are no longer affected by the oil spill (http://www.evostc.state.ak.us, retrieved April 20th, 2011). Furthermore, there are specific economic conditions that have complicated the recovery of the commercial fishing industry, such as the global increase in supply of salmon and shrimp. Finally, the committee describes the issue of fewer resources that need to be shared by the commercial fishing industry, tourism and subsistence fishers.

Secondly, in a separate study, the University of California studied the losses in intrinsic value after the Exxon Valdez oil spill and concluded that the area is still recovering (Carson, 1991, http://www.evostc.state.ak.us/projects/ProjectInfo.cfm?project_id=1668). Passive use is the aesthetic service provided by an ecosystem and strongly depends on the perception that the public has of the area and its recovery. The committee explains that is it crucial to provide up-to-date and accurate information on the local situation and the progress made in the recovery process. The committee states on its website that the area is still suffering from misperceptions and therefore is still recovering (http://www.evostc.state.ak.us, retrieved April 20th, 2011).

Thirdly, recreation and tourism have severely declined after the oil spill and are still recovering. The committee states that this sector will have recovered when the beaches are no longer impacted by the oil spill and when the fish and ecosystem have recovered (http://www.evostc.state.ak.us, retrieved April 20th, 2011).

Fourthly, the subsistence sector is also still recovering from the oil spill and will be recovered when the impacted natural resources on which they depend have recovered and when their production is back at pre-oil spill levels. The committee states that after the spill, the subsistence harvest has declined ranging from 9% to 77% for each of the 10 native communities that are located on Prince William Sound. It took a few years of recovery for the harvest composition to return to a new normal. Another issue was that of food safety: between 1989 and 1994 the harvests were strictly monitored for oil contamination and it appeared that contamination levels were very low. However, the fear and perception that food was contaminated was persistent until 2003 when a survey showed that most users had regained their trust in the local marine harvest.

A study of the economic losses for recreational fishing (Carson and Hanemann, 1992), measured in number of anglers, fishing trips and days and the species fished for, showed that there is an upward trend in recreational fishing activities. The first three indicators all showed a drop for recreational fishing activities for the Prince William Sound area. Strikingly, the number of fishing trips decreased much more than the days fished (Carson and Hanemann, 1992). Carson and Hanemann (1992) have four possible explanations for this. First, they argue that the quality of recreational fishing opportunities had decreased because of the spill; the numbers of boats available was low because they were taken away for clean-ups; the areas that were not affected by the oil became overcrowded and finally, the fishermen were too busy with the clean up. Carson and Hanemann (1992) raise the issue of the baseline that should be used to compare the post-disaster changes with and describe two different approaches. First, one post-disaster year can be compared with a previous year or with an average of pre-disaster years. The disadvantage of this approach is that (seasonal) trends need to be taken into account. The other approach is to construct a baseline of what the expected situation would have been in a specific year had the disaster not taken place.

2.2.4 Measuring Environmental Recovery

There are different ways to address environmental recovery: (1) study the environmental damage itself, (2) study the damage it has on other aspects, and finally (3), study the extent to which the environmental recovery contributed to the overall recovery. The first aspect is addressed by environmental damage assessment as conducted, for example, by the EPA (EPA, www.epa.gov, retrieved April 20th, 2011). The second aspect is being addressed by studies that describe ecosystem services and their recovery, for example, Drenthen (2009) explains that the state of the environment has a direct influence on how the inhabitants feel towards their place. Drenthen (2009) studies the extent to which the recovery or the structure of the environment has influenced them. The third way to address environmental recovery aims to describe the role of the environmental recovery in the larger framework of the overall recovery process. This has not been done yet and is one of the goals of the NSF recovery project of which this study is part.

As explained before, one might argue that when speaking of the "recovery of natural systems" an anthropocentric paradigm is being used since it suggests that a disaster is not part of a natural cycle. Here, it depends what type of recovery is being meant. The recovery of the natural environment is often measured in terms of its contribution to a return to pre-disaster levels of 'the quality of life'. Attributes of the quality of life are often measurable in price (e.g. price of wood, clean water etc.) or in qualities such as the provision of aesthetics and recreational space (see also figure 2-4).

However, these attributes, as mentioned in figure 2.4 under the heading 'provisioning', are anthropocentric attributes of the quality of life. White (1973) explains that economic optimization is the main driving force in the post-disaster recovery decision-making period. This perception is merely anthropocentric. However, natural systems, such as a coastal system, go through a process of recovery as well. This type of recovery is different in that it doesn't involve humans and is not expressed in economic terms. This duality shows that the perception of humans of the natural environment and the way humans perceive themselves with regard to the natural environment is crucial for the perception of recovery of natural systems. The National Research Council (NRC; 2004) points out that the existing literature on the valuation of ecosystem services is scarce. This section will review the most recent and relevant literature on this topic.

The NRC (2004) emphasizes the importance of (coastal) ecosystem services to the need to increase the understanding of the importance of these ecosystems for human systems. By expressing the value of the ecosystem in terms of its support to human societies, the NRC (2004) takes an anthropocentric approach in measuring the value of coastal ecosystems. The NRC (2004) defines an ecosystem as 'an interacting system of biota and its associated physical environment' (The National Research Council, 2004, p. 7). Figure 2.6 shows the diagram that the NRC (2004) uses to capture 'the value and valuation aquatic ecosystem services' (NRC, 2004, p. 240). First, the NRC (2004) measures the value of the goods and services that are produced by an ecosystem and are valued by humans. Secondly, they distinguish the 'existence of aquatic ecosystems for their own sake' (NRC, 2004, p. 240) in which case economic valuation is 'the process of quantifying the economic value of a particular change in the level of a good or service' (NRC, 2004, p. 243). This can be measured in two ways: (1) as the willingness to pay of an individual or group to secure the change and (2) as the amount needed to compensate an individual or group for the change. The advantage of this method is that it is couched in existing economic theory (NRC, 2004). Next, the NRC (2004) argues that the total economic value of ecosystem

services is the sum of the use and the non-use values. The NRC (2004) explains that integrating economics and ecology is crucial for understanding the linkages between eco- and human systems. The NRC (2004) acknowledges that difficulties in valuation can arise when there is insufficient knowledge or data available for an ecosystem.

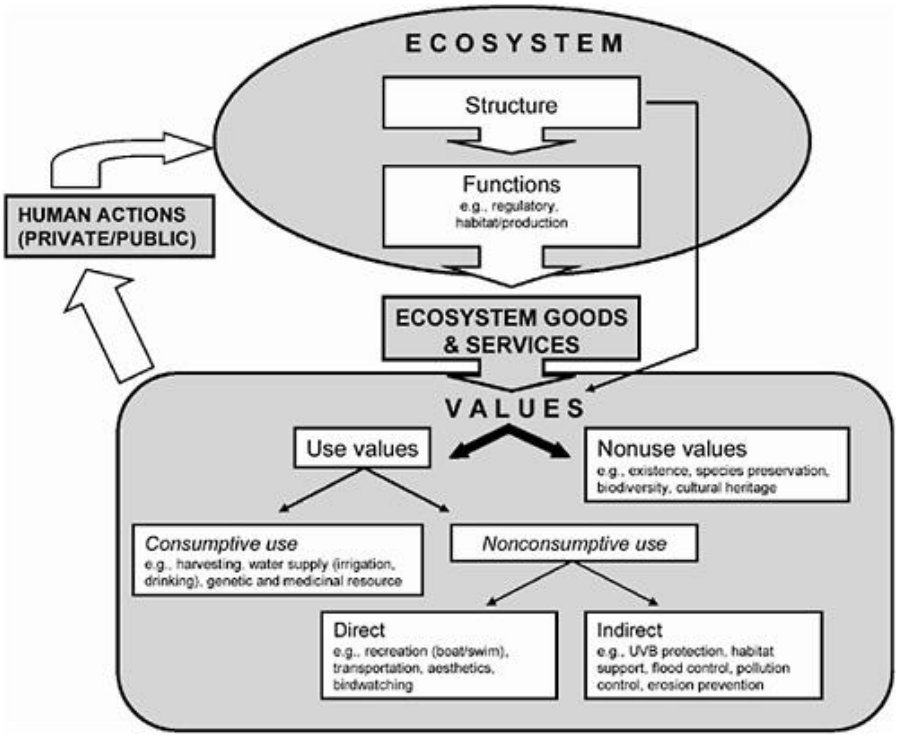

Figure 2.6 Connections between ecosystem structure and function, services, policies and values. Source: NRC (2004), p. 241 (used with permission).

Kousky and Zeckhauser (2006) define ecosystem services as 'the benefits people derive from ecosystems', which includes commodities as well as recreation. The writers explain that human actions can reduce the services provided by an ecosystem. Like the NRC, Kousky and Zeckhauser (2006) recognize that the economic approach of measuring ecosystem services is growing.

Finally, as explained in section 2.2.1.2, sustainability is perceived as another aspect of the ecocentric paradigm where the ecosystem is valued for both its economic and its intrinsic value. However, the NRC (2004) explains that humans do not necessarily value ecosystems only for their function (marketability) but also value an ecosystem in 'its own right' such as forests that are not only valued for the price of the wood but also for their intrinsic value. According to the NRC (2004), the integration of economics into ecology and vice versa is a recent process. However, the intrinsic value of natural systems can't be captured in a quantitative value and is therefore difficult to assess by policy makers.

The Environmental Protection Agency (EPA) also explains that often environmental considerations and possible ecosystem services are being ignored in decision-making processes. The EPA

argues in favour of integrated management; incorporating the knowledge about ecosystem services into the overall decision-making process and moreover, into the environmental decision-making process. They claim that this should create understanding among policy makers of the values and risks associated with the impacts of their decisions on the natural systems. The fact that ecosystem services are largely not being taken into account in environmental decision-making points out that the environmental decision-making process is not only or *per se* driven by anthropocentric reasoning, but also possibly by a lack of knowledge. The impacts of this behavior can be large. As Burby (1998) explains, by trying to conquer nature, the vulnerability of a community is often increased instead of decreased.

The Ecosystem Services Research Program (ESRP) from the US Environmental Protection Agency (EPA) defines measures for environmental accountability as follows:

Extent X Condition X Functions = Services; Value = f(services)

The writers explain that the stock of a natural resource (e.g. fish populations, beaches) forms the basis for valuing ecosystem services and with a decreasing amount of available stock the value increases. They continue that up till now, the effects of human intervention on ecosystem services and managing of these effects has not been studied much. They state that the ecosystem services paradigm does not only provide a tool to measure the quality of an ecosystem, but also measure the value of the natural environment. The EPA recognizes two methods for measuring environmental values: direct (such as market price) and indirect (e.g. travel cost). They raise the issue of how to value both monetary and the non-monetary value of the environment. The writers introduce the Relative Valuation of Multiple Ecosystem Services Index (RESVI) which measures sustainability in either relative units or a dollar unit. Another problem with the ecosystem services as provided by natural environments is explained by the European Commission (EC; 2008) in its report on valuation of ecosystems and biodiversity: most of them are public goods that lack a market and market prices.

Jordan et al. (2010) state that indicators for measuring general economic development have the advantage of being easily measurable. They also point out that indicators for 'environmental performance' as well as a unit of measurement don't exist. This is partly due to the fact that many of these indicators measure qualitative value rather than quantitative (Jordan et al., 2010).

Chuenpagdee et al. (2001) state that there is a lack of agreement among scholars on how to estimate the monetary value of environmental losses. The writers suggest not using these monetary values but instead basing estimates on a predetermined overview of how a community judges changes in its environmental assets and resources. They argue that these 'damage schedules' provide a better representation of a community's preference than monetary tools such as Willingness to Pay do.

Repetto (2007, Comment on environmental accounting)) writes in his commentary that natural assets with an economic importance can be expressed in terms of their market value (e.g. wood, fish and water); this allows for some aspects of the natural environment to have monetary value.

Comerio (1998) describes the following four basic models for recovery that have been adopted since the seventies: (1) a national government finances the recovery; (2) both governments and/or charities provide funding for recovery; (3) funding comes from private insurance companies who cover (partly) some of the costs, governments might provide some funding for the poor; (4) funding and setting of the prices is completely market driven. The implications for the recovery of the natural

environment of the first model is that it is economically driven as it is dependent on the availability of governmental funding over the full time-span of the recovery and is strongly subject to the political system at the time of the disaster. The second model allows for NGOs to fund recovery of ecosystems. The third model is according to Comerio (1998) 'unbalancing' in a developed urban setting: it tends to overlook the less-affluent of a community (Comerio, 1998, p. 127).

Therefore, it seems justified to take an economic approach in assessing the value of environmental services and products for human societies. The recovery of the link between environmental and economic recovery will therefore be measured in the value of its contribution to the fisheries sector, which is dependent economically on the local coastal ecosystem.

Garza et al (2008) argue that in the valuation of economic damages to the fisheries sector, a distinction should be made between short-term and long-term effects. This study will only account for the short-term losses because of the relative short time passed by since the Hurricane. Short-term costs are measured by Garza et al (2008) as 'the variations in the catch of affected species' and are being compared with the pre-disaster values of the same variables (Garca et al, 2008, p. 3).

2.2.5 Linking Environmental and Economic Recovery

This section first discusses the existing frameworks for measuring and linking environmental and economic recovery. Next, case study research from hurricane-stricken coastal areas will be discussed. Finally, the diagram for linking environmental and economic recovery (Figure 2.10) will be adjusted based on the findings in this literature review.

2.2.5.1 Frameworks

This thesis aims to develop and refine a framework for the linkages between environmental and economic recovery. Ecosystem services are a key link between environmental and economic recovery in the framework used in this thesis and therefore, frameworks for valuing ecosystems services are being reviewed. Frameworks to address the value of ecosystem services exist. The base of the pyramid in Figure 2.7 by the EC (2006), is formed by the ecosystem services, a layer up is the qualitative review, part of that is a quantitative assessment and part of that is the monetary valuation. However, a conceptual framework to address environmental recovery doesn't exist yet. Monday (2009) suggests to approach recovery from a broader perspective and presents a holistic framework for community recovery couched on the concept of 'sustainability' which comprises disaster resilience, the built environment and the economy. Monday (2009) defines sustainability as the harmonic balance in the interaction between the social, economic and environmental systems of a community.

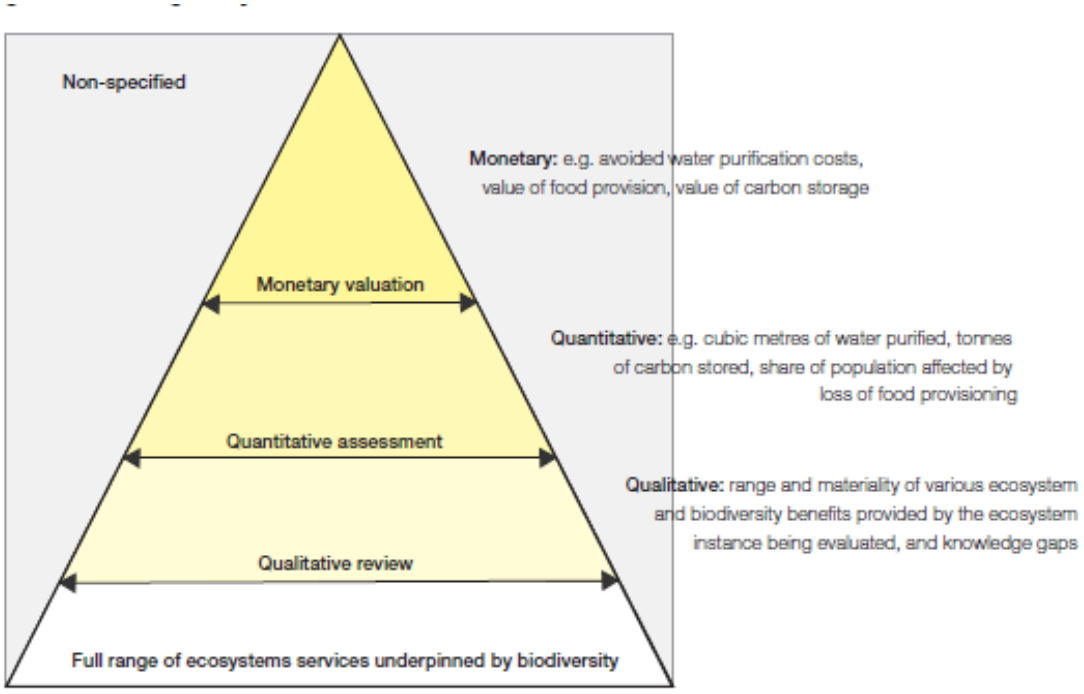

Figure 2.7 Valuing ecosystem services. Source: EC (2008), The economics of ecosystems and biodiversity. Banson Production, Cambridge UK (used with permission).

The EC (2008) developed the framework as shown in Figure 2.8 depicting the linkages between biodiversity and the output of ecosystem services. The EC (2008) emphasizes that the link between ecosystems and economic benefits is subject to lag times and non-linear changes that are caused by complex ecological processes.

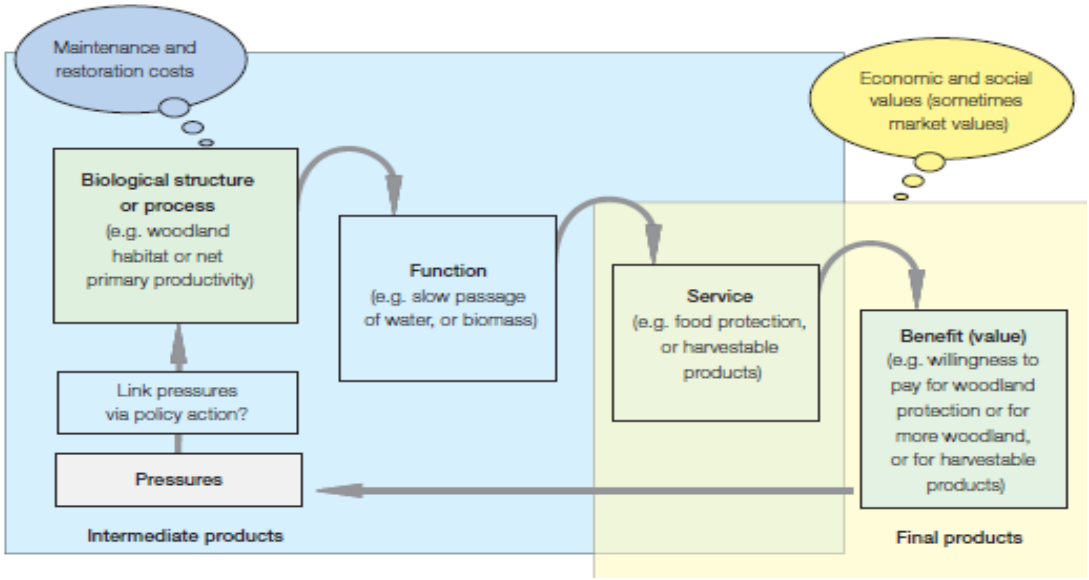

Figure 2.8 The link between biodiversity and the output of ecosystem services. Source: EC (2008), The economics of ecosystems and biodiversity. Banson Production, Cambridge UK (used with permission).

Costanza and Farley (2007) introduce the concept of ecological economics (EE) applied to coastal disasters. The writers define ecological economics as an economic system that seeks to "allocate available resources in a way that equitably and efficiently provides for the sustainable well-being of people by protecting and investing in all four types of capital" (Costanza & Farley, 2007, p. 249). The four types of capital are: built, natural, social and human capital. EE aims to assess not only the 'marketable' aspect of the economy but also the non-marketed aspects. Dale and Farley (2004) explain that ecological economics is different from environmental economics in that the latter's main goal is to pursue efficient allocation, like neoclassical economics, and to a lesser extent taking the limits and distribution of available resources into account.

The NRC (2004) explains that nowadays humans tend to regard the natural environment and the ecosystem of which it is part as natural capital. As dictated by the anthropocentric paradigm, the natural capital is assessed by the value of its services. An ecosystem provides humans with a variety of 'marketable goods'. These values determine the actions of humans with regard to an ecosystem (see Figure 2.9). For assessing the recovery of natural systems this implies that humans will try to (re-) establish these economic values of an ecosystem after a disaster.

BOX 3-1
Understanding Ecosystem Terminology

Ecology is a scientific field that studies the relationships between and among (micro)organisms such as plants, animals, and bacteria and their environment. Like most scientists, ecologists use a variety of terms to describe aspects of their discipline. A few of the terms used throughout this report are defined below in the interest of facilitating the readability and understanding of this report.

Ecosystem biodiversity describes a number and kinds of organisms in a specific geographic area that can be distinguished from other areas by its physical boundaries (e.g., lake, forest), though such boundaries can be somewhat arbitrary. In addition to biodiversity, ecosystems have properties such as the amount of plant and animal matter they produce (***primary and secondary production***) and the flow of chemical elements within and through the system (***nutrient cycling***).

Ecosystem structure refers to both the composition of the ecosystem (i.e., its various parts) and the physical and biological organization defining how those parts are organized. A leopard frog or a marsh plant such as a cattail, for example, would be considered a component of an aquatic ecosystem and hence part of its structure. The relationship between primary and secondary production would also be part of the ecosystem structure, because it reflects the organization of the parts.

Ecosystem function describes a process that takes place in an ecosystem as a result of the interactions of plants, animals, and other (micro)organisms in the ecosystem with each other or their environment and that serves some purpose. Primary production (most notably the generation of plant material) is an example of an ecosystem function. The ***net primary production*** in an ecosystem is determined by the number and kinds of plants present; the amounts of sunlight, nutrients, and water available; and the amount of this productivity used internally by the plants themselves.

Ecosystem structure and function provide various ***goods and services*** to humans that have value: for example, rare species of plants or animals, fish for recreational or commercial use, clean water to swim in or drink. The functioning of ecosystems (interaction of organisms and the physical environment) often provides for services such as water purification, recharge of groundwater, flood control, and various aesthetic qualities such as pristine mountain streams or wilderness areas.

Figure 2.9 Understanding ecosystem terminology. Source: NRC (2004) (used with permission).

2.2.5.2 Case Studies

Wiley et al. (2006) conducted a study for NOAA on the economic impacts of beach closures and changes in water quality for the South of California after some oil spills and sewage spills that were caused by California State agencies in the late nineties. The models developed by them look at the economic

impacts of changes in beach use related to the economic welfare and take into account (1) substitution to other sites and (2) the changes in water quality and other beach attributes. Their study showed that the economic impacts of beach closure and decreased water quality can be expressed in economic terms and that the cost of the losses are vast.

Berke et al. (2008) studied the post-disaster recovery and resilience of the coastal communities in Thailand after the 2004 tsunami. This study looks into the human-ecological dimensions of disaster resilience of the fisheries communities in specific. This study finds that the approaches taken by the different communities to restore the main coastal ecosystems, the mangroves, were very different. Changes that occurred in the linkages between the ecology and the economy were related to changes in the fisheries industry and disaster resilience. The former was forced by equipment losses and changed the economic activities. The increased disaster resilience was pursued by incorporating ecological resilience and development activities into the recovery process (Berke et al., 2008).

The World Bank (2002) studied the economic impacts of climate change and looked at different ecosystems. Their study explains that tourism and fisheries are often the most important economic pillars for coastal communities and that changes in coastal ecosystems will result in severe impacts on the community, its economic strength and social aspects.

Wemple (2011) studied the economic recovery after Hurricane Ike (2008). First, Wemple (2011) makes a distinction between acute and chronic impacts; the latter can take longer to manifest and are more difficult to address. Wemple (2011) explains the fisheries sector is in the latter category. He continues to explain that especially for resource-based, local communities the impacts of losses in the fishery sector can be devastating. This is because not only are the natural resources impacted, but so too are the on-land seafood facilities (Wemple, 2011).

Du et al. (2010) studied what they claim is a new topic in natural disaster research: Marine Disaster Economics. This research studies the economic effects of all marine disasters in 2008 on the Guangdong Province in China. It appears that the economic costs of the marine disasters in 2008 was higher than the annual average of all years until 1989. The disasters have severely impacted the natural environment and the fisheries industry of the province had to endure vast economic losses (154.429 Yuan RMB) (Du et al. 2010) .

2.2.5.3 Diagram for Linking Environmental and Economic Recovery

Based on the literature reviewed in this chapter, the diagram for the linkages between environmental and economic recovery (initially presented in chapter 1, Figure 1.6) can be adjusted. Figure 2.10 shows the diagram for the time period right after the disaster. The four main issues mentioned in the literature reviewed in this chapter are: supply losses for fishermen, decreased accessibility of tourism areas such as beaches, over-use of non-affected areas for both the commercial fishing industry and the tourism sector and finally, perception of contaminated seafood as well as polluted recreational areas. The diagram shows that the last two types of linkages affect both fisheries and tourism. Perception has been located outside the region in the diagram because it appears to be mostly the perception of people outside the area whose perception is not in line with the actual situation, in the case of the Exxon Valdez oil spill local subsistence fishers were also reluctant to trust the safety of the local fish stock. This diagram will be revised in subsequent chapters based on the Hurricane Katrina case study.

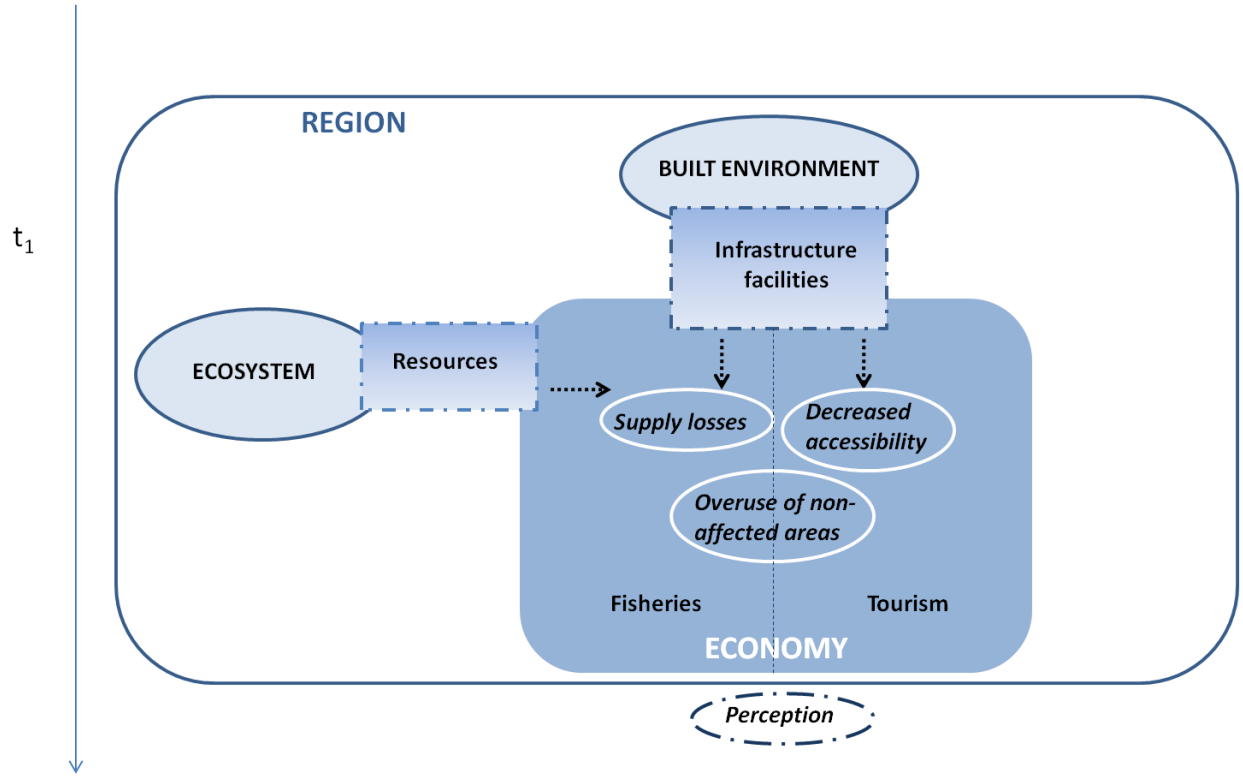

Figure 2.10 Adjusted diagram for linking environmental and economic recovery based on the literature reviewed in this chapter.

2.3 Case Study

To set the stage for the case study that forms the core of this thesis, this section will first provide background information and a detailed community profile of the city of Biloxi and its county, Harrison County in the south of the State of Mississippi. The demographics, economics and physical characteristics of the city will be described as they were both before and after Hurricane Katrina hit the Gulf Coast in August 2005.

2.3.1 Economics

2.3.1.1 General

The City Council writes in its comprehensive plan, published in December 2009, that the strongest economic sectors in Biloxi are the hospitality, government and retail industries. Since the late 1800's, the fishing industry has been of high importance for the city of Biloxi in terms of economic strength and as one of the main providers of employment. The tourism industry has strongly developed since the early nineties. According to the US Census Bureau, the number of establishments (businesses in operation) in 2004, before Hurricane Katrina, was 434, the number of paid employees was 15,294 and the annual payroll was $4.1 million. The largest industry was the professional, scientific and technical services industry with 70 establishments and retail trade was the second largest with 64 establishments.

According to the annual financial report (Biloxi Annual Financial Report, 2008) prepared by the Department of Finance and Administration, the unemployment rate in 2008 was 6.3%. Governmental expenditures were stable before Hurricane Katrina hit the Biloxi coast, as shown in Figure 2-11, and were heavily influenced by Hurricane Katrina in 2005/2006. Figure 2.12 shows stable governmental revenues, mostly coming from gaming and sales taxes, before the hurricane and the impacts of Hurricane Katrina in the first years of the post-disaster recovery.

Twenty months after Katrina, when 98% of the debris had been removed, 78% of the students had returned and the important players in Biloxi's economy (the air force base and the casino industry) were back at pre-disaster levels for both employment numbers as well as revenue; 55% of the Coast Hotels are back in business (most of which are the major hotels). In 2007 a repair and improvement project for the small harbor (an investment of $10 million by the City) started (The City of Biloxi, 2007).

According to the City of Biloxi Comprehensive Plan (2009) the retail sector has returned to pre-disaster levels (from 1,353 retail establishments in 2002 to 1,367 by the end of 2006), however the unemployment rates haven't reached that yet (5.4% in 2004 to 8.9% in 2005) and as the city council writes, this is a sign that the post-Katrina economy is still recovering.

The City Council (2009) states that in the aftermath of Katrina, the hospitality, government and retail sectors have proven to be most resilient. They would like to strengthen the post-disaster economy by diversifying it, with for example expansions of the seafood and shipbuilding industry and secondly by enhancing the local tourism industry.

Another issue for businesses who want to return is the increased insurance costs; this makes it especially difficult for small businesses to return or open a store. However, the City Council considers these issues to be outside its influence. The city's Innovation Centre tries to create employment in cooperation with the major employers and institutions (City of Biloxi Comprehensive Plan, 2009).

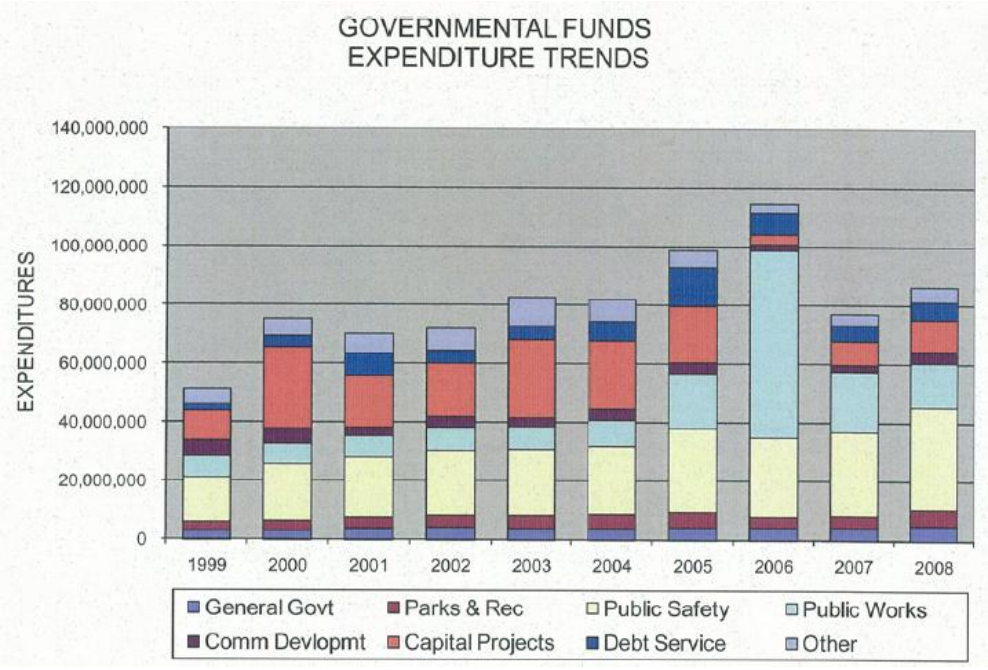

Figure 2.11 Governmental funds expenditure trends for Biloxi, MS, in 1999-2008. Source: http://www.biloxi.ms.us/pdf/cafr08.pdf (used with permission).

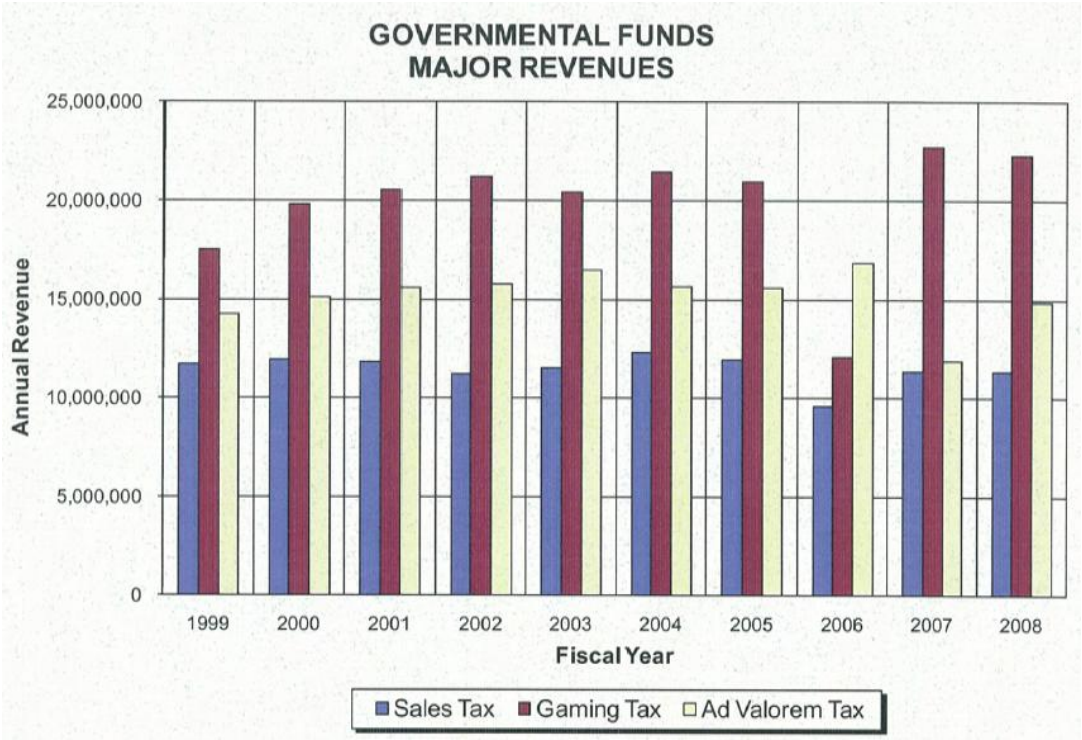

Figure 2.12 Governmental funds major revenues for Biloxi, MS in 2008. Source: http://www.biloxi.ms.us/pdf/cafr08.pdf (used with permission).

2.4 Summarizing Key Findings

This chapter has provided an overview of the most important literature on post-disaster recovery research, focusing on economic and environmental recovery. This literature review is used to answer the first research question of this master thesis and to that end, discussed two main issues. First, theories and frameworks of post-disaster recovery were discussed. Secondly, literature employing different paradigms that influence thinking about environmental recovery were reviewed. This has been used to answer the first research question: what does environmental recovery mean after a natural disaster and how can it be measured?

Measuring environmental recovery can be approached from an anthropocentric or an ecocentric paradigm. It appeared that the anthropocentric paradigm is the prevailing paradigm used in the West for valuing environmental losses. This is therefore the paradigm used in this master's thesis to study the linkages between environmental and economic recovery of the tourism and fisheries sectors. The services provided by an ecosystem can determine the economic value of the benefits derived from ecosystems for the people who use them. The extent to which the local ecosystem can sustain or contribute to the pre-disaster economic sectors depends on the resources provided by the natural environment. The change in economic value of these goods and services provided by natural ecosystems can be measured in two ways: (1) as the willingness to pay of an individual or group to secure the change and (2) as the amount needed to compensate an individual or group for the change.

From the literature discussed it appeared that perception forms an important link between environmental and economic recovery. Other linkages determined by the literature are: supply loses, decreased accessibility and overuse of non-affected areas.

The next chapters will discuss the methods used for the case study and the findings based on the recovery of the city of Biloxi.

3 Methodology and Data Description

This chapter describes and discusses the methods used to gather data for determining the overall economic recovery based on the tourism sector and fishery industries in particular. The data collected for the recovery of the fishery industry will be used to determine the linkages between environmental and economic recovery. First, an introduction to the Biloxi, MS, case study will be provided, describing the city's and the county's background and a brief overview of the impacts of Hurricane Katrina. Next, the quantitative data collection and analysis will be discussed**.** Here, the economic time series collection and analytical approach for the tourism and fishery industries will be described. Thirdly, the qualitative data collection will be discussed. This includes a description of the fieldwork for the case study of Biloxi, MS and an explanation of the approach taken for the expert judgment interviews. Finally, the approach for consolidating the quantitative and qualitative data and analysis will be described.

3.1 Research Methods

3.1.1 Biloxi Case Study

3.1.1.1 Site Selection

The city of Biloxi and Harrison County were chosen by the NSF project as the case study area from a list of cities along the Gulf Coast impacted by Hurricane Katrina based on criteria such as: population count, data availability for the different dimensions of recovery as studied by the NSF Post-Disaster Recovery project, the availability of imagery and VIEWS[6] data, and whether or not the economy was coastal-resources dependent. The NSF Post-Disaster Recovery study uses two case studies: the first case study was the city of Punta Gorda in Charlotte County, Florida. The area was affected by Hurricane Charley in 2004 and has an estimated population of 46,406. For the second fieldwork, on the Mississippi Gulf Coast, the research team chose the city of Biloxi for the following reasons: (1) its population size is similar to the population count of Punta Gorda[7] and the research team preferred the two case studies to be of similar population size for comparison reasons, (2) the impacts of Hurricane Katrina on the area east of New Orleans have been relatively understudied, and (3) it allowed for an incorporation of the effects of the recent BP oil spill.

3.1.1.2 Selection of Economic Sectors

This study uses a case study to exemplify a broader concept: that of linkages between environmental and economic recovery. It uses the tourism as an example of the general economic recovery and the fisheries sector for determining the linkages between environmental and economic recovery. There are several

[6] Visualizing Impacts of Earthquakes with Satellites (VIEWS) is a system developed by ImageCat that `links high-resolution QuickBird imagery, digital photographs and digital video footage to a real-time GPS feed`. This results in detailed maps with street-view imagery and is very useful in comparing pre- and post-disaster built-up environment (www.imagecat.com, retrieved May 2011).

[7] According to the US Census Bureau the city of Biloxi had a population of 45,670 in July 2008. (www.city-data.com, August 12th, 2010)

reasons that justify the choice of these sectors**.** First, there are three primary economic sectors in the City of Biloxi, MS (Person D, personal communications, [October 18th, 2010]):

- Military and universities
- Casinos and other tourism
- Fishing industry

There is no data accessible for the military Kessler Air Force Basis in Biloxi (Person D, personal communications, [October 18th, 2010]) and the military sector is funded by the federal government and therefore less subject to local changes in the economy and the natural environment. For the same reason, universities don´t serve well as a proxy for the general economic recovery of Biloxi. The tourism sector is used to increase understanding of the economic recovery in a broader context and the fisheries industry is used to understand the linkages between environmental and economic recovery. The fishing industry represents the strong ties that exist between the economic viability of the sectors and its dependency on the local coastal environment. This chapter discusses the methodologies used to address the economic recovery and the linkages between the fishery industry and the natural environment.

3.1.2 A Combined Analytical Approach

To examine how economic sectors, such as tourism and fisheries, of a coastal community recover when the local natural environment is damaged by a natural disaster, an interdisciplinary approach is taken, combining qualitative data (e.g. from expert judgment interviews) and quantitative data (e.g. time series data). The interdisciplinary approach is visible through the use of different types of data. This approach is used to get a full understanding of the different processes taking place during the recovery phase and to determine how these different processes influence each other. Some of the analyses of post-disaster recovery developments such as income in the tourism and fisheries sectors only use quantitative data, others such as the measure for diversity explained in section 3.5.1 use a combination of quantitative and qualitative data analysis.

The interdisciplinary approach aims to address the second research question, by combining quantitative time series analysis of economic developments from pre- to post-disaster situations and qualitative data provided by expert judgment interviews indicating their perspective on the timeframe and trajectory of the recovery and the linkages involved. The analyses of the time series data and expert judgment interviews will be based on the guidelines for measuring post-disaster community recovery (Chang et al, 2010). The analyses of the time series data and expert judgment interviews will provide a basis for the combined analysis of the linkages between environmental and economic recovery and how the two economic sectors compare.

This study acknowledges the difficulties and ambiguities raised by the NRC (2004) that arise when trying to pursue a combined assessment of economic and environmental recovery. The approach used for creating a diagram of linkages and framework which explain how environmental recovery relates to economic recovery is therefore derived from both the qualitative and quantitative research. First, there is the quantitative data analysis of the time series data. Subsequently, the qualitative aspects of this study will be discussed; factors that influence the recovery of both the tourism and the fishery sectors are derived from expert judgment interviews. It is not the aim of this study to do a full qualitative

research but to combine the insights gained from the three different studies to explain the recovery linkages. Finally, there is a description of how the Biloxi case study has influenced the diagram.

The aim is to explain the economic recovery of the tourism and fisheries sectors, where the tourism sector is less likely to depend on the natural environment than the fishery industry, as has been described by several of the interviewed experts. Therefore the environment is considered to be an independent variable. Based on the data discussed in this chapter, chapter four will present the last refinements to the linkages diagram.

3.2 Quantitative Data Collection and Analysis

As noted earlier, statistical data are used to track the economic recovery in terms of three related aspects: the trajectory, the timeframe of recovery and the changes in the economy compared to pre-disaster levels

Potential Metrics for Tourism and Fisheries Recovery

Table 3-1provides an overview of metrics that are preferred (primary metrics) and metrics that serve as a proxy in cases where the primary preferred metric is unavailable or data is of insufficient quality. Table 3-1 provides an overview of concepts and metrics of environmental and economic recovery linkages and accompanying sources as identified before the fieldwork. Both the quantitative and the qualitative data collection can be drawn back to the concepts in this table.

Table 3-1Concepts and accompanying metrics for measuring the linkages between environmental and economic recovery.

Concept	Metric(s)	Source
Extent of impacts on tourism industry – visitors	-Number of coastal tourists/visitors* - Number of hotel beds (capacity vs. Occupancy)**	**NOEP, Harrison County Dev. Office**
Extent of impacts on tourism industry -	- Income*, - Employment and/or production of local tourism sector	**NOEP, Harrison County Dev. Office, US Census Bureau**
Extent of impacts on fisheries industry	- Income*, - Employment and/or production of local fisheries sector, - Available fishing equipment, - Aqua-life health	**NOEP, Harrison County Dev. Office, US Census Bureau**
Extent of impacts on ship/marine industry	- Income*, - Employment and/or production of local ship building sector	**NOEP, Harrison County Dev. Office, US Census Bureau**

Notes: *= primary metric; ** = complementary metric

To examine the extent of the recovery of the tourism sector, the following aspects of this sector will be studied: the demand side (e.g. visitors) and the supply side (e.g. hotels, restaurants). For fisheries, a

distinction will be made between on-shore activities (e.g. seafood sales industry and processing plants) and off-shore activities (e.g. shrimp and oyster fishing).

Measuring Environmental Recovery

In this research, environmental recovery is the independent variable and its recovery is measured in terms of natural resources. Table 3-2 shows the metrics derived from relevant literature as discussed in chapter 3 and used in this study to assess the extent of environmental recovery. The two most important aspects that determine environmental recovery are land-use change and environmental quality.

Table 3-2 Concepts and accompanying metrics for measuring environmental recovery.

Concept	Metric(s)	Data Type	**Source**
Land-use change	- Availability of accessible beach area - Availability of accessible park and other recreation areas - Accessibility of the ocean	GIS	**Harrison County Dev. Office**
Environmental quality	- Biodiversity of local environment - Sustainability of local environment - Water and sea-life quality	Qualitative interview data	**Expert Judgment interviews**

3.2.1 Data Criteria

The quantitative data collected for this study have to meet criteria for the temporal and spatial scale, which are described in the sections below. Only when data on a certain metric were very valuable for the study, exceptions for a shorter time scale were made as long as the data set covered the period 2002-2008.

3.2.1.1 Temporal scale

For the quantitative analysis in this study, statistical time series data have been collected for the years 2001-2009 to have a four year range both before and after Hurricane Katrina. It turned out not always to be possible to collect data over the preferred time period, in which case the criteria for taking the data into account were: the availability of proxy indicators and the lesser preferred time range including six sequential years within the range of 2001-2009. Most data series were only available on an annual basis and therefore all analyses have been conducted on this temporal scale.

3.2.1.2 Spatial scale

This study aims to collect and use statistical data for Harrison County as well as the Metropolitan Statistical Area (MSA)[8] of Biloxi (see Figure 1.2 in Chapter 2 for a map of the region). Data for the state of Mississippi will be collected to normalize the MSA and County data for trends that are common at the scale of the State, such as the economic crisis that started in 2008. The aim is to eliminate trends that were not linked to the impacts of Hurricane Katrina and therefore increase the reliability of the data on the linkages between the environmental and economic recovery (Chang, 2010; Chang and De Ruiter, 2011).

3.2.1.3 Sources

Most time series data has been obtained via online databases from the US Census Bureau and US Bureau of Labor Statistics. Other time series data such as Biloxi-MSA lodging data, including data series on annual occupancy and revenues, have been provided by experts contacted during the fieldwork.

Figure 3.3 provides an overview of the collected data and their sources, temporal and annual scales and categories.

Table 3-3 Overview of data used for the quantitative tourism analysis.

QUANTITATIVE TOURISM DATA				
Data	**Description**	**Temporal Scale**	**Spatial Scale**	**Source**
Lodging Operating Performance	No of rooms; revenue, supply, demand	Annual for 2003 -2010	Biloxi-Gulfport MSA and MS State	MS Lodging association
Employment and wages	Food preparation and serving related; personal care and service; sales; management.	Annual for 2001 - 2009	Biloxi-Gulfport MSA and MS State	US Bureau of Labor Statistics
Business sizes	For all 20 industries; e.g. accommodation and food services	Annual for 2001-2008	Biloxi-Gulfport MSA	US Census Bureau

[8] The MSA of Biloxi and Gulfport is defined by the US census Bureau as: Harrison County, Hancock County and Stone County. US Census Bureau defines MSA as "a geographic entity, defined by the Federal OMB for use by Federal statistical agencies, based on the concept of a core area with a large population nucleus, plus adjacent communities having a high degree of economic and social integration with that core. Qualification of an MSA requires the presence of a city with 50,000 or more inhabitants, or the presence of a UA and a total population of at least 100,000 (75,000 in New England). The county or counties containing the largest city and surrounding densely settled territory are central counties of the MSA. Additional outlying counties qualify to be included in the MSA by meeting certain other criteria of metropolitan character, such as a specified minimum population density or percentage of the population that is urban. MSAs in New England are defined in terms of cities and towns, following rules concerning commuting and population density. MSAs were first defined and effective June 30, 1983." Source: http://www.census.gov/geo/lv4help/cengeoglos.html, February 2nd, 2011.

Table 3-4 Overview of data used for the quantitative fisheries analysis.

QUANTITATIVE FISHERIES DATA				
Data	**Description**	**Temporal Scale**	**Spatial Scale**	**Source**
Employment and wages	Farming, fishing and forestry occupations	Annual for 2001–2009, excl. 2003	Biloxi-Gulfport MSA and MS State	US Bureau of Labor Statistics
Shrimp licenses sold	Residents, non-residents, commercial and recreational	Annual for 2000-2010	Mississippi state	MS Department of Marine Resources
Crab Licenses sold	Residents, non-residents, commercial and recreational	Annual for 1993-2010	Mississippi state	MS Department of Marine Resources
Crab Landings and Values	Weight in pounds and values in dollars	Annual for 1992-2010	Mississippi state	MS Department of Marine Resources
Shrimp Landings and Values	Weight in pounds and values in dollars	Annual for 1992-2010	Mississippi state	MS Department of Marine Resources
Business sizes	For all 20 industries; e.g. fisheries and agriculture	Annual for 2001-2008	Biloxi-Gulfport MSA	US Census Bureau

3.2.2 Analyzing Economic Recovery

The recovery of the economy of Biloxi after Hurricane Katrina is described using the following dimensions of economic recovery: (1) the trajectory, (2) the timeframe of recovery and (3) the changes from pre to post-disaster levels for the tourism sector. The changes in the economy will study (i) economic strength, (ii) economic diversity and (iii) disaster readiness (Chang and De Ruiter, 2011).

The time series data analysis is the main source of the quantitative data analyses and focuses on economic data of the tourism sector (e.g. number of hotel beds; capacity vs. occupancy of hotels) and is used to, first, determine the economic recovery of this sector and secondly to provide a comparison with the economic recovery of the more resource-dependent fishery industry. The measure for change in diversity uses both quantitative and qualitative data and will be fully explained in section 3.5.

3.2.2.1 Three Dimensions of Economic Recovery

The *trajectory* of the economic recovery of tourism and fisheries uses time series data to create a time-path of the post-disaster recovery. The statistical data used for assessing the trajectory for the period 2001 – 2009 will be expressed in percentages. The types of data that have been used will be described in

section 4.2.2.2 for tourism and 4.2.2.3 for fisheries. The *timeframe* of recovery is assessed in terms of when the economy has reached a new stable level, and how long this took. The *change* in economic strength uses a combination of the trajectory of the economic recovery and the assessments by the experts interviewed. The change in economic diversity studies the changes in number of industries in an economy, changes in number of businesses per industry and changes in business sizes per industry and uses time series data and expert judgments. The change in disaster readiness, the implementation of mitigation efforts during the recovery phase, is solely based on expert judgments.

3.2.2.2 Data for Tourism Sector

Economic recovery of the tourism sector is analyzed using data on lodging occupancy, employment and wages. The analysis of lodging occupancies uses data for Biloxi-Gulfport MSA and the state of Mississippi and is available for 2004 to 2010[9]. The analysis is conducted for annual room occupancy, annual room occupancy change rate and annual change rates in annual revenue, supply and demand and focuses on the changes from pre-disaster levels to post-disaster levels. Occupational employment and wages data are available from the Bureau of Labor Statistics and were obtained for the period 2001-2009.

3.2.2.3 Data for Fisheries Sector

Economic recovery of the fisheries sector is analyzed using data on fishery licenses and landings, provided by the Mississippi Marine Department of Resources. Licenses and landing data (value in pounds and dollars) for shrimp and crab are available on an annual basis for the period 2001-2009. Fisheries-related occupancy, employment and wages data have been derived from the Bureau of Labor Statistics and were obtained for the period 2001-2009.

3.2.3 Measure for Change in Economic Diversity

This study will also look at the composition of the local economy: how the dominance of certain industries changes from the pre to the post-disaster situation. Here, the extent of dominance of an industry is measured by looking separately at the ratio of the number of establishments and the number of employees in an industry in contrast to the aggregated diversity measure. The data used for this analysis are derived from the US Census Bureau zipcode data for the area of the MSA of Biloxi-Gulfport. The changes in pre- and post-disaster composition will be measured by comparing the years 2004 (baseline) and 2008. The data are available for six business-size categories and twenty industry-sectors.

3.3 Qualitative Data Collection and Analysis

The expert judgment interviews will be used to supplement the time series data as well as to provide background information to interpret the time series data. In addition, the interviews will also briefly discuss the environmental recovery and the implications for the coastal-reliant industries after the 2010 BP oil spill in the Gulf of Mexico. As explained in section 4.2, the trajectory and timeframe of the economic recovery and the change in economic strength, diversity and readiness all partly or fully use data provided by the experts.

[9] For the US, the global research consultancy Smith Travel Research (STR) collects data from lodging companies in the US. Their aim is to collect as much data as possible, however it should be noted that the average annual participation rate for the time period 2004-2010 in the Biloxi-Gulfport MSA is 49.78%.

This section will first outline the expert judgment interviews. Next, the collection of qualitative data will be discussed; part of this is the layout of the interviews.

3.3.1 Information Collection

The main sources for pre-fieldwork information on the area, for both identifying experts and for a community profile including quantitative data, were derived from disaster related offices, such as the Mississippi State Disaster Recovery Division; planning and (economic) development departments such as the Mississippi Gulf Coast Alliance for Economic Development and the Southern Mississippi Planning and Development District; environmental protection and development offices such as the Mississippi Department of Marine Resources and Mississippi Department of Environmental Quality.

3.3.2 Expert Judgment Interviews

An important part of this study is the data obtained through expert judgment interviews. Meyer and Booker (2001) define expert judgment as 'information and data given by qualified individual' that contribute to the researcher's study, often in addition to other types of data. The expert judgment information and data are often used to validate information and data obtained from other sources. Risk related research in quantitative fields of study is increasingly using information and data from expert judgments to create a better understanding of the quantitative data collected. In this research, the objective of the use of experts' judgments is similar: it is used to (1) increase understanding and interpretation of the quantitative data and data analysis, (2) when other sources of data are scarce or non-existent and (3) to fill in gaps that can't be addressed or that became visible through the quantitative data research (Meyer and Booker, 2001; Speirs-Bridge et al, 2010). Expert judgment interviews can take place in an informal or formal manner. This study will explain the methods used for eliciting and analyzing the expert judgment interviews and is therefore considered to be formal (Meyer and Booker, 2001).

3.3.2.1 Expert Elicitation

First, Meyer and Booker (2001) explain that the recruitment of experts for the expert judgment interviews is subject to a number of requirements. The expert needs to be recognized, for example by his or her peers, as an expert and needs to have sufficient qualifications and background knowledge on the topic. Rosqvist (2003) describes the different experts and their specific roles in a risk-related setting which are shown in Table 3-5. The experts interviewed for this research are decision-makers (e.g. City of Biloxi Administration Office Director), domain experts (e.g. Mississippi Department of Marine Resources representative) and stakeholders (e.g. processing plant directors and local fishermen). The most relevant factors for this research that influence the expert's elicitation are described by Meyer and Booker (2001) as follows: based on the type of information that is sought, the methodological preferences of the data collectors and the amount of time and study the experts will need to provide answers. Taking these factors into account, the experts interviewed for this study had to be in Biloxi and its close surroundings during the fieldwork and available for an hour-long interview. Furthermore, they were identified in advance as being capable in their profession of providing information and data necessary to address quantitative data gaps. More details on the experts elicited for this study are provided in section 3.5.

Table 3-5 Generic roles of experts in risk assessment. Based on: Rosqvist (2003), p. 14.

ROLE	BASIC FUNCTION
1. Decision Maker	Presents the strategic view, presents the status of the decision-makers process, and the objective of the outcome of the group decision.
	Responsible for the decision based on risk management.
	Identifies and selects the stakeholders.
	Defines the resources needed in the process.
	Provides the decision criteria.
2. Referendary	Selects the experts.
	Describe the case.
	Comments on the formats of the experts' judgments.
	Takes part in the discussion.
	Asks the opinion of the stakeholders on the quality of the results: has something been neglected.
	Accepts the summary report.
	Explains the content and the conclusions of the risk assessment to the decision-maker.
3. Normative Expert	Expert in expert judgment methods.
	Responsible for expert training, elicitation of judgments, and combination of judgments in the case of quantitative judgments.
	Responsible for the elicitation of the stakeholders' preferences and the development of utility functions.
	Responsible for reporting.
	Draws conclusions based on the decision criteria.
4. Domain Experts	Familiar with the issue.
	Responsible for the analysis of the issue and giving judgments (qualitative / quantitative) on it.
5. Stakeholders	Affected by the decision.
	Give feedback during the risk assessment process.
	Affirm the scope and completeness of issues.

One of the main issues discussed in the expert judgment interview literature is that of bias and uncertainty (Meyer and Booker, 2001; Speirs-Bridg et al, 2010). Tversky and Kahneman (1974) wrote a foundational paper on the topic of judgment biases and uncertainties. The authors explain that biases will occur even if it's emphasized towards the expert that accuracy is encouraged. A sound way of undermining the biases of an expert doesn't exist according to Tversky and Kahneman (1974). Meyer and Booker (2001) explain that cross-validation and sample size can minimize uncertainties. This study addresses both factors: the interviews are done together with time series data analysis and are intended to validate one another; also, the experts interviewed have slightly overlapping professional fields. Meyer and Booker (2001) also explain that it is not necessarily very insightful to ask the experts to estimate the uncertainty of their answers.

The analysis of the information and data obtained through expert judgment interviews will be used in combination with quantitative data. Meyer and Booker (2001) explain that from expert judgment interviews, general and statistical inferences can be drawn. However, the number of interviewees is not sufficient to undertake a statistical analysis or draw quantitative inferences.

It is ambiguous to draw conclusions on a population based on an assessment by an expert who might be biased. General inference can be made through the assumption that the expert's assessment is

based on knowledge of current affairs. It should be noted that this doesn't necessarily portray the truth but it does give an idea of the current existing knowledge.

In this study, part of the interview questions[10] used descriptive ranking techniques which allows for an easier comparison among the different interviews and secondly, for integration of the outcomes of the interviews with the outcomes of the quantitative data analysis (Meyer and Booker, 2001; Keeney and Gregory, 2005). The way in which an expert arrives at a certain answer is captured in this study. For example, experts will be asked whether they think the community has recovered and secondly what milestones they used for coming at that answer. This second part of the question aims to gain insights into the mental procedure of data as described by Meyer and Booker (2001). Meyer and Booker (2001) discuss two important characteristics of the obtained data set from the expert judgment interviews that are important during the analysis phase: granularity and conditionality. The former refers to 'the level of detail defined or chosen for the data, the analysis and the conclusion' (Meyer and Brooker, 2001, p. 236). The writers advise to establish a level of desired detail before conducting the interviews. In this study the spatial scale is defined as Harrison County and the City of Biloxi and the temporal scale is the time range of 5 years before and 5 years after Hurricane Katrina. Also, data on the local tourism and fishery industry are sought at an aggregate level rather than an individual level. Conditionality relates to 'the inescapable fact that all the elicited data is conditioned on many other factors' (Meyer and Brooker, 2001, p. 236). The writers argue that in order to prevent coming to the wrong conclusions because of unclear structuring of both the answer data and the analysis, it is advisable to make clear how the interview structure influences the interview answers. The scales used in the interview questions allow for an easy transition to quantifying the data.

3.3.2.2 Expert Judgment Interview Scales

The data obtained from the expert judgment interviews in this study will be expressed in quantitative form (e.g., rankings) as well as qualitative form (e.g., textual descriptions of situations). A 7-point scale, based on a 7 point Likert-scale, has been chosen for the economic and environmental recovery assessment at different points in time based on recent literature that discusses constructed scales for expert judgment interviews. Keeney and Gregory (2005) explain that this approach minimizes ambiguity. They continue that the different levels of the scale need to be defined clearly and the scale needs to cover all possible outcomes of the measured objective (here: "how would you rate the economic/environmental recovery") (Keeney and Gregory, 2005). Furthermore, Miller (1956) explains that people have trouble considering more than seven things at once and states that scales used in interviews best not contain more than 7 different levels. He also explains that most accurate output is derived when the expert can compare one state with another. The scale for economic recovery runs from 'none' to 'full' recovery and describes the conditions of each of the different levels as shown in Table 3-6. Having established this, it should be noted that the expert judgment interviews were intended to supplement the statistical data and were not gathered with the intent to provide a fully comprehensive qualitative case study.

[10] The interview questions used for the expert judgment interviews in the Biloxi field deployment have been developed by all members of the NSF Measuring Post-Disaster Recovery Project team.

Table 3-6 Scale for economic recovery. Adapted from 'Guide for measuring economic recovery', Chang and de Ruiter (2011).

	Level of Recovery	Description of Local Economic Conditions[1]
I	None	Very few businesses open, almost no economic production[2] (<5%).
II	Minimal	Some businesses open, little economic production (5~25%), some people back at jobs, total income very low (5~25%).
III	Poor	Many businesses open, low economic production (25~50%), many people back at jobs, total income low (25~50%).
IV	Moderate	Most businesses open, some economic production (50~75%), most people back at jobs, total income moderate (50~75%).
V	Good	Most businesses open, economic production almost normal (75~95%), most people back at jobs, total income almost normal (75~95%).
VI	Almost full	For the most part: businesses open, economic production normal (>95%), people back at jobs, total income normal (>95%). But: some geographic areas doing well while several others struggling; some sectors (e.g., construction) doing well while several others struggling; job situation has some instability (e.g., high unemployment, high percentage part-time or short-term compared to pre-disaster).
VII	Full	Overall: businesses open, economic production normal (>95%), people back at jobs, total income normal (>95%). Almost all geographic areas and sectors doing as well as pre-disaster. Job situation stable.

Notes: (1) Percentages relative to pre-disaster. "Local" refers to the study community, such as a town, city, county, or equivalent.
(2) Economic output or sales.

3.3.3 Qualitative Data Collection

As described in section 4.3.1, expert judgment interviews were conducted to collect qualitative data on economic and environmental recovery and the linkages between both recovery processes in general (see Figure 3.1) and for the local tourism and fisheries sectors in specific (see Figure 3.1) to complement the quantitative time series data.

Expert judgment interview questions determining the linkages between environmental and economic recovery

1. Linking environmental and economic recovery
    a. How would you describe the dependence of the community of Biloxi (or Harrison County) on the local natural environment (e.g. for subsistence, local recreation, tourism)?
    b. Which local economic sectors and industries are strongly dependent on the local coastal environment?
    c. How would you rank and describe these dependencies?

2. How was environmental recovery influenced by economic recovery after Hurricane Katrina (and vice versa)?

3. I would like to determine the extent of the dependency of the recovery of the economic sectors such as tourism, fisheries and aquaculture on the recovery of the local natural environment.
    a. How did Hurricane Katrina influence the dependency of the local economy on the local natural environment?
    b. If changes in this dependency have taken place during the recovery period, what explains these changes?

4. How has the tourism sector been influenced by Hurricane Katrina in relation to the recovery after Hurricane Katrina?

5. Did some types of businesses do much better, or especially worse, than others in the recovery after Hurricane Katrina? What do you think explains these differences in recovery?

6. This question aims to determine the current conditions of the local tourism, fisheries and aquaculture sectors of the recent oil spill in the Gulf of Mexico?
    a. How would you describe the current conditions of the local tourism, fisheries and aquaculture sectors compared to the recent pre-oil spill disaster situation?
    b. How would you describe the impacts of the recent oil spill on the local environment?
    c. Are there any signs/actions of recovery?

Figure 3.1 Expert judgment interview questions determining the linkages between environmental and economic recovery

We are interested in understanding economic conditions in [community] before and in the years after [disaster].

1. First, please tell us how familiar you are with the local economy…

    a. …**before** the [disaster] (very familiar, somewhat familiar, or slightly familiar)?

    b. …**after** the [disaster] (very familiar, somewhat familiar, or slightly familiar)?

    We would like to get your expert judgment on economic conditions at different points in time. This will help us to interpret and contextualize the statistical data we have on the economy. Please consider the following scale of I~VII, where I= "none" and VII= "full" recovery (Table 1).

    2. On this scale, how would you rate the **economy recovery of [community]** at each of the following points in time:

    a. Immediately after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

    b. 3 months after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

    c. 1 year after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

    d. 2 years after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

    e. 3 years after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

    f. 4 years after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

    g. 5 years after the [disaster] ([month/year])? (I…II…III…IV…V…VI…VII)

3. At about what point in time would you say the economy of [community] had recovered to a new, post-disaster "normal" situation? (prompts: month/year OR not yet stabilized OR don't know)

    a. Why do you say that? (prompts: milestone events, sense of moving forward)

4. Please consider the degree to which the "new normal" economy differs from the pre-disaster economy. Consider first the **strength** of the local economy. Please refer to the following scale of -3~+3, where -3= "major negative change" and +3= "major positive change" (Table 2). On this scale, to what degree has the strength of the economy changed? [-3…-2…-1…0…+1…+2…+3] Why do you say that?

5. Consider now the **diversity** of the local economy. Please refer to the following scale of -3~+3, where -3= "major negative change" and +3= "major positive change" (Table 3). On this scale, to what degree has the diversity of the economy changed?
   [-3…-2…-1…0…+1…+2…+3] Why do you say that?

6. Please consider now the **disaster readiness** of the local economy. Please refer to the following scale of -3~+3, where -3= "major negative change" and +3= "major positive change" (Table 4). On this scale, to what degree has the disaster readiness of the economy changed? [-3…-2…-1…0…+1…+2…+3] Why do you say that?

Figure 3.2 Expert judgment interview questions determining economic recovery. (Tables 1-4 in this interview script refer to tables 3.6, 3.8, 3.9 and 3.10, respectively, in this thesis).

3.3.3.1 Expert Recruitment

A cross-section of experts was selected to provide qualitative data and background information on the environmental and economic recovery of the area and on the linkages between them. In this context, 'expert' primarily means 'practitioner' (e.g. staff of local government offices). The practitioners selected for the expert judgment interviews were categorized based on their professional role: mainly environmental, mainly economic and professionals who work at the intersection of the two. A list of 44

experts was developed classified based on their importance for this research: priorities (high, medium and low) were assigned after which 25 experts with higher priority first were contacted by e-mail to inquire into their interest in participating in the research. The e-mail explained the goal of the NSF post-disaster recovery project, explained potential data requests (e.g. economic statistical data and GIS data of the local area) and outlined the importance of their input for the study.

Table 3-7 shows the professional affiliations of experts who were interviewed during the fieldwork. Fieldwork was conducted during the week of October the 18th, 2010, as part of a field visit with other research team members from the NSF Post-Disaster Recovery project to the Mississippi Gulf Coast[11]. The focus for this thesis lay on interviews with practitioners in environmental and/or economic related professions. The reason for collecting this qualitative data was twofold: first, to gain insights into the impacts of the Hurricane and the oil spill on the local economy and environment and second, to find out how the experts assess the linkages between the economic and environmental recovery, focusing on the tourism and fisheries sectors. First, this section will discuss the criteria for selecting Biloxi, MS as a case study area for this research. Next the information collection is described and finally the process of selecting experts for the expert judgment interviews and the interviews conducted is described. During the fieldtrip 13 interviews were conducted: 5 of these were economic focused, 6 environmental and 2 other. Of those, 5 interviewees were also presented with the linkages questions. Two of the experts, who were considered to be highly important for the study but were unavailable during the field trip, were interviewed by phone during the month after the field trip to Biloxi. The low participation rate could be explained by a tiredness of being subject of research and fear for negative perception that would decrease the demand for local fish and tourism. Finally, attempts were made to talk to both seafood processing plant directors and local fishermen. However, both parties were unwilling to cooperate. The main reason for this appeared to be the negative publicity that they have thus far received: both claim that the image that has been put out by media is one that gives a negative image of mainly the safety of the fish caught by the local fishing industry and this has decreased the sales significantly.

To maintain confidentiality, as indicated in the Ethics Review application that was approved for this study, the interviewees are not referred to by name in this thesis. Instead, they are coded as interviewees A through M, as indicated in Table 3-7.

[11] The team fieldwork had multiple purposes: a number of expert judgment interviews with local professionals in economic, environmental and planning related offices were conducted; VIEWS data in the coastal area of Harrison County were collected and finally the research team collected data by observation and from local offices that played a role in the post-disaster recovery process or data collection.

Table 3-7 Interviews conducted in Biloxi or after the field deployment by category.

EXPERT	OFFICE	INTERVIEW CATEGORY			
		Economic	Environmental	Linkages	Other
PERSON A	Gulf Coast Tourism and Convention Centre*	X			
PERSON B	Mississippi Hotel and Lodging Association+	X		X	
PERSON C	City of Biloxi – Community Development Office*	X			
PERSON D	City of Biloxi – Administration Office*	X			
PERSON E	Gulf Regional Planning Office*	X		X	
PERSON F	City of Biloxi – Port Office*		X	X	
PERSON G	City of Biloxi – Public Works*		X	X	
PERSON H	Coastal Environmental Inc.*		X	X	
PERSON I	Mississippi Department for Environmental Quality		X	X	
PERSON I	Mississippi Department for Environmental Quality – Beach Monitoring		X		
PERSON J	Mississippi Department of Marine Resources*		X	X	
PERSON K	Harrison County Zoning Commission*				X
PERSON L	Gulf States Marine Fisheries Commission+		X		
PERSON M	Harrison County Information Technology GIS				X

Notes: * Interviews conducted by me and one of my colleagues from the NSF project team.
+ Interviews conducted by me by phone after the fieldwork.
Unmarked interviews have been conducted during the fieldwork by my colleagues.

Table 3-7 shows, ten interviews were conducted specifically for this thesis research. This section provides a brief background on each of the offices and institutes selected for the expert judgment interviews.

Gulf Coast Tourism and Convention
The Gulf Coast Tourism and Convention Center promotes all types of recreational activities in the Mississippi Gulf Coast. They are located in the recently built Coliseum in Biloxi (www. gulfcoastorg.mobi).

Mississippi Hotel and Lodging Association
The Mississippi Hotel and Lodging Association is a non-profit organization that promotes and represents the lodging industry in the state of Mississippi. The organization represents about 350 members and over 50,000 rooms. (www.mshla.com/).

City of Biloxi´s Community Development Office
The City of Biloxi´s Community Development Office is responsible for the city's development and aims to stimulate its growth. The office was also in charge of the redevelopment of the 6,000 lots of houses and businesses that were destroyed by Hurricane Katrina (www.biloxi.ms.us/communitydevelopment/).

City of Biloxi´s Port Office
The City of Biloxi´s Port Office oversees all commercial and residential ports in Biloxi and stays in close contacts with the local fisherman and employees of the processing plants (F. Person F, interview October 20th, 2010).

City of Biloxi´s Public Works Office
The City of Biloxi´s Public Works Office is responsible for maintaining and improving all infrastructure, sewage systems and city buildings and equipment. (www.biloxi.ms.us/publicworks).

City of Biloxi´s Administration Office
The City of Biloxi´s Administration Office responsibility includes overseeing large capital projects and regular operations of the city's government (www.biloxi.ms.us/administration/).

Gulf Regional Planning Office
The Gulf Regional Planning Office is the only regional planning commission for the Mississippi Gulf Coast serving governmental bodies in Hancock, Harrison and Jackson Counties (www.grpc.com).

Coastal Environmental Incorporated
The Coastal Environmental Incorporated is a research institute located in New Orleans and in the city of Biloxi. The organization focuses on planning and development of cultural and natural resources from an interdisciplinary perspective (www.coastalenv.com).

Harrison County Zoning Commission
The Harrison County Zoning Commission oversees the regulations as they are written down in the Zoning Ordinance. (http://co.harrison.ms.us/departments/zoning/).

Mississippi Department of Marine Resources

The Mississippi Department of Marine Resources represents the following sectors for the state of Mississippi: commercial seafood processors, non-profit environmental organizations, charter boat operators, recreational fishermen and commercial fishermen. Among other things, they are responsible for the provision of fishing licenses (www.dmr.state.ms.us/).

Gulf States Marine Fisheries Commission

The Gulf States Marine Fisheries Commission is a multi-state agency that is recognized via Congress and state charters for its role in facilitating Gulf-wide marine management decisions. The commission act as a pass through agency in the administration of federal funds that aid in the management of the marine resources of the Gulf of Mexico including the assimilation and dissemination of scientific data collected in and from commercial and recreational fishermen in the Gulf (Person M, personal communications, [October 23rd, 2010]).

3.3.3.2 The Interview's Lay-Out

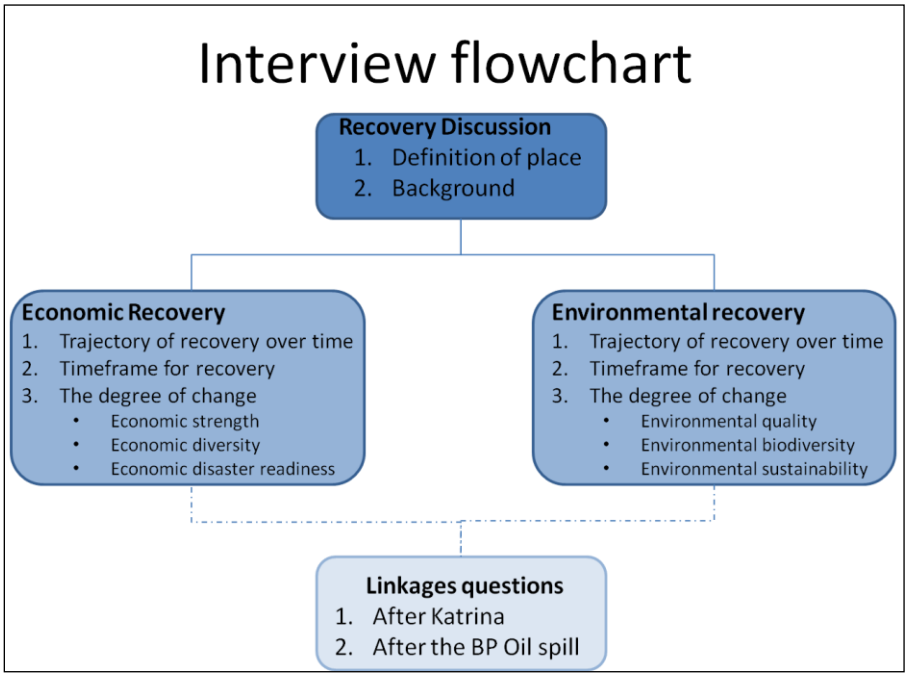

Figure 3.3 Flowchart of the different components of the expert judgment interviews.

The one-hour expert judgment interviews focused on three concepts: environmental recovery, economic recovery and the linkages between environmental and economic recovery. Respondents were asked to answer questions about the recovery as they perceived it in their role as a professional for either the city of Biloxi, Harrison County or the Mississippi Gulf Coast, depending on the spatial scale of their work. Based on their role as a professional, the interviewee was either asked the economic or the

environmental list of questions. Experts whose background consisted of a combination of the different disciplines were asked the linkages questions in addition to the recovery questions.

The flowchart in Figure 3.3 shows the layout of the expert judgment interviews. The first part of the interview aimed to gain a general understanding of the interviewee and his/her relationship with the Biloxi area in his/her professional background and discusses the expert's general ideas on the community's recovery. Furthermore, the spatial scale on which the interviewee bases his/her answers (i.e. the city of Biloxi, Harrison County, or the Mississippi Gulf Coast) is determined. This approach was chosen for two reasons: to ensure that the interviewee has a spatial framework for his/her answers that correlates with his/her professional spatial framework, and for the researchers to make a meaningful comparison across the interviews.

The second part of the interviews, referring to either the economic or environmental recovery, aimed to collect qualitative data from practitioners' judgments on the recovery process in his or her discipline: providing data on the trajectory and timeframe of recovery. Finally, this part aimed to collect data on the extent of changes in local economy or environment from the practitioner's point of view. For practitioners classified as environmentally focused (see table 3-7 for classifications) this led to a collection of the extent of change of (1) environmental quality, (2) environmental biodiversity and (3) environmental sustainability data at pre-disaster levels (2004) and at the level that they recognized as a 'return to normalcy'. For qualitative data on the economic recovery, obtained from the experts classified as economic, the extent of change in (1) economic strength, (2) economic diversity and (3) economic disaster readiness were considered at pre- and post-disaster levels (see Table 3-8, Table 3-9 and Table 3-10). In the last question of this section, each interviewee was asked in an open-ended question to compare the effects of the BP Deepwater Horizon oil spill (April 2010) with the effects of Hurricane Katrina. Unlike most questions in this part of the interview, an open-ended question has been used to prevent researcher-bias, since the BP Deepwater Horizon Oil Spill was very recent at the time of this research and possible linkages between the recovery of Hurricane Katrina and the oil spill were difficult to determine prior to the interviews.

In the third part of the interviews, the focus was on collecting insights into how the experts perceive linkages between environmental and economic recovery in general and for the tourism and fisheries sectors in specific. The interviewees were asked directly to name linkages but also to explain the extent of the linkages and clarify if and how differences in pre- and post-disaster linkages changed.

Table 3-8 Scale for economic strength. Adapted from 'Guide for measuring economic recovery', Chang and de Ruiter (2011).

Scale	Change
- 3	**Major negative change compared to pre-disaster** (>50% decline). Decline in economic strength severe and pervasive. Substantial decline in number of jobs, many businesses failed, many businesses in much poorer financial health, local economy much less competitive.
- 2	**Some negative change** (25~50% decline). Decline in economic strength severe in some geographic areas or sectors.
- 1	**Minor negative change** (5~25% decline). Some decline in economic strength, but not severe.
0	**Essentially no change** (-5~+5%).
+1	**Minor positive change** (5~25% improvement). Some improvement in economic strength.
+2	**Some positive change** (25~50% improvement). Improvement in economic strength substantial in some geographic areas or sectors.
+3	**Major positive change** (>50% improvement). Improvement in economic strength substantial and pervasive. Substantial increase in number of jobs, businesses thriving, many businesses in much better financial health, local economy much more competitive.

Table 3-9 Scale for economic diversity. Adapted from 'Guide for measuring economic recovery', Chang and de Ruiter (2011).

Scale	Change
- 3	**Major negative change compared to pre-disaster** (>50% decline). Economy became much less diverse. Recovery very uneven across sectors, business types, business size, occupations, etc. Dominant businesses and sectors became much more dominant.
- 2	**Some negative change** (25~50% decline). Economy somewhat less diverse. Recovery somewhat uneven.
- 1	**Minor negative change** (5~25% decline). Economy slightly less diverse. Recovery slightly uneven.
0	**Essentially no change** (-5~+5%).
+1	**Minor positive change** (5~25% improvement). Economy slightly more diverse.
+2	**Some positive change** (25~50% improvement). Economy somewhat more diverse.
+3	**Major positive change** (>50% improvement). Economy much more diverse. Many new businesses, new types of businesses, new types of jobs, businesses competitive in new economic niches.

Table 3-10 Scale for economic disaster readiness. Adapted from 'Guide for measuring economic recovery', Chang and de Ruiter (2011).

Scale	Change
- 3	**Major negative change compared to pre-disaster** (>50% decline). Decline in disaster readiness severe and pervasive. Businesses less aware of hazards, have much less insurance, are undertaking many fewer activities to reduce their risk and prepare for disasters (training personnel, planning for contingencies, strengthening their buildings, taking other protective actions for property and personnel).
- 2	**Some negative change** (25~50% decline). Some decline in disaster readiness of businesses.
- 1	**Minor negative change** (5~25% decline). Slight decline in disaster readiness of businesses.
0	**Essentially no change** (-5~+5%).
+1	**Minor positive change** (5~25% improvement). Slight improvement in disaster readiness of businesses.
+2	**Some positive change** (25~50% improvement). Some improvement in disaster readiness of businesses.
+3	**Major positive change** (>50% improvement). Much improvement in disaster readiness. Businesses much more aware of hazards, have much more insurance, are undertaking many more activities to reduce their risk and prepare for disasters.

3.4 Analytical Approach

The analytical approach taken in this study for assessing recovery is three-fold. The recovery will be assessed in terms of the trajectory, the time of recovery and the three dimensions of change. This section will introduce the analytical approach for each of these three different recovery assessments and will include the integration of quantitative and qualitative data. As pointed out by the NRC (2004), studying the linkages between humans systems and their environment require an integrated approach of valuing both economic and environmental features.

3.4.1 Economic Recovery Trajectory

Analysis of the trajectory of the economic recovery of tourism and fisheries combines statistical data and expert judgment data as explained in Table 3-11. The expert judgment data is derived from the average expert assessment in question 2 in Figure 3.1 and using the recovery scales as shown in Table 3-6. Chang and De Ruiter (2011) describe that when discrepancies occur in recovery levels as portrayed by the different data sources, the recovery level that is supported by the most evidence should be used and statistical data on wages should be assigned the highest weight.

Table 3-11 Consolidation scale for economic recovery timeframe. Adapted from 'Guide for measuring economic recovery', Chang and de Ruiter (2011).

Data / Scale	*Expert data*	*Statistical data*		
	Level of Recovery	**Income**	**Employment (jobs)**	**Production**
I	None	<5% overall	0~25% overall	<5% overall
II	Minimal	5~25% overall	5~50% overall	5~25% overall
III	Poor	25~50% overall	25~75% overall	25~50% overall
IV	Moderate	50~75% overall	50~95% overall	50~75% overall
V	Good	75~95% overall	>75% overall	75~95% overall
VI	Almost full	>95% overall, notable geographic and/or sectoral disparities[4,5]	>95% jobs overall, notable geographic and/or sectoral disparities[4,5], and/or unstable[6]	>95% overall, notable geographic and/or sectoral disparities[4,5]
VII	Full	>95% overall, few disparities	>95% overall, few disparities, stable	>95% overall, few disparities

3.4.2 Timeframe of Economic Recovery

The timeframe of recovery is established as the average of the timeframe for income to stabilize, and the mean of the experts' judgments. The data used is normalized for spatial and seasonal effects using data at the level of the state of Mississippi. The pre-disaster data is used to establish the normal range of variability and post-disaster stabilization is reached when the variability returns to the pre-disaster range of variability (see Chang (2010)).

3.4.3 Changes in the Economy

The scale for change in economic strength and economic diversity use both quantitative and qualitative data. This section presents how these different types of data are combined.

3.4.3.1 Change in Economic Strength

The change in economic strength uses the data obtained from the economic trajectory scale and the data obtained from the expert judgment interviews about the strength of the economy as shown in Table 3-12.

Table 3-12 Consolidation scale for change in economic strength. Adapted from 'Guide for measuring economic recovery', Chang and de Ruiter (2011).

Change in Economic Strength (D_s)		Economic Recovery Level	Mean (μ_s) of Expert Judgment Ratings*
-3	(Major negative change)	I, II, or III	$\mu_s<0$
-2	(Some negative change)	IV	$\mu_s<0$
-1	(Minor negative change)	V	$\mu_s<0$
0	(Essentially no change)	VI	$\mu_s=0$
+1	(Minor positive change)	VII	$0<\mu_s\leq1$
+2	(Some positive change)	VII	$1<\mu_s\leq2$
+3	(Major positive change)	VII	$2<\mu_s\leq3$

*Notes: Each separate expert rating is a value between -3 and 3 as shown in Tables 3-8 - 3-10.

3.4.3.2 Change in Economic Diversity

This measure of change in economic diversity[12] has been developed for this thesis to measure the change in how diverse a local economy is in terms of different business sectors and their size measured in number of business per size category[13]. It is important to measure the change in economic diversity because different economic sectors recover differently after a disaster, and the overall composition and diversity of the economy can change during the recovery. To assess the change in diversity a combination of expert judgments and time series data analysis is used. For this measure, comparable measures for diversity in the economy and ecology have been studied.

Measures of diversity in economics

In economics, a measure for diversity of industrial structure for a certain geographical area is described by Wasylenko and Erickson (1978) taking into account the number of industry classes. However, the measure for change in economic diversity in this study would preferably also take different business sizes into account.

Measure of diversity in ecology

Within ecology three types of diversity are being distinguished: diversity within one sample site (alpha), the difference in diversity between sample sites (beta), or regional global diversity (gamma) (Legendre and Legendre, 1998). The measure of change in diversity for comparing pre- and post-disaster situations developed for this research is based on the first type of diversity: alpha-diversity, because the measure for change in diversity uses the sample site of a by a disaster affected site. The Shannon index is a commonly used measure of species diversity:

$$H = -\sum_{i=1}^{q_i} p_i ln(p_i) \qquad \forall p_i \neq 0 \tag{1}$$

[12] While the majority of the analytical approach has been developed jointly by the NSF Recovery team, the measure for Economic Diversity is an original contribution developed by me and presented in both this thesis and the Guidelines for Economic Recovery (Change and De Ruiter, 2011).

[13] The business size categories, based on number of employees, are: 1-4; 5-9;10-19;20-49;50-99 and 100-249.

where $p_i = \frac{n_i}{N}$

q = the number of species (species richness)

p_i = the relative abundance of each species

n_i = the number of individuals in each species

N = the total number of individuals in each species

H_{max} = ln(q)

This measure of ecological diversity is applicable to qualitative descriptors and ordered descriptors divided into classes.

Measure of change in local economic diversity

The economic and ecological measures for diversity are similar and therefore the measure for change in local economic diversity developed for this study is based on the Shannon index (Legendre and Legendre, 1998). The qualitative descriptor used in the Shannon index aligns with the industry classes in the economic diversity model and the ordered descriptor here is the business classes. When converting this index to assess the diversity of a local economy based on industry sectors and business sizes, the adjusted Shannon index for measuring local economic diversity H at time t is:

$$H_{adj} = -\sum_{i=1}^{q_i}\sum_{j=1}^{q_j} p_{ij} ln(p_i) \qquad \forall p_{ij} \neq 0 \tag{2}$$

where $p_{ij} = \frac{n_{ij}}{N}$

q_i = the number of industry classes

q_j = the number of business size classes

n_{ij} = the number of businesses in industry i and size class j

N = the total number of businesses in the study area

Note that the minimum possible value of H is 0, which represents the case of no diversity (i.e., all businesses are of the same industry type and business size class). The maximum possible value of H is:

$$H_{max} = \ln(S) = \ln(q_i.q_j) \tag{3}$$

where S is the total number of classes in the analysis. Note that diversity H increases if S increases and/or if the distribution of businesses among the classes becomes more even. H can be evaluated at any point in time before, during, or after the disaster using data for the number and distribution of businesses at that point in time.

To obtain the overall measure of *change* in local economic diversity D_d ($3 \leq D_d \leq +3$) both the quantitative diversity index H and expert judgments regarding diversity change from the interviews are combined:

$$D_d = \frac{1}{2} \cdot \left| \mu_d + 3 \cdot \left(\frac{H_{t^*} - H_{-1}}{H_{-1}} \right) \right| \quad (4)$$

where μ_d is the mean of the experts' assessments on diversity change ($3 \leq \mu_d \leq +3$) and the quantity in parentheses in the equation addresses the proportion change in the diversity index *H* when comparing the "recovered" economy at $t=t^*$ and the pre-disaster economy at $t=-1$ also known as α.

Data to assess *H* can be obtained from the U.S. Census Bureau's County Business Patterns (CBP) program or the US Census Bureau's zipcode data. Numbers of businesses by industry classes and business size classes are reported at the zip code level on an annual basis. In the CBP data, business counts are reported in a standard format for 20 industry classes and 9 business size classes. For any particular community, it is unlikely that all industry and businesses size classes will be represented; that is, it can be expected that $n_{ij}=0$ for many *ij* classes.

Qualitative data is obtained from expert judgment interviews where the practitioners were asked to rank the change in local economic diversity, μ_d, using Table 3-9.

3.4.3.3 Change in Disaster Readiness

The measure for change in disaster readiness is solely derived from the average of expert's judgments on the change in post-disaster readiness using the scale for disaster readiness, as presented in Table 3-10. The scale ranges from -3, major negative change, to +3, major positive change, and focuses on awareness and the implementation of mitigation efforts.

4 Results and Analysis

This chapter provides and discusses the results of the quantitative and qualitative data analysis of the case study of the city of Biloxi, MS and aims to answer the second research question of this thesis:

2. How does environmental recovery relate to economic recovery?
   a. How do coastal communities recover economically from natural disasters?
   b. What is the role of the environmental recovery for resource dependent sectors of coastal communities?

This research uses a case study to explore a broader concept: that of linkages between environmental and economic recovery using the tourism and fisheries sectors in particular as the focus of the data analysis where the tourism results are used to exemplify the coastal economy as a whole (as addressed in research question 2a) and the fisheries industry as an environmentally dependent sector (as addressed in research question 2b). Therefore, the results explaining the recovery of the tourism and fisheries sectors for the Biloxi case study will be presented and discussed first. Next, the linkages between economic and environmental recovery as resulting from the case study research will be discussed. Finally, the diagram that summarizes the linkages between environmental and economic recovery will be revised using the insights gained from the results presented in this chapter.

It should be noted that precautions should be taken with the analyses in this chapter because the analyzed data sets are available at different spatial scales. Chapter two discussed the pre-disaster general economic situation of Biloxi and this chapter will provide a brief overview of the post-disaster general economic situation using Biloxi city data. However, for other parts of the data analysis, the preferred and smallest scale is that of Harrison County. The analysis of data on this level is very particular and accurate for Biloxi and the county as a whole. Secondly, it is the scale that has been used by the majority of the experts interviewed. When data was not available on this preferred spatial scale, the MSA of Biloxi, Gulfport and Pascagoula[14] level was used. Finally, if data was not available on MSA level either, state level data has been used. The implications of this are twofold. First, the data provides a less accurate image of the recovery of Biloxi and secondly, it is more difficult to compare with the data of different spatial scales.

[14] The MSA is defined by the US Census Bureau as Hancock County, Harrison County and Stone County. Source: http://www.census.gov/

4.1 Recovery of the Tourism Sector

One of Biloxi's most important economic sectors is tourism, which is mostly dependent on the local gaming industry. This industry in particular developed strongly from the early nineties in combination with affordable lodging compared to other gaming cities such as Las Vegas. Visitors who contribute to the tourism sector are mostly from the Gulf Coast region; they are people for whom it is possible to drive to Biloxi. Other major pull factors of the Biloxi's tourism industry are: the casinos (gaming industry), beaches, fishing opportunities and other water-related activities.

This section describes the results of the quantitative and qualitative post-disaster tourism sector recovery. As explained in the methodology chapter, the economic recovery is being assessed through three different dimensions of recovery: (1) the trajectory, (2) timeframe and (3) changes in economic strength, diversity and disaster readiness of post-disaster recovery.

4.1.1 Trajectory of Recovery

As explained in chapter 4, the *trajectory* of the economic recovery of tourism and fisheries uses time series data to create a time-path of the post-disaster recovery. The aim was to find statistical data used for assessing the trajectory for the period 2001 – 2009, expressed in percentages.

4.1.1.1 Time Series Analysis

The data series studied in the time series analysis are: employment and wages in the tourism industry, specific lodging occupancy data and detailed occupational employment and wages trends. It appeared that not all data were available at the preferred temporal scale. First, the average wages and employment for the tourism sector is studied. Next, the lodging trends over the time period of 2004 - 2010 are being analyzed. Finally, the sub-sector occupational employment and wages trends for the tourism sector are analyzed.

General Post-Disaster Economic Conditions

Chapter one elaborated on the pre-disaster economic situation of Biloxi and the immediate impacts of Hurricane Katrina. This section will explore the longer-term impacts using US Census Bureau Data for the city of Biloxi specifically using zipcode data[15] to provide a precise recap of the general post-disaster conditions in comparison to the pre-disaster conditions as discussed in chapter two. In 2008 the number of establishments was 328; the number of paid employees was 14,186 and the annual payroll was $436 million. The largest industry was the Professional, Scientific and Technical Services industry (54 establishments in 2008); retail trade is the second largest industry (48 establishments in 2008). The Keesler Air Force Base was in 2008 the largest employer with over 10,000 employees, followed by the Beau Rivage Casino and Resort with almost 3,000 employees (Us Census Bureau Data).

According to the annual financial report (Biloxi Annual Financial Report, 2008) prepared by the Department of Finance and Administration, the unemployment rate in 2008 was 6.3%. Governmental expenditures were heavily influenced by Hurricane Katrina in 2005/2006 (see Figure 2.11); the governments revenues are shown in Figure 2.12.

[15] The zip code areas for Biloxi are 39530, 39531 and 39532, and annual US Census Bureau Business patterns data for Biloxi can be found here: http://censtats.census.gov/cgi-bin/zbpnaic/zbpsect.pl?Zip=39530.

From Figure 4.1 it appears that there has been a sharp decline in the number of accommodation and food establishments in Harrison County as a ratio of the number of establishments in the state of Mississippi and secondly, that a new stable level, lower than the pre-disaster level, has been reached in the four years after the Hurricane.

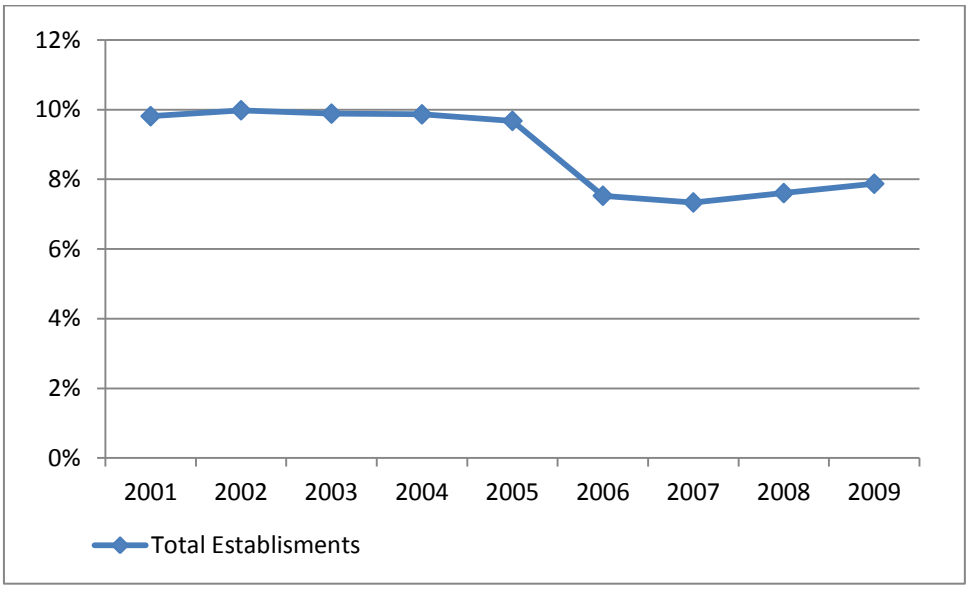

Figure 4.1 Total establishments for accommodation and food services for Harrison County as a proportion of Mississippi State. Source: Census County Business Patterns data

Employment and Wages

The tourism sector employment and wages data was available at the spatial scale of Harrison County and compared with Mississippi state data. The data sets are derived from the Census County Business Patterns data and were available for the time period of 2001 to 2009. First, the data for the Harrison County data has been normalized using the Mississippi state data as shown in Figure 4.2 and Figure 4.3. The employment data shows a clear stabilization from 2007 on. This is lower than the pre-disaster level but a stabilization for three years in a row has been established. The wages data shows a stabilization as well with the exception that in 2006 the wages decreased but by 2009 they had returned to the 2006 and 2007 levels. It should also be noted that the wages weren`t stable in the years before Hurricane Katrina hit the coast of Harrison County. The time series analysis assessment in Figure 4.2 uses Table 3-11 to assess the different stages of recovery based on the employment and wages time series data. It appears that the sector has found a new stable level during the period of 2007 to 2009 at a lower level than the pre-disaster level.

Figure 4.2 Average annual wages for all tourism sectors in Harrison County as a proportion of Mississippi State. Source: Census County Business Patterns data.

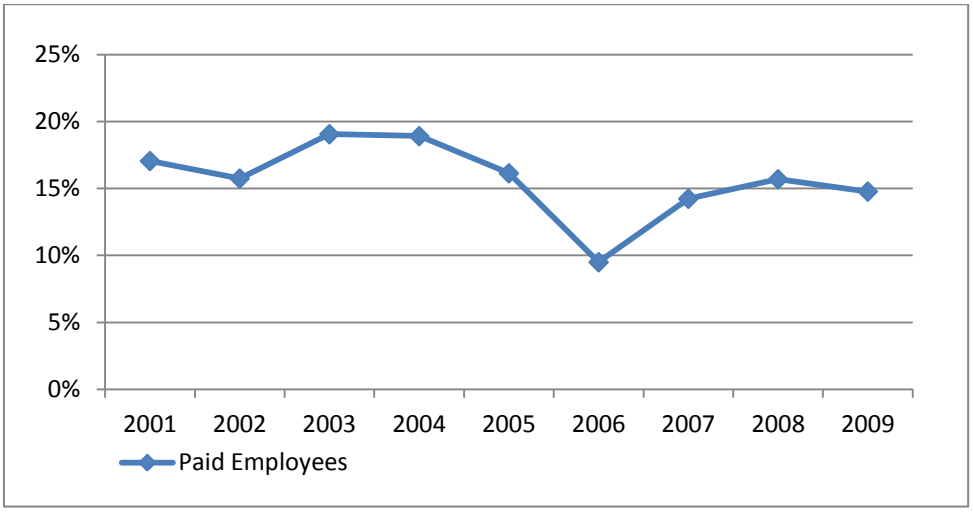

Figure 4.3 Annual number of paid employees for all tourism sectors in Harrison County as a proportion of Mississippi State. Source: Census County Business Patterns data. Note: * the Census data is only available on an annual basis and therefore the ´immediately after´ and ´three months after' are extrapolated

Table 4-1 Time series data analysis of trajectory of the recovery of the tourism sector.

Assessing the extent of economic recovery...	**Time series analysis assessment (1-7 scale)**
Immediately after - August 2005*	3
3 months after - November 2005*	3
1 year after - August 2006	3
2 years after - August 2007	4
3 years after - August 2008	5
4 years after - August 2009	5
5 years after - August 2010 (incl. oil spill)	5
Now (October 2010)	Data unavailable

Lodging Trends

The analysis of lodging occupancies uses data for Biloxi-Gulfport MSA as the data wasn't available for Harrison county. Both this data set and that of the state of Mississippi are available for 2003/2004 to 2010[16]. The analysis is done for annual room occupancy, annual room occupancy change rate and annual change rates in annual revenue, supply and demand.

The number of hotel rooms in 2007 was still behind compared to the number of hotel rooms in 2004 (respectively 5,444 and 9,277). In general, the Biloxi city council is aiming to strengthen the tourism sector because it is being perceived as one of the key sectors for future economic growth of Biloxi. This is being done by the development of large visitor-oriented projects such as the Convention Center and the area around the Center; and the development and improvement of commercial and entertainment facilities. The goal is not only to increase the number of visitors but also to increase the spending per person.

Based on the proportion occupancy as shown in figures 4.3 to 4.6, the absolute occupancy has declined from 2,759 rooms in 2004 to 1,538 in 2005, but has been growing ever since 2006 (2,467). The peak shown in room occupancy for 2010 (4,489) is explained by several of the experts interviewed during the fieldwork as a boost created from BP employees staying in the region for the cleanup after the BP Horizon Oil Spill. The change rates in revenues, supply and demand follow the trend that is visible for the state but show a strong decline for 2005 and 2006 but a major peak in 2007. Another extreme low demand and revenue takes place in 2009 which is explained by the experts as a result of the economic downturn which hit the coastal region of Mississippi hard. From Figure 4.6 to Figure 4.8, it appears that the Biloxi-Gulfport MSA and the state diverge as a result of Hurricane Katrina for the period of 2005 -

[16] For the US, the global research consultancy Smith Travel Research (STR) collects data from lodging companies in the US. Their aim is to collect as much data as possible, however it should be noted that the average annual participation rate for the time period 2004-2010 in the Biloxi-Gulfport MSA is 49.78%.

2007 but converge again for 2008. These trends suggests that the economy of the Biloxi-Gulfport MSA stabilized after Hurricane Katrina around 2008.

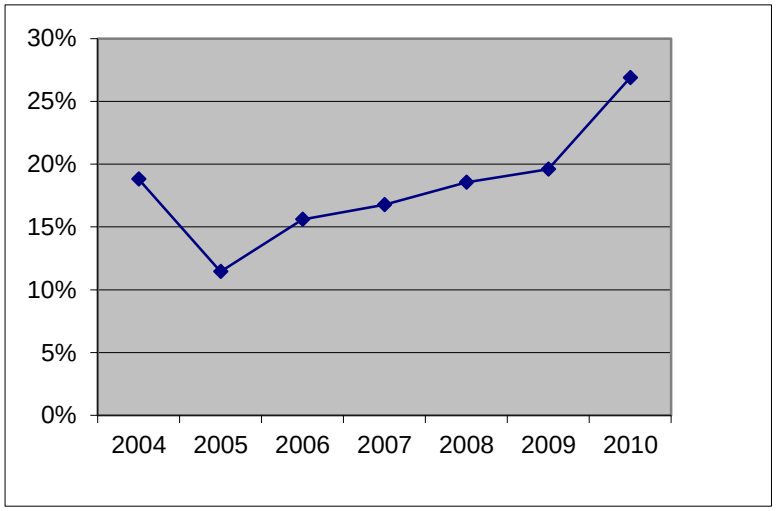

Figure 4.4 Biloxi-Gulfport MSA annual room occupancy as a proportion of Mississippi State for the Period 2004 - 2010. Notes: * Year to date data: starting January 1st of every year.

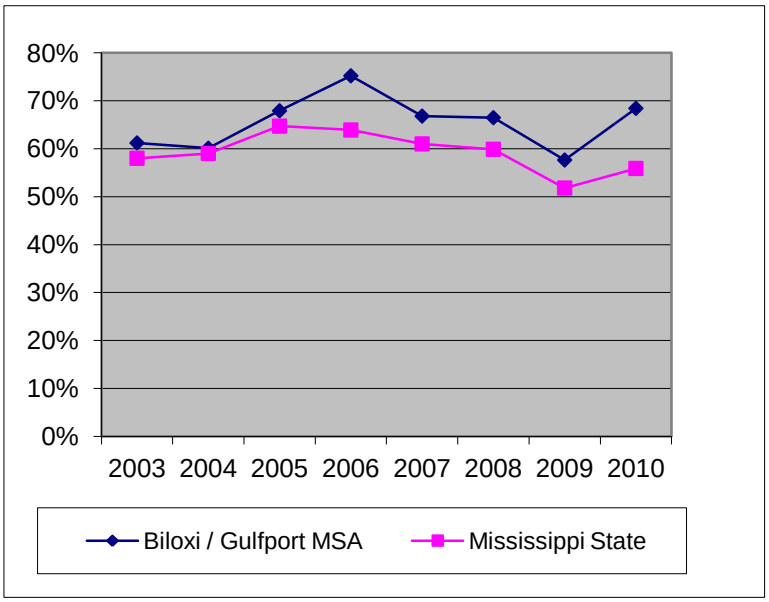

Figure 4.5 Year to date annual room occupancy proportion for Biloxi - Gulfport MSA and MS state over the period 2003 - 2010.

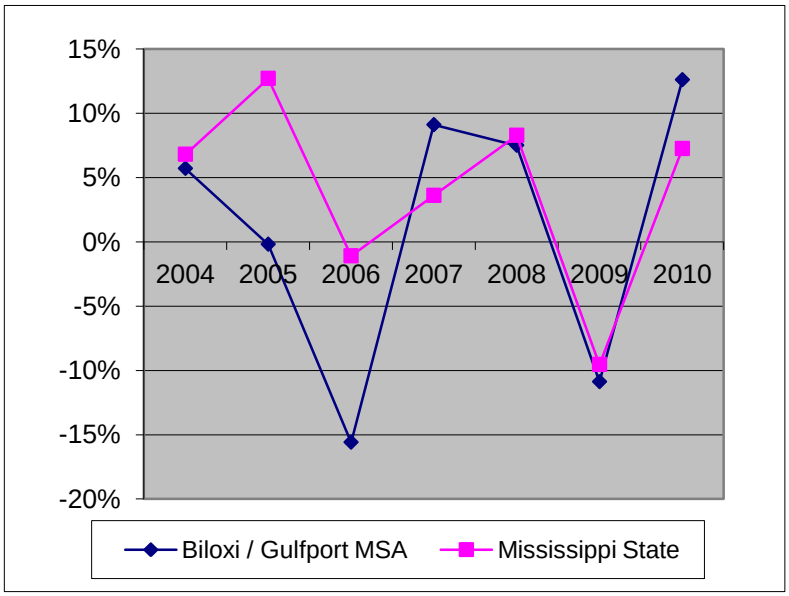

Figure 4.6 Annual room revenue change proportion for Biloxi - Gulfport MSA and MS over the period 2004-2010.

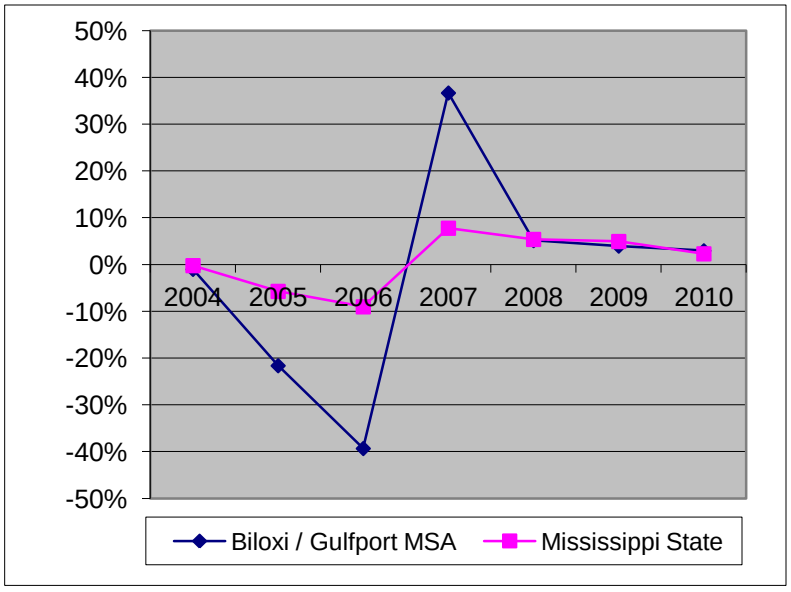

Figure 4.7 Annual room supply change proportion for Biloxi - Gulfport MSA and MS over the period 2004-2010.

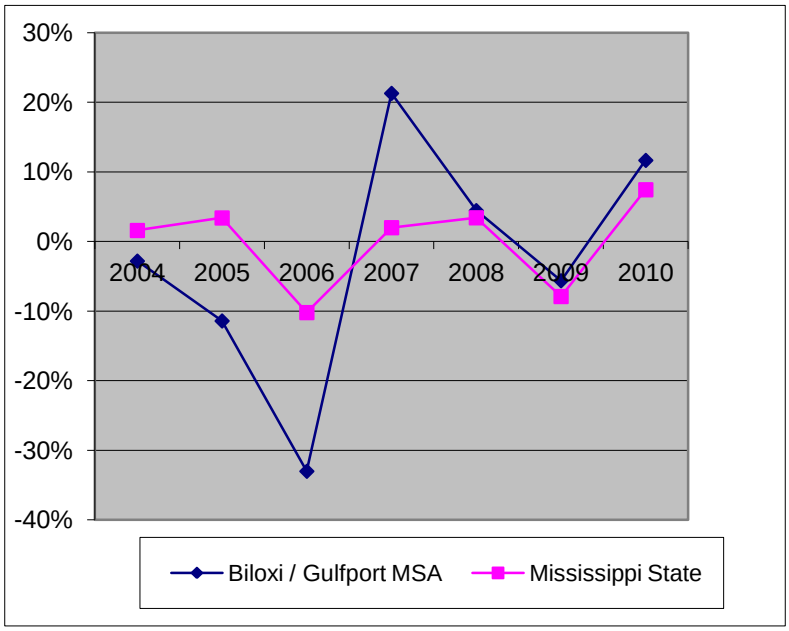

Figure 4.8 Annual room demand change proportion for Biloxi - Gulfport MSA and MS over the period 2004-2010.

Occupational Employment and Wages Trends

Occupational employment and wages data have been derived from the Bureau of Labor Statistics for the Biloxi-Gulfport MSA and is available for the period 2001-2009[17] as shown in figures 5.9 - 5.15. It should be noted that the trend for "All Occupations" in Figure 4.9 shows a strong decrease from 2005 on and the subcategories follow this trend. Interestingly, wages in the same sectors all show the same trend: an increase in wages for all occupations and sub-occupational categories from 2005 or earlier on.

[17] For some of the sub-occupational categories related to tourism and fisheries, data were available for fewer years and have therefore been excluded from this study. This was the case for: "Personal Care and Service Occupations' sub-category Tour Guides and Escorts" and the "Farming, Fishing, and Forestry Occupations" sub-category "Logging Equipment Operators" which could have been used to determine trends for farming and fishing without the influence of forestry occupancies.

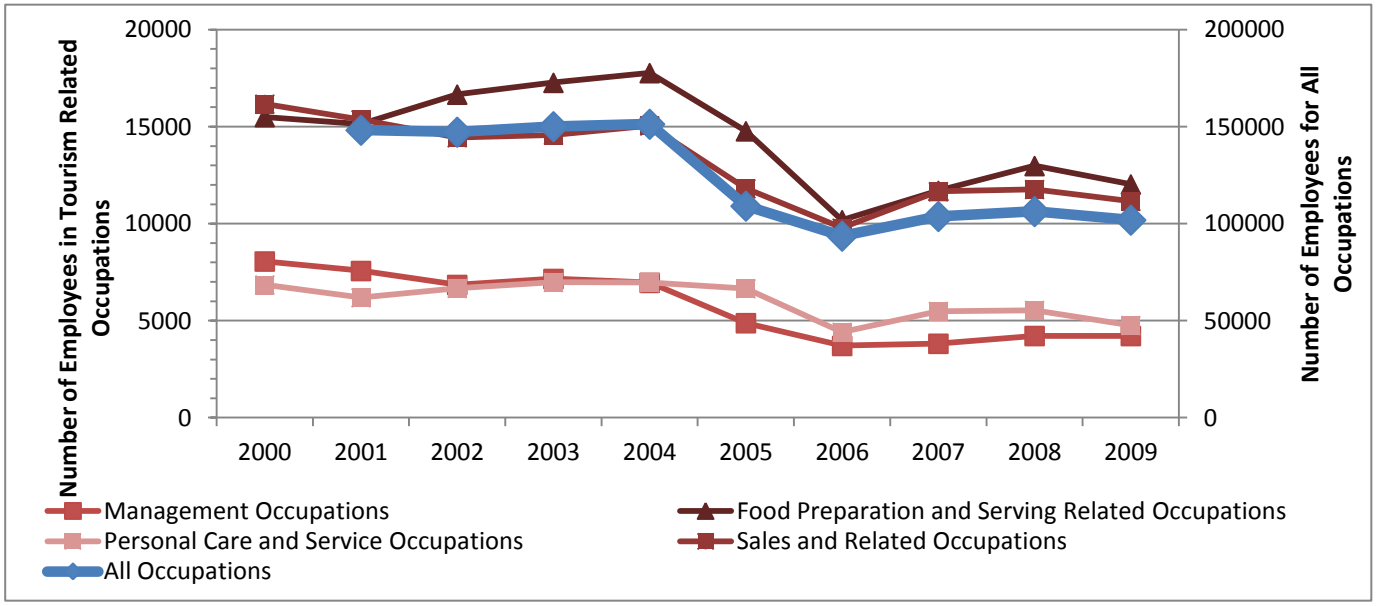

Figure 4.9 Estimated total employment rounded to the nearest 10 (excludes self-employed) for 'all occupations' and tourism related occupations in the Biloxi - Gulfport - Pascagoula MSA over the period 2000 - 2009.

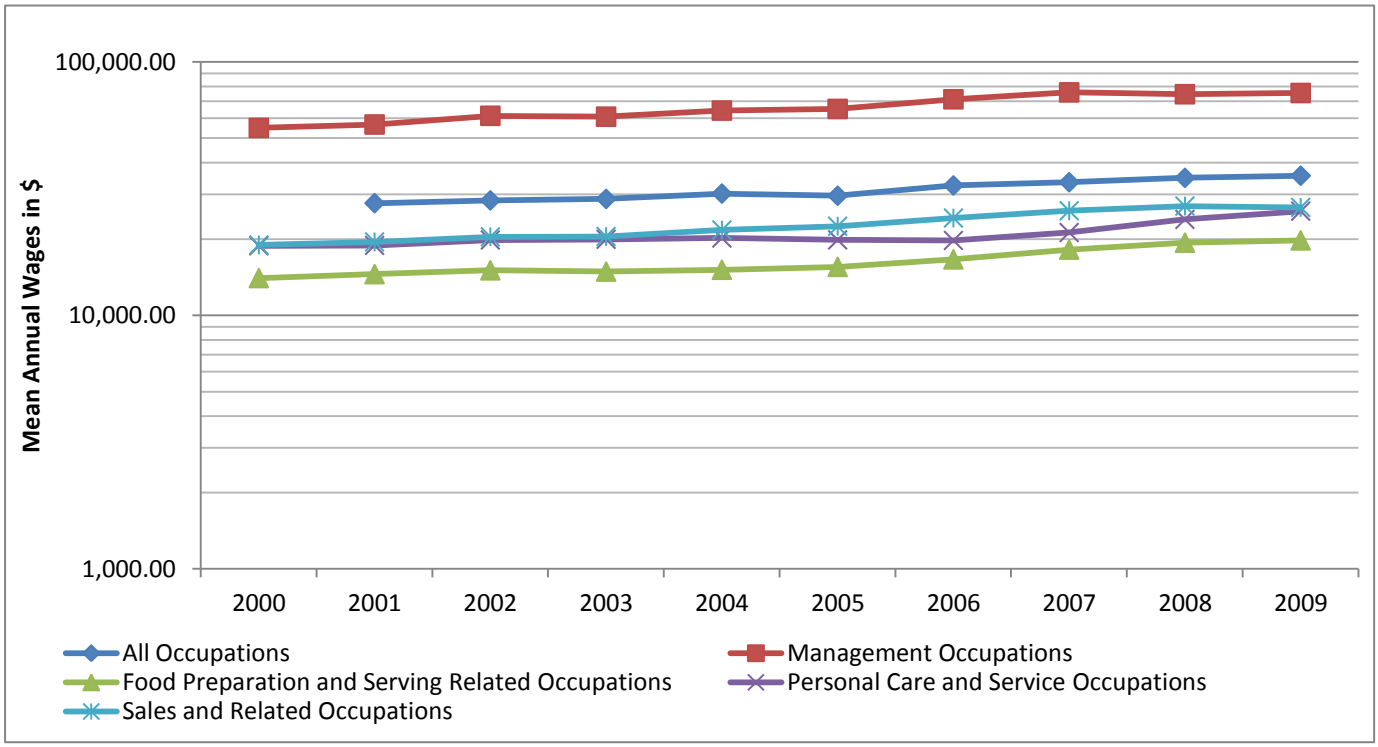

Figure 4.10 Mean annual wages for 'all occupations' and some of the tourism related occupations in the Biloxi - Gulfport MSA over the period 2000 - 2009.

Table 4-2Annual number of paid employees in Gulfport-Biloxi MSA. Notes:* For pay period including March 12th.

Industry Code Description	2004	2008	Change proportion 2004-2008
'Total'	90845	86501	-0.05
'Forestry, fishing, hunting, and agriculture support'	374.5	125	-0.67
'Mining'	59.5	18	-0.70
'Utilities'	1749.5	1749.5	0
'Construction'	4186	5235	0.25
'Manufacturing'	4093	5440	0.33
'Wholesale trade'	2276	1998	-0.12
'Retail trade'	13923	13345	-0.04
'Transportation & warehousing'	2195	2002	-0.09
'Information'	1304	1293	-0.01
'Finance & insurance'	3624	3256	-0.10
'Real estate & rental & leasing'	1189	1285	0.08
'Professional, scientific & technical services'	4246	4878	0.15
'Management of companies & enterprises'	864	298	-0.66
'Admin, support, waste mgt, remediation services'	3749.5	4243	0.13
'Educational services'	1749.5	861	-0.51
'Health care and social assistance'	14802	13624	-0.08
'Arts, entertainment & recreation'	3335	1749.5	-0.48
'Accommodation & food services'	24961	21622	-0.13
'Other services (except public administration)'	3348	3237	-0.03
'Unclassified establishments'	59.5	9.5	-0.84

4.1.1.2 Expert Judgments' Analysis

Table 4-3 shows the outcomes of the expert judgment interviews regarding the trajectory of recovery. As discussed in chapter three, the interviewees were asked to define the spatial level on which they based their assessments and answers. All experts but the city administration experts used the county's coastal area as their spatial reference. The assessments by the city administrative experts based on the city of Biloxi have been extrapolated to Harrison County's coastal area.

It appears that there is a steady recovery taking place in the tourism sector according to the experts interviewed. However, it should also be acknowledged that according to some of the experts, complete recovery has not yet been established as tourism numbers are still lacking behind their pre-disaster levels: "as far as commercial development, we are not nearly as far as most conservative prognoses predicted the development of the beachfront would be" (Person B, personal communications, [November 1st, 2010]). Another reasons provided for the still ongoing recovery is that in the years after Hurricane Katrina, the economic downturn and the oil spill have hampered full recovery (Person A, personal communications, [October 22nd, 2010]). However, it was also pointed out that the city of Biloxi is lucky that it is not a beach destination but a casino destination, unlike neighboring areas that have had more difficulties during the post-disaster recovery process in their tourism sectors (Person A, personal communications, [October 22nd, 2010]). The difficulties with payouts by insurance companies is another influence on the recovery process recognized by experts (Person D, personal communications, [October 18th, 2010]).

Table 4-3 Expert judgment assessment of trajectory of the recovery of the tourism sector.

How do you assess the extent of economic recovery...	Average expert assessment (1-7 scale)
Immediately after - August 2005	1
3 months after - November 2005	2
1 year after - August 2006	3
2 years after - August 2007	3
3 years after - August 2008	4
4 years after - August 2009	4
5 years after - August 2010 (incl. oil spill)	4
Now (October 2010)	5

One of the interview questions asked the interviewees to explain which milestones of recovery they had in mind when trying to map the recovery trajectory. This question is important in providing insight into what experts perceived as major changes that took place during the recovery. Table 4-4provides an overview of the foremost milestones of recovery, and it appears that most milestones are related to general or specific tourism sectors changes.

Table 4-4 Overview of milestones of recovery as identified by the interviewed experts.

EXPERT	MILESTONES
Person A	Return of casinos
Person B	Infrastructure being restored -> the ability to navigate around and money started circulating again Tourism events
Person D	Rebuilding of highway 90 Development along the highway 90
Person E	Debris removal with FEMA and the US Army Corps of Engineers Establishing power
Person F	First make-shift repairs Then return of the fleet in 3 months after the Hurricane
Person G	Return of the live oaks Return of the pelicans

4.1.1.3 Establishing Trajectory of Recovery

Using Table 3.11 and the data assembled in Table 4-3 and Table 4-3, Table 4-5 shows the composite trajectory for economic recovery of the tourism sector of Biloxi. It appears that the trajectory of recovery is steady and that full recovery had not yet been reached at the time of the fieldwork.

Table 4-5 Composite trajectory of the recovery of the tourism sector.

Time	Recovery Composite (1-7 scale)
Immediately after - August 2005	2
3 months after - November 2005	2.5
1 year after - August 2006	3
2 years after - August 2007	3.5
3 years after - August 2008	4
4 years after - August 2009	4
5 years after - August 2010 (incl. oil spill)	4
Now (October 2010)	5

4.1.2 Timeframe of Recovery

The timeframe of recovery refers to when the economic sector reached a new stable state and uses the time required for income to stabilize (from the statistical data analysis) and the mean of the experts´ judgments. It appeared from the data shown in Figure 4.2 that it took the economy of Biloxi until 2007 to stabilize incomes for the tourism sector. The experts interviewed all agreed that Biloxi hadn't fully recovered yet by then. This was partly due to the economic downturn starting in 2008 and also because of the oil spill in May 2010. Some experts pointed out that tourism was on its way back in 2007-2008 but couldn't fully recover due to the economic situation (Person H, personal communications, [October 19th, 2010]). Another interviewee explained that the casinos have helped the recovery of Biloxi's tourism sector by maintaining an influx of tourists but simultaneously set several local businesses out of business; however, the perception of the beaches still being covered by oil remains a big problem for the local economy (Person B, personal communications, [November 1st, 2010] and Person C, personal communications, [October 21st, 2010]).

4.1.3 Changes in Economic Characteristics

Three types of changes in the economic sector are addressed: the change in economic strength, the change in economic diversity, and the change in disaster readiness. Table 4-6 shows the assessments as done by the experts interviewed and the mean (rounded) of their ratings for each type of change.

Table 4-6 Changes in economic characteristics for the tourism sector assessments by experts.

Change in	Experts' Assessments				Mean (μ_s) of Expert Judgment Ratings
Economic strength (D_s)	-2	-1.5	-1	-2	-2
Economic Diversity (D_d)	+2	-1	0	0	0
Disaster Readiness (D_r)	+3	+1	+3	+3	+3

4.1.3.1 Change in Economic Strength

The analysis for change in economic strength, as discussed in section 4.5.3.1 uses the data from the economic trajectory of recovery scale and the assessments made by experts during the expert judgment interviews using Table 3-12. The level of economic recovery on the 7-point scale for the tourism sector in 2009 was 4, or moderate recovery. As shown in Table 4-7, the experts judged the change in economic strength of the sector on average as: -2, some negative change. Using Table 3-12 this leads to a -2 on the scale for change in economic strength: some negative change. The experts gave examples such as low gaming revenues compared to pre-Hurricane Katrina levels and a decline in number of restaurants, rental properties and tourists (Person A, personal communications, [October 22nd, 2010] and Person E, personal communications, [October 19th, 2010]).

4.1.3.2 Change in Economic Diversity

As explained in section 3.4.3.2, the measure for change in economic diversity was developed for this thesis. To implement this scale, the diversity change rating (-3 to +3) should be evaluated as the average of (a) a quantitative measure of diversity change and (b) the mean rating of diversity change from the expert interviews. While the quantitative measure uses objective statistical data, the expert judgments allow for consideration of diversity changes that may not be captured or apparent in the data yet are locally important. The quantitative analysis shows that α, the percentage change in pre- and post-disaster economic diversity is 0.057; the range of α is [0; 3.33], implying close to no change in diversity. The data for this has been obtained from the US Census Bureau and the most recent post-Hurricane Katrina data available at the time.

Equation 4 presented in section 3.4.3.2 shows how both quantitative and qualitative data are used to combine the assessment the change in economic diversity from 2004 to 2008 made by the experts and the measure for change in economic diversity. The diversity change index D_d for the economy of Biloxi is 0.084; the range of D_d is [0; 1.66], implying that no change in diversity has taken place.

Same experts mentioned that in the post-disaster situation, there is less diversity than prior to the storm (Person B, personal communications, [November 1st, 2010] and Person C, personal communications, [October 21st, 2010]), while others pointed out that the Biloxi economy had three main pillars (the gaming industry, Kessler Air force Base and retail) and was therefore never diverse (Person D, personal communications, [October 18th, 2010]). However, others pointed out that they have been forced to diversify: they always had a heavy reliance on tourism and military and that was what helped them to recover (Richard Person A).

Table 4-7 shows the most prevalent businesses for 2004 and 2008 and uses the same US Census Bureau data as used for the change in economic diversity measure. It appears that the prevalence of the tourism related sector, accommodation and food services, has decreased during the post-disaster recovery period.

Table 4-7 Number of establishments per industry in Biloxi-Gulfport MSA relative to the total number of establishments in 2004 and 2008.

Industry Code Description	Percentages	Percentages
Retail trade	20.00%	18.78%
Accommodation & food services	9.87%	10.43%
Other services (except public administration)	9.61%	9.75%
Health care and social assistance	9.60%	9.62%
Professional, scientific & technical services	9.08%	9.52%
Construction	8.28%	8.94%
Finance & insurance	7.51%	7.42%
Real estate & rental & leasing	4.79%	5.48%
Admin, support, waste mgt, remediation services	4.22%	4.25%
Wholesale trade	4.00%	4.04%
Transportation & warehousing	3.31%	3.17%
Manufacturing	2.92%	3.14%
Information	1.71%	1.64%
Arts, entertainment & recreation	1.58%	1.42%
Educational services	1.26%	0.89%
Utilities	0.78%	0.70%
Forestry, fishing, hunting, and agriculture support	0.66%	0.32%
Management of companies & enterprises	0.39%	0.32%
Unclassified establishments	0.34%	0.11%
Mining	0.09%	0.06%
Total	100.00%	100.00%

4.1.3.3 Change in Disaster Readiness

As shown in Table 4-5, almost all the experts agreed that the disaster readiness of the tourism sector underwent an extensive positive change (+3) compared to the pre-Katrina situation. Experts explained that several programs were adopted after the Hurricane to help local businesses increase awareness and their disaster readiness. After the oil spill, BP gave money to the state of Mississippi which distributed the money among the businesses (Person A, personal communications, [October 22nd, 2010]). Also the city government of Biloxi has strongly improved its practices; there are new regulations relating to building standards in place that have a much higher standard than their pre-disaster equivalents (Person C, personal communications, [October 21st, 2010]). Person C also stated that if Hurricane Katrina were to happen now, the damage would be significantly lower. Person E (personal communications, [October

19th, 2010]) also pointed out that there is more sustainable urban planning, incorporated with smart growth practices, taking place these days whereby future impacts have been increasingly taken into account.

4.1.4 Recovery of the Fisheries Sector

The city is historically known for its large seafood industry and the shrimp fishing industry in particular (City of Biloxi Comprehensive Plan, 2009). The crab industry of the state of Mississippi only contributed for 1% to the total Gulf Coast crab industry in the mid-nineties (Posadas, 1996), and therefore the focus of this section will be on the shrimp industry. Table 4-9 shows the contribution of shrimp landings in Harrison County to state total.

Table 4-8 Contribution of shrimp landing in Harrison County to Mississippi State total. Source: DMR.

Year	Harrison County (%)
2001	76.90%
2002	76.10%
2003	83.80%
2004	79.10%
2005	93.00%
2006	99.90%
2007	99.90%
2008	99.90%
2009	98.50%

It appears from table 4-9 that Harrison County is the main contributor of the shrimp landings for the state of Missisippi and this increased after Hurricane Katrina. However, because of the low prices of imported sea-products and facilities lost due to Hurricane Katrina, the absolute size of the sector has declined over the last few years (City of Biloxi Comprehensive Plan, 2009). For 2003, the total economic impact of the industry for the Greater Biloxi area was $900 million and it provided employment to 16,800 people. The community has tried to re-strengthen the seafood industry after Katrina by organizing several seafood related events. One of the planned developments is to expand the commercial docking facilities on the Peninsula to both ensure that Biloxi's commercial seafood industry remains a key sector for its economy and to broaden the tourism pull factors.

The FAO (2008) writes in its global shrimp report that there are two main types of shrimp fisheries operating in the US. The southeast Atlantic coast and the Gulf of Mexico are the main locations for warm-water shrimp fishing, and the northeast and northwest of the country are the locations for cold-water shrimp (FAO, 2008). The report states that the shrimp fishing industry in the US is the second most important after the crab fishing industry measured in landings but shrimp is the most frequently eaten seafood in the US (FAO, 2008). The warm-water shrimp fishing industry makes up the vast majority of the total shrimp landings: 90% of 140,000 tons in 2004 (FAO, 2008). An important issue that has taken place in recent years is that of the expansion of the import of foreign shrimps with a value of 500,000 tons on an annual basis. Finally, the cost-price of shrimp has declined over recent years as well which according to the FAO (2008) has led to financial crises for many shrimp fishers.

This section describes the results of the quantitative and qualitative post-disaster recovery of the fisheries sector as an example of an environment dependent economic sector. As with tourism, the economic recovery of the fisheries sector is being assessed through three different dimensions of recovery: (1) the trajectory, (2) timeframe and (3) changes in economic strength, diversity and disaster readiness of post-disaster recovery. This section will determine the economic recovery of the fisheries sector to compare it in the next section with the recovery of the non-environment dependent sector tourism.

4.1.5 Trajectory of Recovery

The *trajectory* of the economic recovery of the fisheries sector uses time series data to create a time-path of the post-disaster recovery. The aim was to find statistical data used for assessing the trajectory for the period 2001 – 2009, expressed in percentages.

4.1.5.1 Time Series Analysis

The data series studied in the time series analysis are: employment and wages in the fisheries industry, specific licenses and landings data and detailed occupational employment and wages trends. It appeared that not all data were available at the preferred temporal scale. First and foremost, the employment and wages time series have been analyzed and combined with the experts' judgments. Next, license numbers and volumes of shrimp and crab landings are analyzed. Finally, the sub-sector occupational employment and wages trends are analyzed.

Employment and Wages

The Census Business County Business Patterns data for fisheries sectors was not available for most years in the time period of 2001 - 2009 for Harrison County. Therefore, fisheries sector employment and wages data were obtained for the Biloxi-Gulfport MSA[18] and Mississippi state are derived from the Bureau of Labor Statistics. These data were available for the time period 2001 to 2009 with a gap in 2003. First, the data for the Biloxi-Gulfport MSA time series analysis of employment and wages data in the fisheries sector is plotted in Figure 4.11 and Figure 4.12. The data has been normalized to the state of Mississippi wages and employment in order to adjust for economic fluctuations that take place in the entire state and that are not significant for the fisheries sector. The graphs show that both mean annual wages and employment for the Biloxi-Gulfport MSA as a percentage of Mississippi state have increased during the first three years after Hurricane Katrina.

[18] The US Bureau of Labour Statistics defines the Biloxi-Gulfport MSA as the assembly of Hancock County, Harrison County and Stone County. Hancock county is the coastal county located West of Harrison County and Stone county is the county bordering Harrison County on the North.

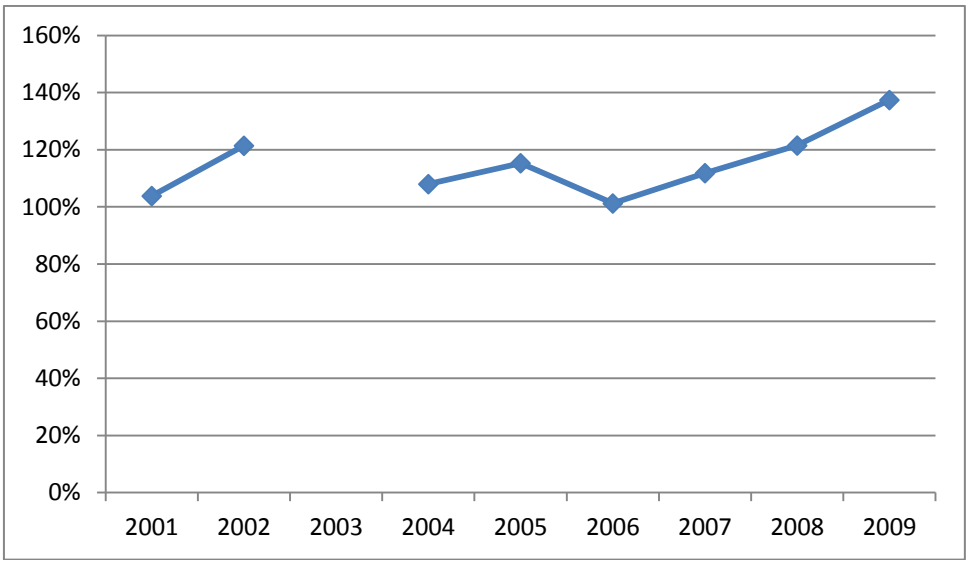

Figure 4.11 Average annual wages (measured annually in May) for all fisheries sectors in the Biloxi/Gulfport MSA as a percentage of Mississippi State. Source: BLS data.

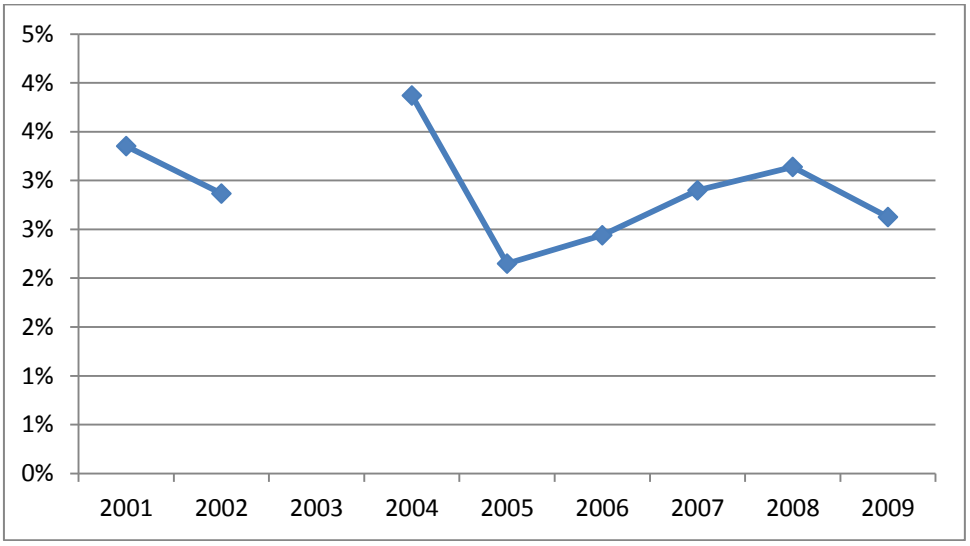

Figure 4.12 Annual employment for all fisheries sectors in the Biloxi/Gulfport MSA as a proportion of Mississippi State. Source: BLS data. Note: * the BLS data is only available on an annual basis and therefore the immediately after and three months after periods are extrapolated.

Licenses Numbers and Landing Volumes

As explained in chapter 3, the shrimp sector has historically been the most important harvesting type within Biloxi's fisheries sector. The data on shrimp landings in pounds and dollar values and the fishing licenses issued by the Department of Marine Resources (DMR) have been provided by the DMR as shown in Figure 4.13 and Figure 4.14. The data shows that both the dollar value and the amount of shrimp caught have declined after Hurricane Katrina, and the oil spill in 2010 has caused it to decline even more after a new stable state had been established in 2006 to 2009.

The number of licenses given out to residential commercial shrimp fishers has decreased since 2005 but has reached a new stable level. Non-residential commercial shrimp fishers seemed to be less

affected by Hurricane Katrina, but their licenses request did decline after the oil spill in 2010. This is in line with the picture painted by the experts interviewed. The Gulf Regional Planning Commission explained that many of the fisheries population left the area and moved further north after Hurricane Katrina (interview with Person E). The Gulf States Marine Fisheries Commission also explained that the oil spill was the last push for many shrimp fisheries to leave their business after the hardship of a declining industry, being hit by Hurricane Katrina and the 2008 economic downturn (Person M, personal communications, [October 23rd, 2010]).

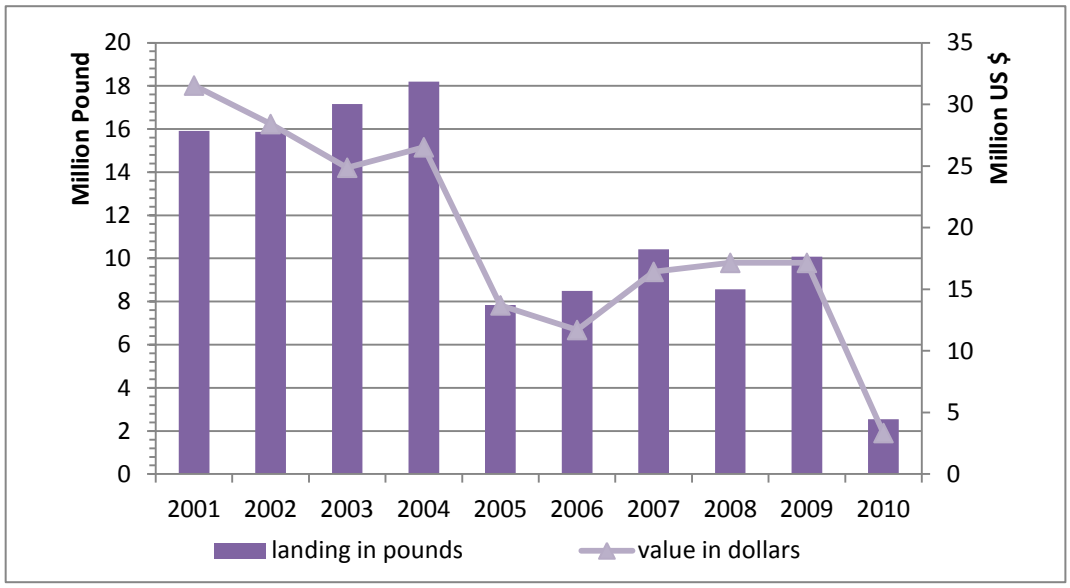

Figure 4.13 Mississippi shrimp landings in pounds and their dollar value for the period 2001 - 2010. Source: Mississippi Department of Marine Resources.

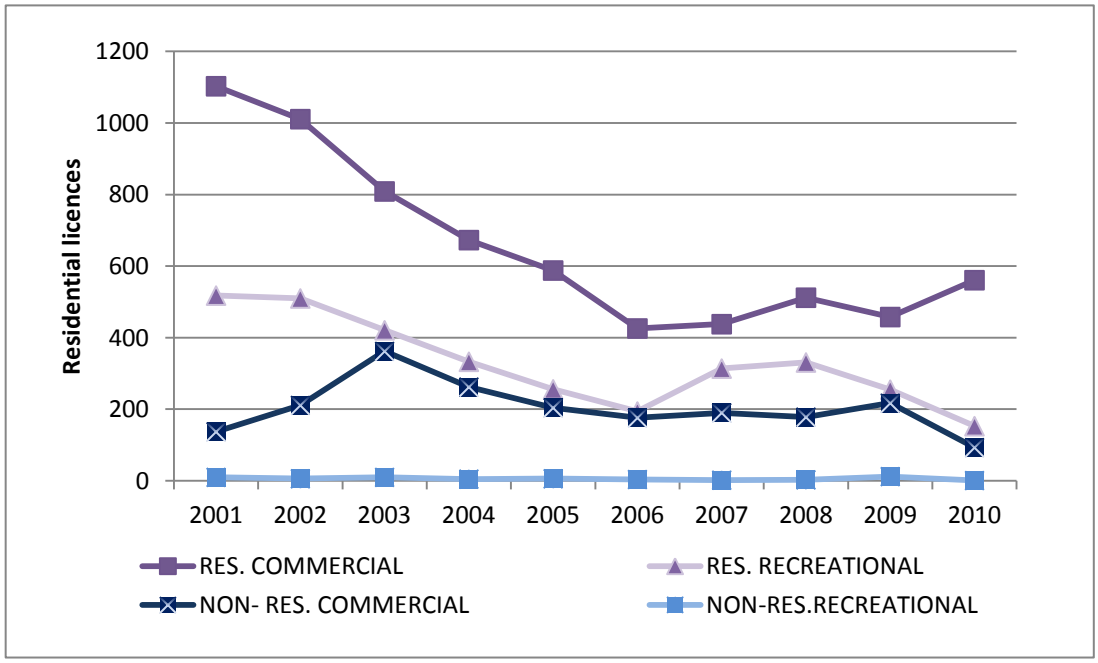

Figure 4.14 Mississippi shrimp resident and non-resident licenses for the period 2001 - 2010. Source: Mississippi Department of Marine Resources.

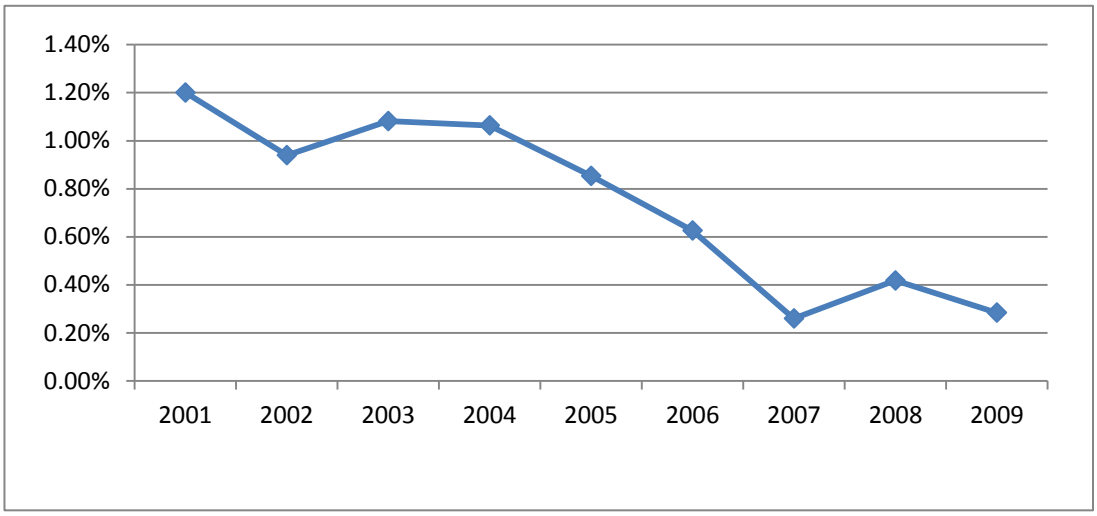

Figure 4.15 Total establishments for forestry, fishing, hunting, and agriculture support for Harrison County as a proportion of Mississippi State. Source: Census County Business Patterns data

Figure 4.15 shows the decline in the number of establishments in the forestry and fisheries sector in Harrison County as a ratio of Mississippi state. From 2007 on, a new stable state has been reached which is lower than the pre-disaster level; a decline of 66%.

Sub-Sector Occupational Employment and Wages Trends

Detailed sub-sector occupational employment and wages trends are provided by the US Bureau of Labor Statistics US for the Biloxi-Gulfport MSA. However, there are not many sub-sectors within the fisheries sector. It appears from Figure 4.16 and Figure 4.17 that the farming, fishing and forestry occupations follow the trend for all occupations in terms of a sizable and sustained post-Katrina drop in employment.

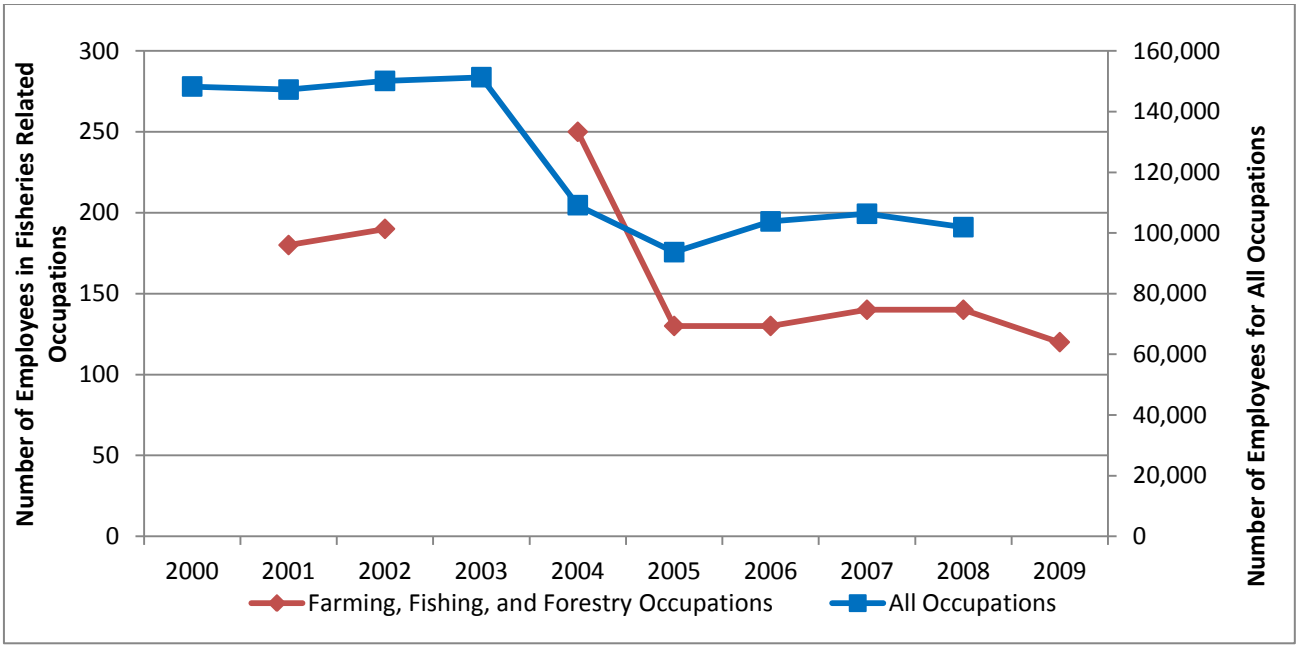

Figure 4.16 Estimated total employment rounded to the nearest 10 (excludes self-employed) for 'all occupations' and fisheries related occupations in the Biloxi - Gulfport MSA over the period 2000 – 2009. Source: BLS.

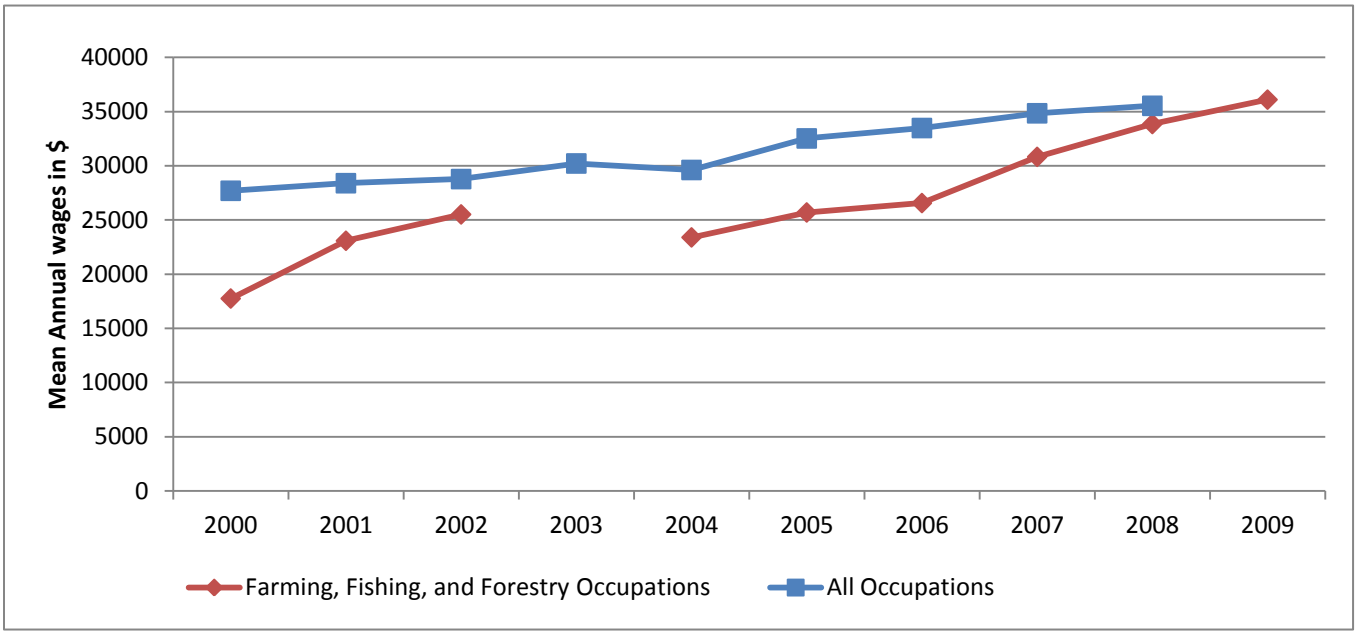

Figure 4.17 Mean annual wages for All Occupations and Farming, Fishing and Hunting related Occupations in the Biloxi - Gulfport MSA over the period 2000 - 2009. Source: BLS

Table 4-9 Time series data analysis of trajectory of the recovery of the fisheries sector.

Time	Trajectory (1-7 scale)
Immediately after - August 2005*	2
3 months after - November 2005*	2
1 year after - August 2006	2
2 years after - August 2007	3
3 years after - August 2008	3
4 years after - August 2009	4
5 years after - August 2010 (incl. oil spill)	3
Now (October 2010)	Data unavailable

4.1.5.2 Expert Judgments' Analysis

As explained in section 5.1.1.1, the spatial reference used by most of the interviewees is the coastal area of Harrison county, only the experts from the city of Biloxi used the city as their spatial reference. The majority of the coastal and aquaculture activities in the coast of Harrison County are located in Biloxi and

the data obtained from the different interview assessments can therefore be used together despite slight differences in spatial reference.

Table 4-9 shows the outcomes of the expert judgment interviews regarding the trajectory of recovery. It appeared that after the hurricane and the economic downturn the oil spill had stopped the recovery process and moreover, had an aggravating negative impact on the fisheries sector setting it back to previous, lower recovery levels (Person F, personal communications, [October 20th, 2010]). Other issues that negatively impacted the recovery of the fisheries sector were the damage to the equipment (e.g. fishing boats, docks, and harbors) and the difficult process of obtaining funding from FEMA to restore the damaged equipment (Person F, personal communications, [October 20th, 2010]). A spatial issue that occurred after Hurricane Katrina was that of relocation of people in the south of Harrison County: many people moved up north, past the I-10 highway (interview with Person E). As was the case for tourism, the importance for the recovery of the restoration of the infrastructure was mentioned by several experts (Person G, personal communications, [October 18th, 2010] and (Person F, personal communications, [October 20th, 2010]).

Table 4-10 Expert judgment assessment of trajectory of the recovery of the fisheries sector.

How do you assess the extent of economic recovery...	Average expert assessment
Immediately after - August 2005	1
3 months after - November 2005	1
1 year after - August 2006	3
2 years after - August 2007	3
3 years after - August 2008	4
4 years after - August 2009	4
5 years after - August 2010 (incl. oil spill)	4
Now (October 2010)	5

4.1.5.3 Establishing Trajectory of Recovery

Using Table 3-11 and the data assembled in Table 4-10 and Table 4-11, the consolidation scale for economic recovery timeframe of the fisheries sector of Biloxi, it appears that the trajectory of the recovery of the fisheries sector is slow and also has endured a setback caused by the oil spill. Moreover, full recovery had been reached at the time of the fieldwork but that the new levels of wages, employment and production are much lower than pre-disaster levels. The quick recovery after the summer of 2010 can be explained by the economic stimulus caused by the influx of BP employees working on the clean-up after the oil spill.

Table 4-11 Trajectory of the recovery of the fisheries sector.

Trajectory of Fishery industry Recovery	Recovery Scale
Immediately after - August 2005	1.5
3 months after - November 2005	1.5
1 year after - August 2006	2.5
2 years after - August 2007	3
3 years after - August 2008	3.5
4 years after - August 2009	4
5 years after - August 2010 (incl. oil spill)	3.5
Now (October 2010)	5

The milestones of recovery as shown in Table 4-12 show the major changes that took place in the recovery process of the fisheries sector. It appeared that environmental changes such as the return of the Live Oaks that are very characteristic of the local environment and the return of pelicans had a large influence on the perceived recovery by the experts.

Table 4-12 Overview of milestones of recovery as identified by the interviewed experts.

EXPERT'	MILESTONES
Person E	Debris removal with FEMA and the US Army Corps of Engineers Establishing power
Person F	First make-shift repairs Then return of the fleet in 3 months after the Hurricane
Person G	Return of the live oaks Return of the pelicans

It appeared from several of the expert judgment interviews that Hurricane Katrina damaged the reefs in the Mississippi Gulf Coast affecting the Biloxi fishermen. The oyster beds needed restoration: the reefs had to be cleaned-up and stock assessments were conducted as part of the post-disaster research. Because of the severe damage they suffered, the restoration of the oyster beds was the main receiver of funding from the Gulf States Marine Fisheries Program (GSMFP), which had 127 million dollars available for the post-Katrina recovery of 5 coastal states (including Mississippi) and had spent 77% of the available funds[19]. The planning of the GSMFP is to have restored 12,000 acres of oyster beds for the state of Mississippi by Spring 2011. The Mississippi Gulf Coast has artificial reefs for geographical reasons[20].

[19] As of November 2010.

[20] According to the GSMFP the coast of the Mississippi is to shallow for natural reefs. Therefore,

The GSMFP explains that Hurricane Katrina has caused a decline in the number of licenses issued, the number of commercial fishermen, and employees of processing plants. All environmentally related expert judgment interviewees identify the fishermen and the employees of the processing plants as the main victims of the damage done by the hurricane. The time series data analysis on the number of shrimp and crab licenses issued provided by the DMR supports the trend that because of the damage done by Hurricane Katrina, the number of licenses issued for the different types of harvesting declined.

The oil spill in 2010 caused some of the restoration to oyster fields to be postponed. Furthermore, no shrimp or fin fishing took place during the period of April to August 2010 because of contamination of the oyster reefs that are very sensitive. After that period, waters were opened again for fishing; however, because of a prevailing perception throughout the US that 'the Gulf Coast beaches are covered in oil' turnover declined further.

An interesting role is being played by the barrier islands in front of the Biloxi coast: according to the GSMFP, the islands have caused the physical damage of Hurricane Katrina to be relatively small.

Another aspect of the Biloxi shrimp market and the shrimp market in the US in general is the large shift that has taken place in consumption. Up till 1994, the US consumed mostly shrimps that were harvested in the US, however, nowadays the majority of the consumption consists of imports (FAO, 2008 and GSMFP). The processing plants industry suffered less from this shift because many of the imported shrimps are being processed in the US (Person M, personal communications, [October 23rd, 2010]).

The city is historically known for its large seafood industry and the shrimp fishing industry in particular (City of Biloxi Comprehensive Plan, 2009). However, because of the low prices of imported sea-products and facilities lost due to Hurricane Katrina, the size of the sector has declined over the last few years (City of Biloxi Comprehensive Plan, 2009). For 2003, the total economic impact of the industry for the Greater Biloxi area was $900 million dollars and it provided employment to 16,800 people. The community has tried to re-strengthen the seafood industry after Katrina by organizing several seafood related events. One of the planned developments is to expand the commercial docking facilities on the Peninsula to both ensure that Biloxi's commercial seafood industry remains a key sector for its economy and to broaden the tourism pull factors.

4.1.6 Timeframe of Recovery

The income and production of the fisheries sector had normalized by 2009 at a level lower than the pre-disaster levels until the oil spill occurred. The Biloxi port director acknowledged that in October 2010 they were waiting for FEMA approval to built two commercial docks and that he will call the sector fully recovered after these two harbors are finished. Another interviewee stated that the sector has recovered as a new normal has been established. However, operationally the recovery is not completed yet: the current governmental projects of the city are all related to the recovery after Hurricane Katrina.

Several of the interviewees described the oil spill as a setback in the post-Katrina recovery process. The main cause in the decreased sales after the oil spill, as described by all interviewees, is that of misperception. All interviewees complained that the national media was portraying the area as completely covered in oil and that therefore seafood from the area is contaminated and unsuitable for consumption. However, the Mississippi Department for Environmental Quality conducted tests through the summer of 2010 testing the quality and safety of the fish caught in the Biloxi area, and concluded

that all seafood was safe for consumption in August 2010 (Person J, personal communications, [October 18th, 2010] and Person M, personal communications, [October 23rd, 2010]).

4.1.7 Changes in Economic and Environmental Characteristics

The fisheries sector is strongly dependent on the environment and therefore the changes in environmental characteristics have been considered. Three types of changes in the environment have been addressed: the change in environmental quality, the change in economic diversity and the change in disaster readiness. Table 4-13 shows the assessments as done by the experts interviewed and the mean of their ratings for each type of change.

Table 4-13 Changes in economic characteristics for the fisheries sector assessments by experts.

Change in	Experts' Assessments				Mean (μ_s) of Expert Judgment Ratings
Environmental Quality (E_Q)	+3	-1.5	-1	-1	-1
Biodiveristy (E_B)	0	0	0	0	0
Environmental Sustainability (E_S)	0	+1	0	+1	+0.5

4.1.7.1 Change in Environmental Quality

Most of the experts agreed that there was a minor change in environmental quality, only the City of Biloxi (Person G, personal communications, [October 18th, 2010]) argued that there was a major positive change in environmental quality, mentioning the natural growth of the Live Oak trees. Other experts mentioned that there are were many invasive species immediately after the Hurricane made landfall, which persisted for years after the Hurricane (Person H, personal communications, [October 19th, 2010]). Others mention the permanent changes done to the barrier islands, which played an important role in protecting the Biloxi coast. Finally, many of the experts mentioned how the presence of debris spread by Katrina has decreased the environmental quality (Person I, personal communications, [October 19th, 2010]; Person J, personal communications, [October 18th, 2010] and Person M, personal communications, [November 23rd, 2010]).

The impacts of Hurricane Katrina are diverse and led to several post-Katrina projects. First, in 1996 the Mississippi State University developed a 1.2 hectare salt marsh using plants that are native in the Mississippi beach environment to see to what extent the tidal pool could function as a storm drain. When in August 2005 Hurricane Katrina hit, the site gained a vast amount of sand. Furthermore, several of the artificial reefs were damaged (Person M, personal communications, [November 23rd, 2010]). All Biloxi's harbors directly located along the Gulf Coast were damaged as was much of the infrastructure and built-up environment.

Among the direct effects of Hurricane Katrina on the coastal environment were the following: spread of debris; extensive tree loss and nearly complete loss of vegetation at the mid-beach; some parts of the dune grasses were heavily de-rooted (Person G, personal communications, [October 18th, 2010]).

The Harrison County Sand Beach Commission writes that post-Katrina recovery projects are still ongoing. Several recovery projects are ongoing: a US Army Corps of Engineers has a project to bring back the lost sand to the beaches; the Mississippi Coastal Improvement Program has received funding to re-

establish the vegetation of the sand dunes; and parking lots near the seawall are being restored. Finally, the cleaning of the near-shore waters is finished (Person M, personal communications, [November 23rd, 2010]).

4.1.7.2 Change in Biodiversity

None of the experts said there was a change in biodiversity caused by Hurricane Katrina. All the same species as were present before the hurricane came back or stayed after. Person M explains that 127 million dollars from Congressional funds had been used for resource recovery, restoring the oyster beds, cleaning up the habitats and providing post-disaster research on stock assessment (Person M, personal communications, [November 23rd, 2010]). Of this five year grant, 77% was spent by November 2010 and 12,000 acres of oyster beds will be restored by spring 2011. He also explains that because the coast in front of the state of Mississippi is shallow, and therefore artificial reefs had to be established which were restored after Hurricane Katrina damaged them. Person M acknowledged that the oil spill has caused a setback in the post-disaster progress and development, but the Gulf States Marine Fisheries Commission is now planning on putting the last oyster fields in spring 2011 (Person M, personal communications, [November 23rd, 2010]).

4.1.7.3 Change in Environmental Sustainability

The changes in environmental sustainability have been very minor. One expert mentioned that the connection between residents and the environment had become stronger and that awareness had increased (Person H, personal communications, [October 19th, 2010]). the Gulf States Marine Fisheries Commission states that there was a minor increase in environmental sustainability with the recent implementation of monitoring tools that control the state of the restored artificial oyster beds (Person M, personal communications, [November 23rd, 2010]).

4.1.7.4 Change in Economic Diversity

Section 3.4.3.2 studied the change in economic diversity of the city of Biloxi and it appeared that for the fisheries in particular, the prevalence of the fisheries related sector (forestry, fishing, hunting and agriculture support) in absolute numbers remained equal to the pre-disaster situation but its percentage contribution has decreased during the post-disaster recovery period. Person M explains that the number of oyster fisherman has gone down during the recovery period but that the number of shrimp fishers was already decreasing before the Hurricane because of changed markets: imported shrimp has become cheaper from the mid nineties on, causing the local shrimp fishers market to shrink ((Person M, personal communications, [November 23rd, 2010])).

4.2 Analyses: A Combined Assessment

This research uses the tourism and fisheries sectors to address how environmental recovery links to economic recovery, where tourism is used as a representative for the local economy in general and fisheries as a natural resources-dependent sector. Person G, mentioned during the interview: “tourism and fisheries are the primary link between environmental and economic recovery” (Person G, personal communications, [October 18th, 2010]). The tourism sector is dependent on the environment in terms of

the beaches, as Person B, director of the Mississippi Lodging Association, pointed out, but she also explained that people don't come to Biloxi to lay down on the beaches; "if we can get things in place that will encourage the development on the beachfront, that is what most needed". "The tourists who come here like to go to pretty places. They don't like to see these empty lots" (Person B, personal communications, [November 1st, 2010). Person I, Mississippi Department for Environmental Quality, commented: "Employment acts as a base for the link between environment and economy." "Environmental recovery has helped to promote economic recovery, however economic recovery is lagging behind" (Person I, personal communications, [October 19th, 2010]). However, the vast majority of the tourists come for the casinos which are highly independent of the natural environment whereas the fisheries industry has a much strongly dependence.

4.2.1 Differences in Resilience

It appeared from the analyses done in this chapter that the non-environment dependent tourism sector recovered quicker, with more ease and came closer to pre-disaster levels compared to the fisheries industry. However, it should be noted that the tourism industry was stronger before the Hurricane than the fisheries sector as the latter was subject to both local and national decline. Furthermore, the fisheries are almost all local businesses while almost all casinos in Biloxi are part of larger cooperations which explain the difference in financial resilience.

There has been research done studying the resilience of the local fisheries community in Biloxi. A study by Chau Van (2009) describes the resilience of the local Vietnamese resident of Biloxi who make up an important part of the local fisheries community. It explains the strong resilience of the Vietnamese community in Biloxi in terms of the following factors: the experiences and strength gained from the Vietnamese war; the process of having to leave their own country, immigrate to the US and having been discriminated by the American fishermen in Biloxi (Chau Van, 2009).

The resilience of the tourism sector has been explained by many interviewees as caused by the presence and rapid recovery of the large casinos in the area. First, after Hurricane Katrina, the casinos were allowed to built on the north side of the highway 90 (in a range of 150 feet from the highway[21]) which most of the casinos used to move from the south side to the slightly higher located north side. This measure of mitigation, rebuilding away from the beach, taken by the casinos allowed them to rebuild faster than would have been the case if they stayed in the same location. Secondly, the casinos in Biloxi are part of a joint casino with more locations and assets. These factors increased the resilience of the casinos, but also increased the resilience of the community of Biloxi as a whole because it allowed for a continuous influx of tourists which drives the local economy at many levels. As Figure 4.7 shows there is a clear spike in the supply of rooms from 2007 on. There is also an increase in demand for hotel rooms from 2007 to 2008; this change can be explained by the pull factor that the quick recovery of the casinos seems to have been.

However, many of the smaller businesses had more trouble returning to business. Many of the experts mentioned that almost none of the local grocery stores reopened after the Hurricane and many (fish) restaurants had trouble reopening. Causes for the slow and small number of reopening of local

[21] Source: interview with Person C from City of Biloxi Community Development.

business are threefold. First, all interviewees mentioned the slow process by which insurance companies reimburse locals and business for the damage caused by the hurricane. Many of the local grocery and restaurant owners lived in the area as well and needed their financial means to recovery personally first before they could recover their businesses. Secondly, as mentioned before, the fishing industry was severely impacted by the Hurricane which decreased the supply of fish, shrimp, oysters and crab for both the national as well as the local market. Finally, the lack of tourists not only made for a lack in push factors to recover businesses but also decreased income.

4.2.2 The Role of the Barriers Islands

The barrier islands in front of the Biloxi coast in the Gulf of Mexico, fulfilled an important role as a mitigation system. Several experts interviewed emphasized that the damage to the ecology and the reefs was much smaller than it likely would have been without the presence of the islands. The islands themselves were damaged as well because of the Hurricane: some islands have been cut in two, many trees were cut down and some parts of the islands have been eroded. This was also due to the effects of the 1968 Hurricane Camille on the barrier islands which caused severe damage and erosion.

4.2.3 Comparison with Recovery of the General Economy

It has been assumed that the tourism sector would be an appropriate proxy for the recovery of the economy as a whole. This section will briefly present the trajectory of the economic recovery as a whole and compare this with both the tourism and fisheries sector. The data analysis for this trajectory recovery is similar to the analysis of the tourism trajectory of recovery. Figure 4.18 shows the trajectory of the recovery of wages for the entire economy of Harrison county as a ratio of the state of Mississippi. Figure 4.19 shows trajectory of recovery of the number of paid employees in Harrison county as a ratio of the state of Mississippi. From these figures it appears that the trends in the trajectory of recovery of both wages and employment are similar for the tourism sector and the general economy of Harrison County.

The trend for the trajectory of recovery of the number of establishments as shown in Figure 4.20 is also similar to the trends shown by both the tourism and the fisheries sectors.

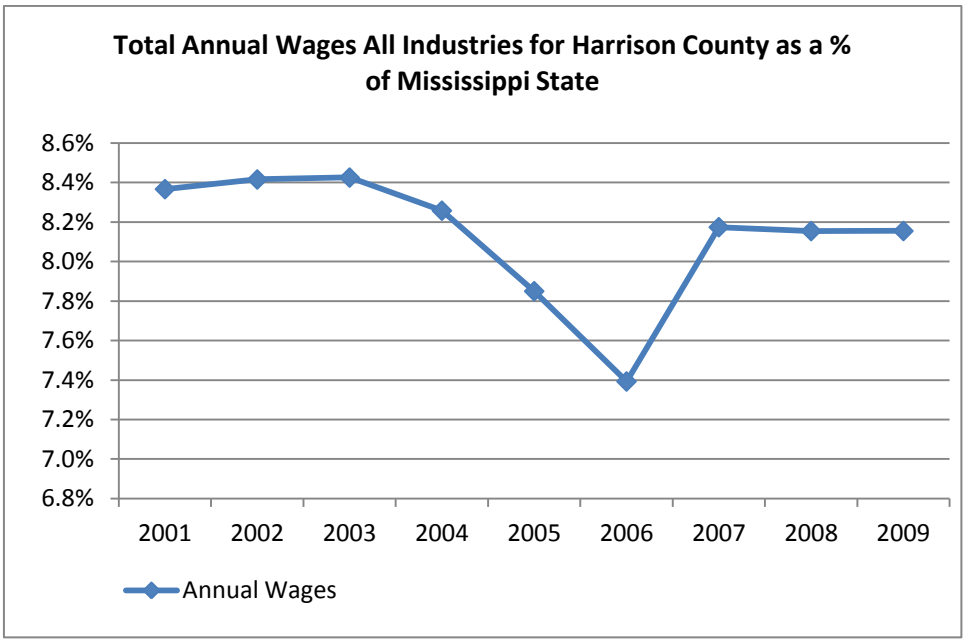

Figure 4.18 Average annual wages for all sectors in Harrison County as a proportion of Mississippi State. Source: Census County Business Patterns data.

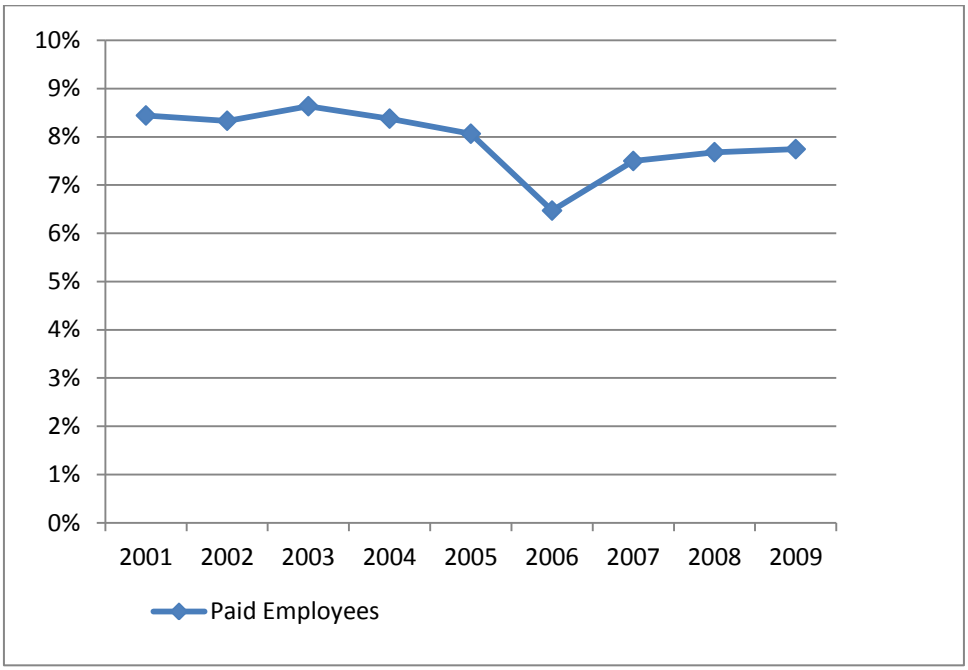

Figure 4.19 Annual number of paid employees for all industries in Harrison County as a proportion of Mississippi State. Source: Census County Business Patterns data.

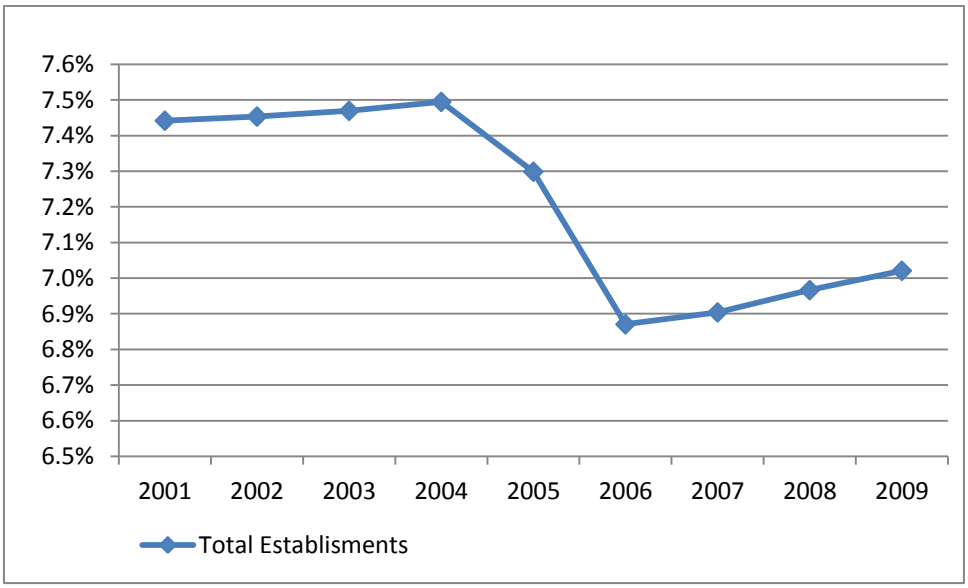

Figure 4.20 Total establishments for all sectors in Harrison County as a % of Mississippi State. Source: Census County Business Patterns data.

4.3 Linkages; the Revised Diagram

This section will present the last version of the linkages diagram, shown in Figure 4.21, using the revisions and additional insights provided by the time series data analysis and the information obtained through the expert judgment interviews. One of the issues mentioned by all experts interviewed is that of perception in relation to the BP oil spill of May 2010, mostly by consumers of fish and potential tourists from outside the region which is why this linkage is placed outside the box in figure 4.21. Another factor originating from outside the region is the economic downturn that caused hardship for the fisheries industry in particular but also for the economy as a whole and the tourism sector as an important pillar of that. This linkage is also located outside the region because experts perceived this as an external factor influencing their recovery.

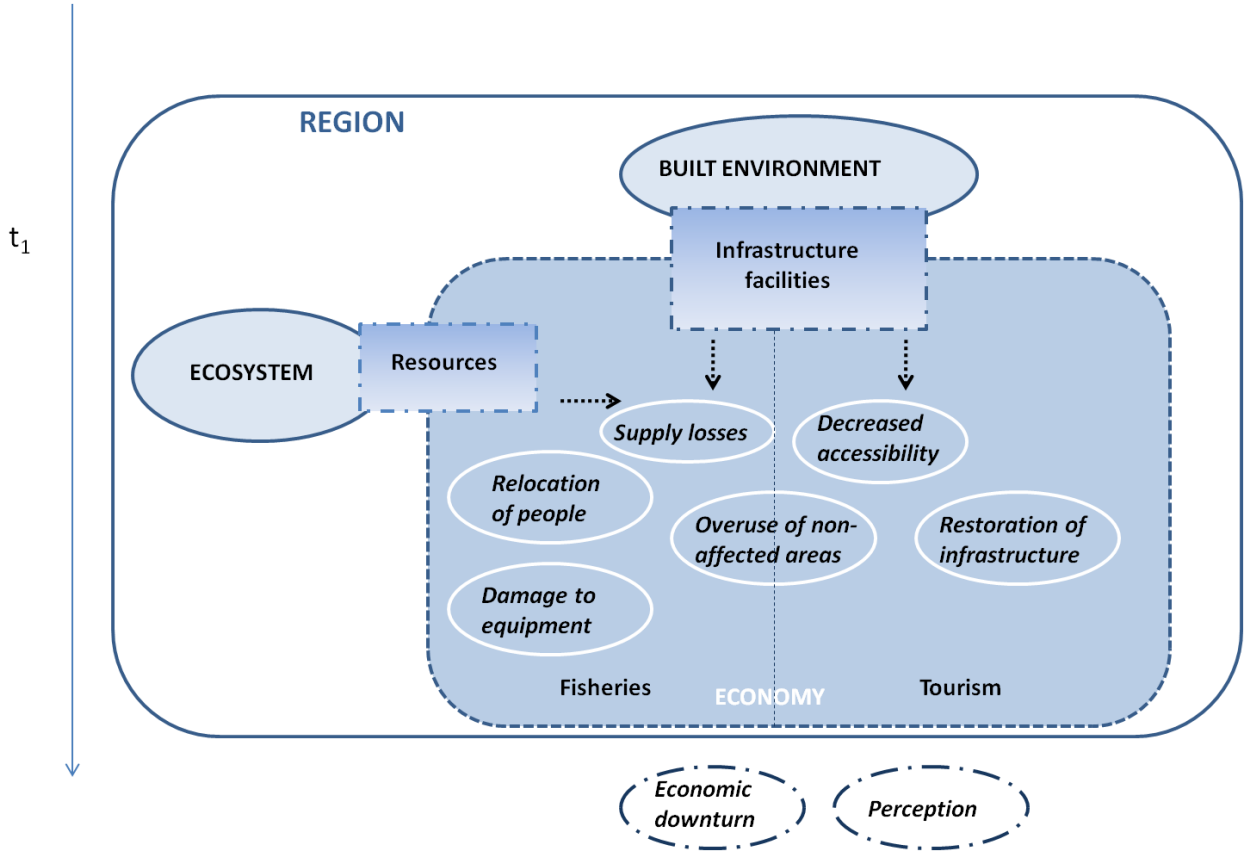

Figure 4.21 Adjusted diagram for linking environmental and economic Recovery based on the literature reviewed in this chapter. The linkages are denoted by the white ovals for linkages within the region and striped blue ovals for linkages outside the region.

Within the region there are different linkages between the recovery of the environment and the recovery of the economy. For the fisheries sector there were several issues. Hurricane Katrina had damaged the fishing equipments which led to fewer landings. Furthermore, a part of the fisheries community had to relocate because of the damage done by the Hurricane and therefore couldn't maintain their life as fishermen. Katrina had damaged the artificial oyster reefs which decreased the supply of fish and shrimp in the Mississippi Gulf Coast. Finally, non-affected areas suffered from overuse which caused the supply of fish to decline as explained by Person M.

The tourism sector suffered from damaged infrastructure and decreased accessibility of the area. Almost all casinos moved from the south (beach) side of the highway 90 to the north side as changed legislation after Hurricane Katrina allowed them to do so.

5 Discussion, Conclusions and Recommendations

This master's thesis research has examined the linkages between environmental and economic post-disaster recovery for coastal communities. This chapter will present the main conclusions, discuss issues that arose during this study, and finally, make recommendations for future academic research and for practitioners based on the findings of this study.

5.1 Conclusions

A goal of this study was to develop a framework to determine the linkages between environmental and economic recovery. To this end, the tourism sector was chosen as a representative of the economy in general and the fisheries industry as a representative of a natural environmental dependent sector. Both tourism and the fisheries industries recovery are the dependent variables and it was hypothetical that the recovery of the fisheries sector could be explained by environmental recovery. The research questions posed for this master's thesis were as follows:

1. *What does environmental recovery mean after a natural disaster?*
    a. *How can this recovery be measured?*
    b. *What empirical insights can be gained from measuring this?*
2. *How does environmental recovery relate to economic recovery?*
    a. *How do coastal communities recover economically from natural disasters?*
    b. *What is the role of the environmental recovery for resource dependent sectors of coastal communities?*

The answers for the first research question and the conclusions drawn based on the literature review can be summarized as follows:

- Environmental recovery can be measured in terms of its value for humans, using the anthropocentric paradigm which was the focus of this thesis, and in terms of its intrinsic, ecosystem value. The literature studied in this thesis was used to answer the first research question and focused on valuing ecosystem services to determine the link between environmental and economic recovery.
- Based on the discussed literature, it was concluded that the extent to which the local ecosystem can sustain or attribute to the pre-disaster economic sectors depends on the resources provided by the natural environment. The change in economic value of these goods and services provided by natural ecosystems can be measured in two ways: (1) as the willingness to pay of an individual or group to secure the change, and (2) as the amount needed to compensate an individual or group for the change.
- From the literature and the case studies discussed in the literature review it appeared that perception forms an important link between environmental and economic recovery. Other

linkages determined by the literature are: supply loses, decreased accessibility and overuse of non-affected areas.

The answers for the second research questions were derived from the case study as discussed in chapter four and the conclusions can be summarized as follows:

- In explaining why large casinos recovered more easy and quickly than the local ones, it can be stated that a large casino that has establishments elsewhere in the country as well, has more resources (in terms of money, employees (economic resources), etc.) and therefore has a higher resilience to withstand the impacts of a natural disaster and is therefore expected to be less dependent on local environmental resources such as the beach and the ocean near which they are located.
- It appeared that there are several issues that influenced the post-Katrina recovery including: the economic downturn, the decrease in the national shrimp market and the BP Horizon oil spill of May 2010.
- It appeared that the tourism sector, which is not very dependent on the coastal environment and has the financial assets from casinos from the same chain in other areas of the country that were unaffected by Hurricane Katrina and the oil spill, recovered more quickly from the disaster than the fisheries sector. However, both sectors are still behind their pre-disaster income and production levels. Therefore, in answer to research question 2a, it can be concluded that the non-environment dependent sectors recover more quickly and better, in terms of income and production levels, from a natural disaster but due to problems with misperception, stay behind their pre-disaster economic levels.
- Furthermore, the general economy changes during the recovery period by the loss of small businesses that didn't return and were replaced by large and (inter)national businesses.
- In answer to research question 2b, for the environment dependent fisheries sector, it appeared that the recovery of the fisheries sector was lagging behind the recovery of the natural environment. This was mostly caused by the post-oil spill perception outside the region that fish from Biloxi wasn't safe to eat. Other issues that played a role are: the general economic decline in the sector, the economic downturn of 2008 and the difficulties for the fishermen who were located in the region and impacted not only economically but also personally.

Additional key insights regarding factors influencing the recovery of the tourism sector as identified by the interviewed experts are:

- Several experts mentioned the importance of the rebuilding of highway 90, which runs west-east connecting New Orleans with Biloxi and the city of Mobile, for the return of tourists and a return to normalcy in general.
- Pre-disaster preparation and mitigation efforts could have alleviated the post-disaster recovery process.
- The different aspects of recovery are all very much intertwined and influence different recovery processes: a lack of tourist in the area in the first years after the Hurricane decreased the

amount of economic means, (local) business couldn't return or went out of business, and local residents dependent on income from these businesses had difficulties rebuilding their houses.

- Especially after the oil spill, many experts felt that it was difficult to deal with the media-created perception of their beaches being covered with oil, which is still persistent. In contrast, the actual conditions of the beaches improved within the first few months and never were as bad in their region as portrayed by the media. This misperception caused tourist and visitor numbers to stay low.

Additional insights on factors influencing the recovery of the fisheries sector as identified by the interviewed experts are:

- Several experts mentioned the impacts of the oil spill on the recovery of the oyster and shrimp-fishing industry after Katrina.
- During the first few months after the hurricane, fisherman were hired to help with cleaning up the debris which provided financial help for fishermen.
- The rebuilding of the harbors, incorporating mitigation efforts such as enforcements of the piers, was crucial and because this process took place already in the first few months after the Hurricane, fishermen were able to get out on the water six months after the Hurricane.

5.2 Discussion

This study has made certain assumptions to keep the scope of this research manageable, which has influenced the outcomes of this study. This section will explain the influences of the choices made. Furthermore, the selection of the case study area used in this thesis has influenced the outcomes as well. As explained in preceding chapters, the case study area was chosen by the NSF project team for the collaborative research with characteristics that were specific for the site and therefore some of the conclusions made can only be drawn for this specific case. First, the theoretical approach chosen for this research and the implications for the outcome will be discussed. Next, the specifics of the case study area and its implications for the results and conclusions, as well as its applicability to other sites, will be discussed.

5.2.1 Theoretical Approach

This interdisciplinary study as reflected in the interdisciplinary character of the combined assessment of the data analysis. A combined assessment, using both quantitative and qualitative data leads to a broader understanding of the results but also potentially lacks a more in-depth understanding of underlying issues. This study didn't aim to do a complete, comprehensive qualitative study, but it should be noted that a more thorough analysis of the expert judgment interview data likely would not have led to different outcomes. Different insights could have been obtained by including non-expert interviews but this was outside the scope of this study as well as of the collaborative research project.

5.2.1.1 The Influence of Using Different Paradigms

In chapter two, two different ways of thinking about the environment – the anthropocentric and ecocentric paradigms – were discussed and used to answer the first research question. Within

ecocentrism, two sub-paradigms were distinguished: weak and strong ecocentrism. The analysis in this thesis is based on an anthropocentric paradigm. However, it should be noted that the choice of these two specific paradigms is optional, and other paradigms could have been chosen which could have let to different outcomes. As explained in chapter two, environmental recovery is one of the least studied aspects of post-disaster recovery. One of the reasons for this is the vast variety of ways in which the recovery of the environment can be studied and ways that intrinsic value can be attached to an ecosystem, its components, the influence of human interactions, and use of the ecosystem (Minteer 2009).The outcome of this thesis would have been different had an ecocentric paradigm been adopted, because the nature of the change that takes place in an ecosystem as caused by a natural disaster would have been viewed significantly differently. The current perception in the western world where ecosystems are valued for their natural resources is best captured by the anthropocentric paradigm. This perception is not or to a lesser extent captured by the ecocentric paradigms. Furthermore, the term "natural disaster" is arguably an anthropocentric one because it assumes that a natural event that influences humans and their environment negatively is a "disaster". Similarly, we tend to speak of floods or hurricanes as "natural events" rather than "natural disasters" when humans are not impacted by or vulnerable to these events (e.g., when they occur in an unpopulated area).

Nonetheless, it is interesting to think of the metrics and ways in which post-disaster recovery of the natural environment could be measured when assuming an ecocentric paradigm. I would even like to argue that within the strong ecocentric paradigm, recovery of an ecosystem might not even exist as a construct, as it is a contradiction in terms when a natural disaster is not perceived as a disaster but as a natural event. Within the weak ecocentric paradigm, measuring environmental recovery is theoretically possible, but there are issues caused by the different ways in which the intrinsic value of nature is defined. Also, the timeframe over which the recovery of the natural environment is measured is challenging to define. When a natural event is part of a longer-term cycle, whether this is a natural cycle of change or to maintain long-term stability, then the impacts of an event such as a hurricane need to be studied over this timeframe, which might be decades.

Finally, two of the anthropocentric definitions of post-disaster can be adopted -- recovery to a pre-disaster situation and recovery to a new stable state-- but how would one define recovery when one assumes that an ecosystem is constantly changing and there is no stable state, natural development to a pre-disaster state, or a state that the environment would have been in had the disaster not occurred? Metrics that could be used to measure post-disaster recovery of an ecosystem in a weak ecocentric paradigm would have to take into account human as well as non-human factors that depend on the ecosystem. Summarizing, I don't think the current phrasing of the research questions would have done justice in providing an appropriate answer when assuming an ecocentric paradigm. I think the research questions would have to have been phrased and framed differently to address the concept of post-disaster recovery of the natural environment from an ecocentric paradigm.

5.2.2 Case Study

5.2.2.1 Specific Economic Characteristics

The case study used in this thesis of the Biloxi area of Mississippi following Hurricane Katrina in 2005 has been chosen by the NSF project team, but the city has some particular economic characteristics that

make it not necessarily representative of coastal cities of Hurricane prone areas in general. It should be acknowledged that the economy of the city of Biloxi is a special case where tourism in a coastal city is not dependent on the environment, unlike other coastal cities in the US` Hurricane prone Gulf Coast.

Another issue is that of national trends in the shrimp industry that according to the experts interviewed, influenced the recovery of the fishing industry of Biloxi significantly. The decline of the shrimp industry can only partly be attributed to the effects of Hurricane Katrina.

It has been acknowledged that a full assessment of the impacts of the Deepwater Horizon oil spill were outside the scope of this study. However, from the research done into the implications, it appeared that the BP Horizon oil spill influenced not only the tourism and fisheries sector for the duration of the oil spill and the clean up, but continued to have negative influence on both visitor numbers and fish sales because of perception.

5.2.2.2 Other Characteristics

The spatial environmental characteristics of the Biloxi coast played an important role in the impacts of Hurricane Katrina. The barrier islands in front of the Biloxi Gulf Coast functioned as a Hurricane mitigation system, lowering the impacts of the Hurricane on land but washing away big parts of the islands. Furthermore, there were data limitations in terms of the spatial resolution of the different statistical time series. Much of the tourism data was available for Harrison County, but much of the fisheries data were only available for the Biloxi-Gulfport MSA. Therefore, the conclusions drawn about the post-disaster recovery of Biloxi are biased by other developments in Harrison County or in the Biloxi-Gulfport MSA.

5.3 Recommendations

This research suggests several recommendations for future academic research as well as for practitioners.

5.3.1 Recommendations for Researchers

First, it would be interesting to do a comparative study where the results of this study are being compared with another case study area of a coastal fisheries community that is affected by a natural disaster. This would provide insights in differences and similarities between the impacts of different disasters on fisheries communities and also provide more insights on the differences in post-disaster economic recovery.

Secondly, this study used the tourism sector as a proxy for the recovery of the general economy. It would be interesting to compare the outcomes of this study with a case study of a coastal area with a large tourism based economy that is highly dependent on the natural coastal environment. The outcomes of that study could not only be compared with the non-environmental dependent tourism sector of this case study but also with the coastal dependent fisheries sector of this study.

5.3.2 Recommendations for Practitioners

Three of the introductory interview questions asked the experts to describe what worked particularly well, what they would have done differently in hindsight, and if they had any recommendations for other

practitioners. The outcomes of these questions provide interesting insights for other practitioners in coastal disaster prone areas.

- Several of the recommendations made by the experts encourage the development of pre-disaster preparation plans in terms of training, education and mitigation. David Person D explained that having pre-disaster contracts for the cleanup of debris shortened the immediate recovery process (Person D, personal communications, [October 18th, 2010]).
- Putting into place pre-disaster building codes and maintaining those updates can decrease the damage caused by a Hurricane.
- Another issue raised by the experts is the importance of communication with the local community. Person B (MS Hotel and Lodging Association Director) explains the importance of communicating the predicted storm track and the potential damage that can be caused by a Hurricane in order to decrease the number of people staying behind.
- Other experts emphasized the importance of cleaning up the infrastructure first to facilitate an easier return of economic actors in the area.
- For funding that becomes available for multiple states, it helps to have pre-disaster methods in place to value damage. Person M explains the trouble of allocating money for recovery when different states use different damage measurements (Person M, personal communications, [November 23rd, 2010]).
- For environmental recovery in particular, it is important to coordinate post-disaster recovery assistance with EPA.

This study examined the linkages between environmental and economic post-disaster recovery for coastal communities using the effects of Hurricane Katrina on the Mississippi Gulf Coast as a case study. The importance of this thesis is emphasized by the rarity of studies looking into the recovery of the natural environment in urban areas and the connection between environmental and economic recovery. This thesis has aimed to reveal these 'hidden losses' of for example, the contribution of the fisheries community to the overall economy and the differences in recovery between an environment dependent economic sector and a non-environment dependent sector. This has been examined within an anthropocentric paradigm. It appeared that the tourism sector, in this thesis used as a proxy for the general economic recovery, recovered more easily after Hurricane Katrina than the environment dependent, fisheries sector.

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Appendix

Appendix A: NSF recovery description and participants

New Methods for Measuring, Monitoring, and Evaluating Post-Disaster Recovery

Project Description

Post-disaster recovery—one of the phases of the disaster management cycle—is a complex physical, social, economic, environmental, and political process. An improved understanding of recovery could promote recovery planning prior to a disaster as well as management following a disaster. Given the importance of recovery, limitations of previous research on it, and new technological opportunities, this project aims to develop innovative methods for systematically and quantitatively measuring, monitoring and evaluating post-disaster recovery.

The systematic examination of recovery using multi-source data can empower communities and provide evidence to support their experiences of the recovery process. It can open a new source of dialogue and discourse that could have practical repercussions for the creation of resilient communities, for the distribution of aid and resources, as well as theoretical discussions on the potential identification of different types of recovery, dependent on their initial conditions and key decisions post-disaster. Further, by augmenting existing ways of empirically measuring recovery, the project advances the state-of-the-art in post-disaster recovery studies and supports the continuing development of a theory of post-disaster recovery.

This project is producing unique comprehensive recovery datasets, including new remote sensing based and previously underutilized statistical data, together with more traditional, qualitative data. New methods for acquiring and analyzing recovery data can provide diverse benefits to those who manage, fund, and study disaster recovery. Methods developed potentially could be used to address questions including:

- For a disaster that has just occurred, over what timeframes and in what ways is recovery likely to unfold?
- Why is recovery proceeding in a particular way?
- How are recovery speed and character correlated with various pre- and post-disaster decisions and actions?

Study Areas and Study Events

Two project study areas support methodological development to focus on communities in Florida impacted by Hurricane Charley, with validation of the method using areas of Mississippi affected by Hurricane Katrina.

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