ECONOMIC DAMAGES TO INFRASTRUCTURE INCURRED BY LOUISIANA FISHING INDUSTRIES DUE TO HURRICANES KATRINA AND RITA IN 2005

Report to the:

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National Oceanic and Atmospheric Administration

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SUMMARY

Hurricanes Katrina and Rita severely damaged the infrastructure and livelihoods of commercial and recreational fishers along the northern Gulf of Mexico, with the majority of this damage occurring within the Louisiana coastal zone. Rapid assessments of economic damage were widely published in the popular media and used as the basis for proposed economic and ecosystem recovery efforts, even though many of the initial estimates lacked the data required to be conclusive in nature. As part of an ongoing effort to assist coastal states in the acquisition and distribution of federal aid during the recovery process, this study provides a more detailed examination of fisheries infrastructure damage using new estimates that were generated from both established and novel procedures for quantifying damage from natural disasters.

Hurricane storm surge modeling data was combined with data on commercial fishing revenues and vessel markets to obtain geographically-specific estimates of the damages to coastal fisheries infrastructure after Hurricanes Katrina and Rita. A GIS context was developed to map peak storm surge height for more than 11,000 geo-coded fishing infrastructure locations in coastal Louisiana (i.e., fishing vessels, seafood dealers, and processors). Ground-truth data from sample sites was used in estimating, among other things, the percent of infrastructure that was lost due to the storms and the dollar amount of that damage for each location. This information was then used to statistically estimate surge-specific damage functions that were subsequently applied to all (non-sample) infrastructure sites, thereby allowing the calculation of aggregate storm impacts. Estimates of direct damages to the commercial and recreational fishing fleet were based on characteristics obtained from pre- and post-storm vessel registration records and from price regressions estimated using data from marine trade publications and websites.

Total losses, estimated at near $582 million, fall near the mid-point of the range of loss estimates generated by the initial coast-wide assessments produced in the weeks following the storms, suggesting that rapid assessment methods (at least in aggregate) may not be as subjective as they first appear. Because of the large geographic scale of the impacts in Louisiana, a regional approach was developed in order to characterize damages within physical sub-basins and political boundaries. Four regions were defined for the purposes of this report: Region 1, the parishes bordering the southeastern and northern shores of Lake Pontchartrain; Region 2, the coastal parishes of southeastern Louisiana; Region 3, the coastal parishes of south-central Louisiana; and Region 4, the coastal parishes of southwestern Louisiana.

As might be expected given the storm tracks, the bulk of physical impacts from the hurricanes were concentrated in Region 2 and Region 4. Consequently, these regions had the highest levels of economic damage ($226 million and $134 million, respectively) proportional to their levels of extant, pre-storm infrastructure. Region 3, an area that is home to a large number of commercial dealers and processors, received the second highest level infrastructure damages, $151 million. At $582 million, the overall damage estimates for Louisiana are almost twice the reported damages incurred to fisheries infrastructure in coastal Mississippi ($293 million) and more than four times the level of damages in Alabama ($112 million). The table below provides a general summary of the coast-wide and regional economic losses for Louisiana fisheries sectors resulting from Hurricanes Katrina and Rita.

SUMMARY TABLE:

Coast-wide and Regional Estimates of Economic Losses to Louisiana Fisheries Infrastructure Resulting from Hurricanes Katrina and Rita.

Coastal Area	Commercial Dealers [a]	Commercial Processors [b]	Commercial Fishermen [c]	Recreational Vessels [d]	Total Losses
Region 1	$5,359,541	$792,716	$4,709,724	$60,945,259	$71,807,240
Region 2	$48,359,012	$5,760,351	$93,508,113	$78,049,621	$225,677,097
Region 3	$29,457,307	$25,541,192	$35,229,893	$60,873,018	$151,101,410
Region 4	$20,346,326	$31,741,883	$57,849,714	$24,136,588	$134,074,511
Total Losses	$103,522,186	$63,836,142	$191,297,444	$224,004,486	$582,660,258

[a] Estimated losses in the market value of a dealer business.

[b] Estimated losses in the market value of a processor business.

[c] Estimated discounted total revenue losses of commercial fishermen through 2010 (in 2005 dollars). Inclusive of vessel losses.

[d] Estimated market value of lost recreational fishing vessels.

INTRODUCTION

On the morning of August 29th, 2005, Southeast Louisiana was hit by the extreme winds and flood surge associated with Hurricane Katrina. Less than 4 weeks later, on September 24th, Hurricane Rita struck the Southwestern part of the state. Louisiana's commercial seafood industry, already in decline for a number of economic reasons, was further crippled as a result of damage to vessels, docks, processors, and the distribution sector. Even those individuals who were able to fish immediately after the storms experienced problems, especially in selling their product, due to destruction of the input supply, distribution, and local retail sectors.

Initial recovery efforts on behalf of the fishing industry required the development of rapid assessments of the physical and economic impacts of the storms. In September 2005, initial damage estimates from Hurricane Katrina were developed by the Louisiana Department of Wildlife and Fisheries ($LDWF_a$ 2005). In October 2005 after Hurricane Rita, subsequent damage estimates were released by LDWF and the Louisiana State University Agricultural Center ($LDWF_b$ 2005; LSU AgCenter 2005). These estimates, widely published in the media, were developed using different methods and assumptions. Despite methodological differences and the wide range of estimated damages, these preliminary reports were frequently cited in support of various emergency funding initiatives.

In January 2006, the National Oceanic and Atmospheric Administration (NOAA) requested that economists in Alabama, Mississippi, and Louisiana develop independent assessments of the economic damages to fisheries infrastructure resulting from hurricanes Katrina and Rita. The purpose of the studies was to provide more detailed estimates of fisheries infrastructure damage that would assist coastal states in the acquisition and distribution of federal aid during the recovery process. In addition, the new estimates were to be generated using both established and, if necessary, novel procedures for quantifying damage from natural disasters using a variety of primary and secondary data sources. This effort was expected to be iterative in nature, especially in Louisiana, where the study was complicated by the magnitude of impacts from two major hurricanes. It was also hoped that the study could provide some guidance on how economic assessments could be conducted following future natural disasters affecting the fishing industry.

This report on the Louisiana study is divided into six sections. Section 1 provides brief overview of commercial and recreational fishing in the northern Gulf of Mexico, with a specific emphasis on Louisiana. This introductory background material provides the context for Section 2, which includes qualitative descriptions of the scope and scale of the storms' impact on particular fishing sectors, and descriptions of the initial recovery efforts in Louisiana. In Section 3, the pre-storm contributions of commercial and recreational fisheries are characterized for four coastal study regions. A description of the data acquisition process and an explanation of damage assessment methods are provided in Section 4. Quantitative results of the damage assessments - expressed for each of the four regions and coast-wide, are detailed in Section 5. The final section, 6, includes a summary of the overall findings for Louisiana, a comparison to economic damage estimates from other states, implications for the fishing industry in Louisiana, and additional research needs.

SECTION 1: STATUS OF NORTHERN GULF FISHERIES

Unlike the case in many other countries, U.S. fisheries in the northern Gulf of Mexico are jointly exploited by commercial and recreational interests, with each being important to the local and regional economies. Given this, it is important to understand the status of both of these sub-sectors prior to the 2005 hurricanes in order to provide the appropriate context for the subsequent analysis of hurricane impacts.

Commercial Fisheries

In the last decade, fisheries landings from the five states[1] of the northern Gulf of Mexico have accounted for 32 to 41 percent of all fisheries landings in the coterminous U.S.[2] (Figure 1.1). Marine fisheries production in this region is stimulated by freshwater input from the Mississippi River, particularly in Louisiana where the river historically built more than 4,700 square miles of prime fisheries habitat in the form of deltaic wetlands. This estuarine influence has made Louisiana ports the perennial leader in U.S. fisheries landings, second only to Alaska. Of the top five U.S. fisheries ports by volume, 4 are located in the northern Gulf and 3 are in Louisiana. In 2004, the ports of Empire-Venice, Intracoastal City, and Cameron were the nation's first, third, and fourth largest commercial fishing ports in terms of volume handled (Table 1.1).

On average, Louisiana contributes approximately 75 percent of northern Gulf of Mexico commercial landings by weight and 41 percent of by value (Figures 1.2 and 1.3). The majority of this volume (85 percent) consists of gulf menhaden (*Brevoortia patronus*), a primary source of commercial fishmeal. Other major fisheries include the eastern oyster (*Crassostrea virginica*),

[1] These states include Texas, Louisiana, Mississippi, Alabama, and the west coast of Florida.
[2] Exclusive of Alaska and Hawaii.

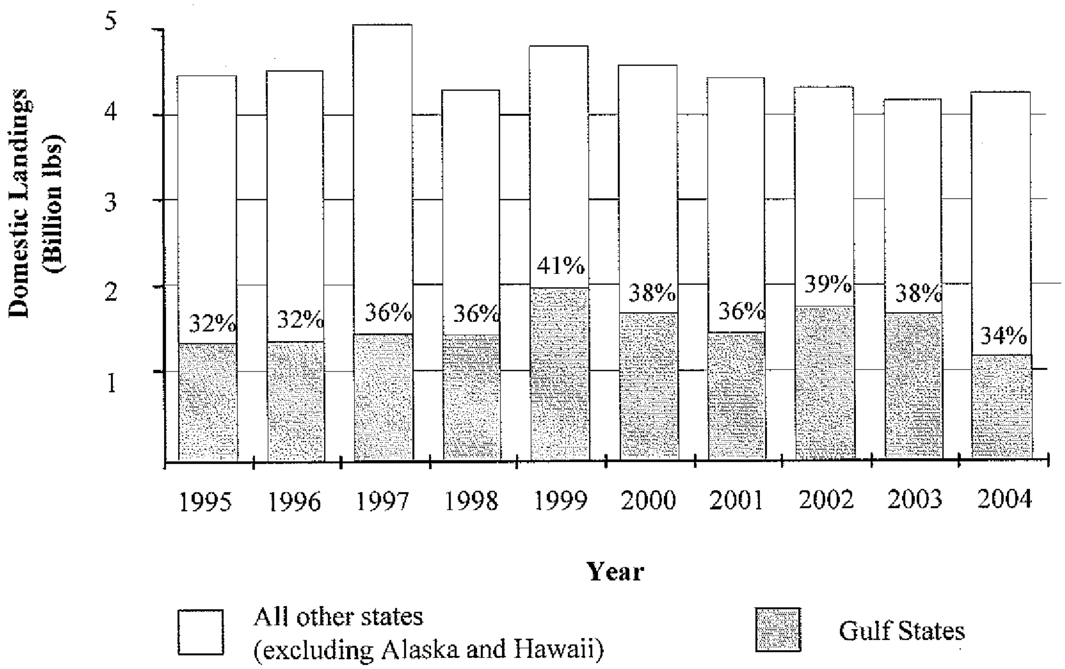
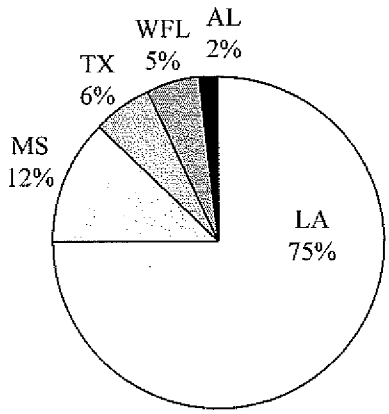


Figure 1.1 Fisheries Landings from Continental United States and Northern Gulf of Mexico

Table 1.1 Top 10 US Fisheries Ports by Volume

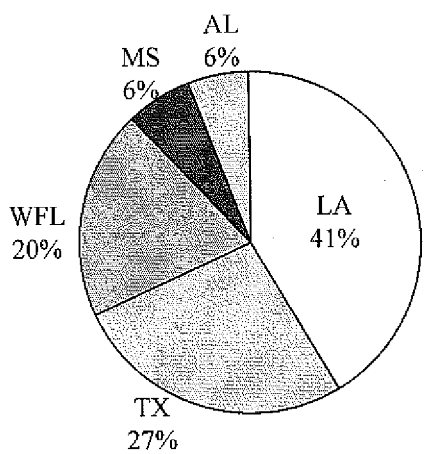
Ports[1]	2004 Landings (millions of lbs)
Empire-Venice, LA	400
Reedville, VA	375
Intracoastal City, LA	325
Cameron, LA	259
Pascagoula-Moss Point, MS	192
New Bedford, MA	155
Astoria, OR	114
Gloucester, MA	89
Los Angeles, CA	89
Portland, ME	69
Total US[1]	2,067
Total LA	984

[1] *Excluding Alaska and Hawaii*
(NMFS 2005)



Fishery	Weight (lbs)	Share
Menhaden	862,946,535	81%
Shrimp	130,724,873	12%
Crab	44,072,835	4%
Finfish	18,628,209	2%
Oyster (meats)	13,902,704	1%

Figure 1.2 Fisheries Landings by Weight for the Northern Gulf of Mexico and LA Landings Volume by Sector (NMFS, Fisheries of the United States 1995-2004).



Species	Value	Share
Shrimp	$138,053,868	55%
Menhaden	$35,253,602	14%
Oyster	$34,893,978	14%
Crab	$29,020,445	11%
Finfish	$15,735,390	6%

Figure 1.3 Fisheries Landings by Value for the Northern Gulf of Mexico and LA Landings share by Sector (NMFS, Fisheries of the United States 1995-2004).

blue crab (*Callinectes sapidus*), and more than 100 species of marine finfish. Of all landed species, however, Louisiana's penaeid shrimp[3] are the most valuable, with average annual landings of $138 million accounting for 40 percent of the average annual value of U.S. shrimp harvested from 1995-2004 (NMFS 2005).

Market forces have exerted tremendous economic pressure over the past two decades on individuals who depend on the seafood industry as their primary source of income. As the largest sector of that industry by value, the shrimp fleet of the northern Gulf is also the most threatened by those market forces. As an example, the number of people commercially harvesting shrimp in state and federal waters of the northern Gulf of Mexico has been declining for several years. In Louisiana, resident commercial fishermen licenses have declined 37 percent since 1987, and shrimp gear license sales have fallen 42 percent (Horst and Holloway 2002).[4] During that same period, the number shrimp processors in the southeastern U.S. declined from 124 firms in 1980 to 72 in 2001 (Keithly et. al. 2006). But, despite these downtrends, the volume of landed and processed shrimp has not declined substantially, ostensibly because of consolidation in the harvesting sector and increased trade in seafood products. In particular, shrimp imports[5] have increased from about 200 million pounds to more than 1.2 billion pounds over the past 20 years (Keithly et. al. 2006), a situation that has at least partially led to a more than 50 percent decline in the real dockside price of Gulf shrimp (Figure 1.4). At the same time,

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[3] Penaeid harvests in Louisiana are primarily composed of the white (*Liptopenaeus setiferus*) and brown (*Farfantepenaeus aztecus*) shrimp species.

[4] It should also be noted that in 1987 a new license structure was implemented, that included provisions to require people who had been shrimping recreationally with trawls larger than 16 foot headrope to either fish with smaller gear or to get commercial licenses. That increased the sales of commercial licenses. As the license datasets are not compatible, there is no simple way to derive an estimate of how many additional licenses were sold in 1987 compared to previous years. Some of the decline in commercial fishermen is due to later changes in laws to allow recreational harvesters to use larger (25' headrope) trawl gear with a recreational license, and other changes. Not all of the decline in the numbers of commercial fishermen licenses should be attributed to market forces, though they certainly have had a significant hand in the decline.

[5] Primarily from countries that support the extensive production of aquaculture shrimp.

changes in harvesting costs due to structural changes in the input supply markets and regulatory actions[6] have also pressured the Gulf shrimp industry. An indication of the severity of these changes are observed in fuel markets, where from a recent low of $0.96 per gallon in 1999 the average price of U.S. diesel fuel increased steadily for 6 years, reaching a high of $3.01 per gallon in October 2005 immediately following Hurricanes Katrina and Rita (Figure 1.5).

Recreational Fisheries

In 2004, approximately 1.5 million individuals purchased recreational fishing licenses in the three northernmost Gulf states, with the largest portion of those licenses (43 percent) being sold in Louisiana, followed by Alabama (33 percent), and Mississippi (25 percent) (ASA 2005). While these states have comparable angler populations, Louisiana anglers account for the majority (68 percent) of the recreational catch of coastal species (Figure 1.6). As much as 92 percent of the catch in a given year is comprised of coastal species, primarily from the family *Sciaenidae.* In Louisiana, spotted sea trout (*Cynoscion nebulosus*) and red drum (*Sciaenops ocellatus*) account for the largest number of fish harvested annually (44 percent and 15 percent of the recreational catch in 2004, respectively). As in the commercial fisheries, the abundance of recreational species in Louisiana is primarily due to the estuarine influence of the Mississippi River.

In contrast to commercial fisheries, Louisiana's recreational sector has been expanding for a number of years. Sales of recreational fishing licenses in the state have increased 60 percent since 1972, with sales of saltwater licenses more than doubling since their introduction in 1988 (Figure 1.7). Motorboat registrations also increased 13 percent statewide in the 15 years prior to

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6 The negative impacts of declining dockside prices have been compounded by an expanding suite of domestic regulatory actions, most of which target the reduction of incidental species by-catch. Although shrimp fishermen assert that such restrictions result in a loss of harvesting efficiency, the costs of regulatory compliance has likely been minor relative to problems associated with rapidly increasing input supply costs.

Hurricane Katrina, or more than twice the rate of population growth (LDWF 2004 and US Census 2005). Most indicative of the burgeoning demand for recreational angling is the growth of the recreational charter boat fleet, which increased more than 900 percent since the introduction of the saltwater charter-boat permit in 1995 (Figure 1.7). These charter operations were perhaps the strongest Louisiana fishing business in the years prior to the hurricanes of 2005.

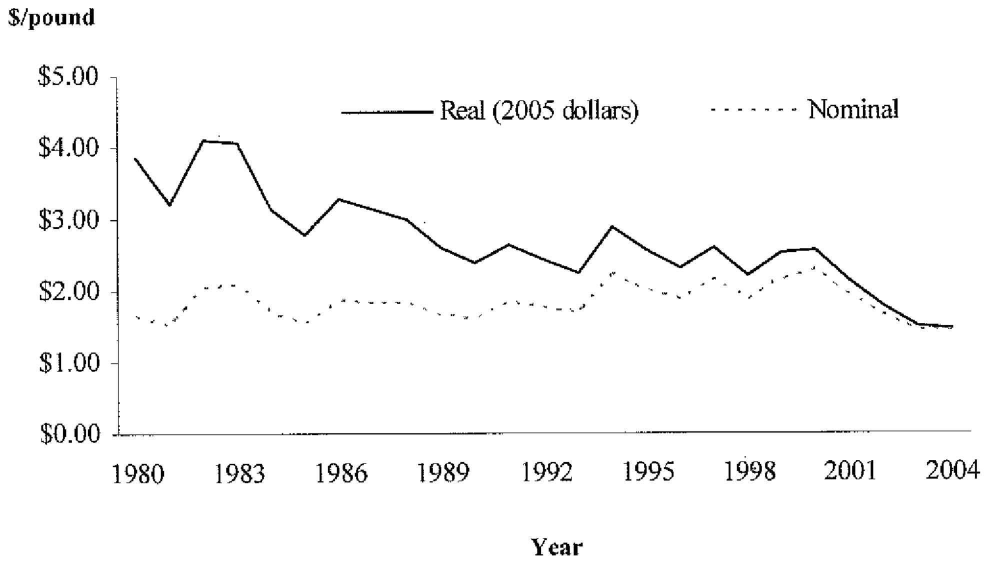


Figure 1.4 Nominal and Adjusted Dockside Price of Gulf Shrimp (NMFS 2005)

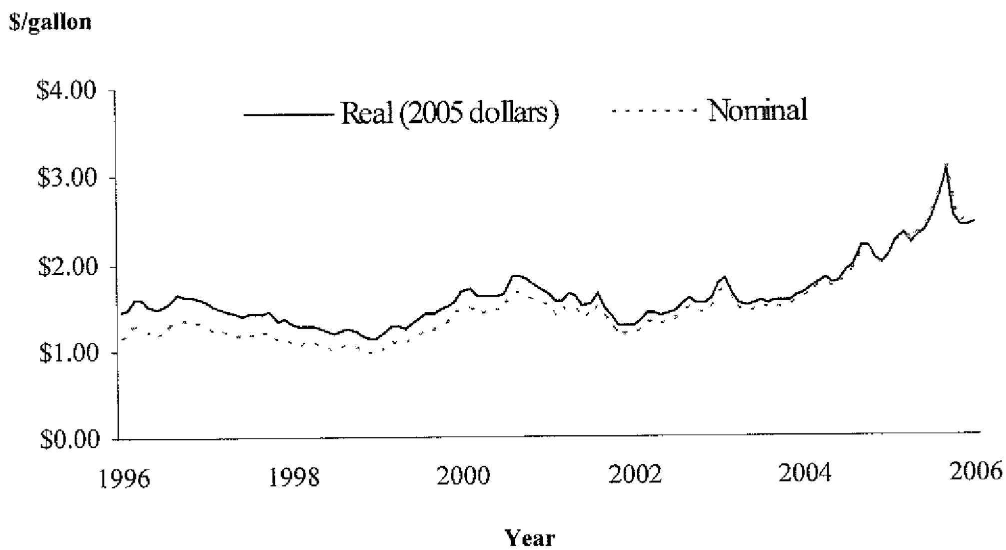
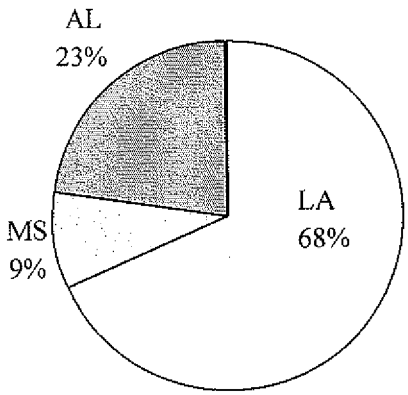


Figure 1.5 Nominal and Adjusted Monthly Prices for U.S. Diesel Fuel (DOE 2005)



Species	Number	Share
Spotted sea trout	16,989,980	47%
Red drum	6,996,243	19%
Other coastal	9,141,365	25%
Reef fishes	2,015,715	6%
Pelagic & Other	783,971	2%

Figure 1.6 Marine Recreational Fisheries Landings for Northern Gulf states and LA Share by Species in 2004
(MRFSS 2005)

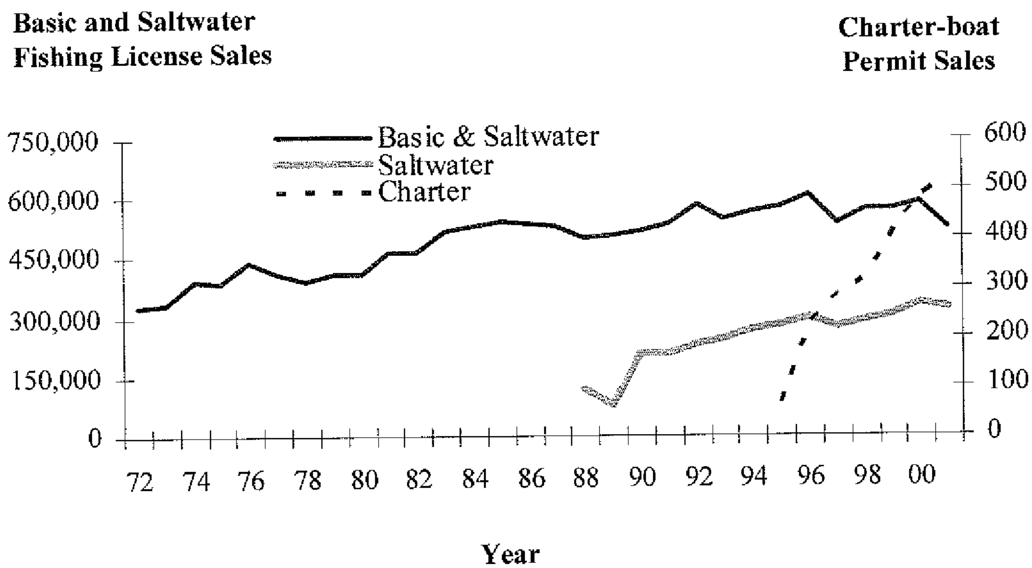


Figure 1.7 Louisiana Sales of Basic and Saltwater Fishing Licenses and Charter-boat Permits
(LDWF 1972-2001)

SECTION 2: THE 2005 HURRICANES

The 2005 hurricane season currently ranks as the most active and costly hurricane season in U.S. history. A total of 28 named storms, 7 of them major hurricanes (category 3 or above), formed over the waters of the Atlantic Basin, including the Gulf of Mexico and Caribbean Ocean. Three major storms had sustained winds that exceeded 156 mph, classifying them as Category 5 storms, the most powerful hurricanes according to the Saffir-Simpson Scale. The peak intensity of these 3 storms, as measured by minimum central pressure (MSP), ranks them as the first, fourth, and sixth most powerful hurricanes recorded to date (NHC 2006). The two most powerful of these 3 hurricanes made landfall on the Louisiana coastline.

Storm Trajectories and Intensity

Hurricane Katrina initially formed as a tropical depression in the Bahamas and crossed over the south Florida peninsula as a minor hurricane on August 23, 2005. After reemerging in the central Gulf of Mexico, Katrina intensified, reaching Category 5 storm on August 27th. On the morning of August 29th, Katrina crossed over lower Plaquemine Parish near the fishing port of Empire, Louisiana (Figure 2.1). The storm continued into the shallow waters of Breton and Chandeleur sounds, before making final landfall near Gulfport, Mississippi.

Katrina was a Category 3 hurricane at landfall, although surge levels in many areas were more than double the heights expected for a Category 3 storm. This tremendous surge was a product of three factors: 1) the low elevation and wedge-shape topography of coastal Louisiana and Mississippi which served to amplify surge levels; 2) the pre-landfall period of severe intensity during which Katrina had maximum sustained winds of 175 mph; and 3) the sheer size of the storm, with hurricane force winds extending in a 100-mile radius from the storm center (NHC 2006).

Estimates vary on the number of human deaths attributable to Hurricane Katrina, as several hundred people still remain unaccounted for in Louisiana and coastal Mississippi. In May 2006, the confirmed death toll (i.e., direct and indirect mortalities) for the two states was 1,836, most of which (1,464) were from Louisiana. Ninety-six percent of the mortalities in Louisiana occurred in the parishes of Orleans, St. Bernard, and Plaquemines, where several levee failures caused rapid and massive flooding (LDHH 2006; Van Heerden and Bryan 2006).

Three weeks after Katrina's landfall, another major hurricane began forming in the eastern Caribbean. On September 21st, Hurricane Rita became the third most powerful hurricane on record in the Atlantic Basin, with maximum sustained winds of 180 mph and a MSP of 895 mbar (NHC 2006).[7] Rita made landfall on September 24th in Cameron Parish near the coastal community of Johnson's Bayou, Louisiana. Although also downgraded at landfall to a Category 3 storm, Rita produced an expansive area of storm surge. As with Katrina, Rita's surge was exacerbated by low-lying topography and a period of pre-landfall intensity above Category 5. The expansive flooding from Rita, however, was primarily due to the storm's trajectory, which exposed the Louisiana coast to the northeast quadrant of the storm (Figure 2.1). Storm surge flooding from Rita occurred as far east as New Orleans, with increasing severity towards the southwestern coastal parishes. According to the US Geological Survey, some areas were inundated more than 30 miles inland (McGee 2006). Hurricane Rita caused only seven deaths,

[7] Although the peak intensity of Rita exceeded that of Katrina, it was not the strongest storm of the 2005 season. In October 2005, during a brief intensification period over the Caribbean (lowest MSP of 882), Hurricane Wilma became the strongest hurricane ever recorded. After skirting the Yucatan Peninsula, Wilma would later cross the southern Gulf of Mexico and make landfall in southwest Florida as a Category 2 storm.

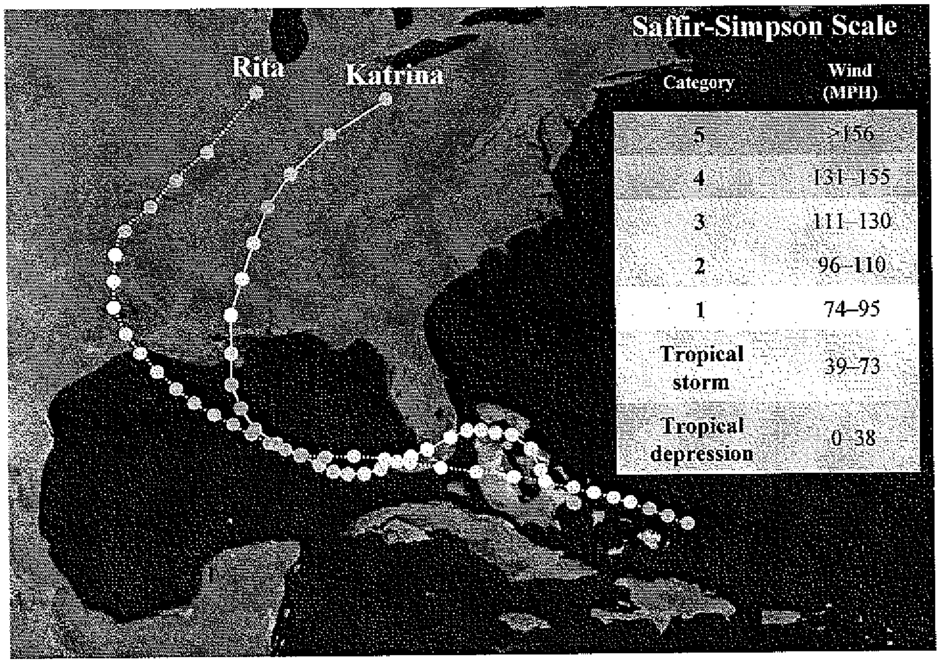


Figure 2.1 Saffir-Simpson Intensity Levels for Hurricanes Katrina and Rita Along their trajectories (NHC 2006)

but the expansive storm surge wreaked havoc on any coastal infrastructure remaining intact after Katrina.

Effects on Habitat and Productivity

An analysis of land change data from satellite imagery and field observation indicates that 217 square miles of Louisiana's coastal wetlands were converted to open water because of Hurricanes Katrina and Rita (USGS 2006). Region-specific estimates of the loss indicate that the largest amount of conversion occurred in southeastern Louisiana, where 96 square miles of wetland habitat was lost, primarily due to Katrina. The second largest loss occurred in southwestern Louisiana, where 84 square miles of coastal wetlands were converted to open water because of Rita.[8] Parishes of the southcentral coast (i.e., comprising the Bayou Teche, Bayou Vermilion, and Atchafalaya River basins) were relatively less impacted, losing a total of 14 square miles. The remaining losses occurred in the Pontchartrain and Pearl River basins, were 25 miles of land were converted to open water (USGS 2006). Despite having more than a year of post storm data, it is too early to ascertain the final extent of land loss caused by the two storms. Additional satellite imagery and field observation over the coming years will be required to determine what percent of these losses will be permanent.

The rapid conversion of such a large amount of fisheries habitat poses a potential threat to future productivity and further compounds an ongoing crisis in which Louisiana has lost more than 1900 square miles (1.2 million acres) of coastal wetland habitat over the last century due to hydrologic modification, nutrient and sediment starvation, and subsidence (Barras et al. 2003; Boesch 1982). The loss of this habitat, however, has yet to cause a measurable decline in fisheries productivity, at least as indicated by fisheries independent sampling and commercial

[8] The 84 square miles of land conversion in southwestern Louisiana included 62 square miles of land in the Mermentau basin, which included significant flooded marshes primarily between Calcasieu Lake and White Lake.

landings (Caffey and Schexnayder 2002). Browder et. al., (1985, 1989) theorized that fisheries productivity, although ultimately threatened by the loss of marsh substrate, may be temporarily enhanced by the expanding land-water interface. The break-up of vegetated marsh causes an increase in the ingress routes and edge habitat so vital for juvenile estuarine fish. In addition to this enhanced edge-effect, hurricanes might provide an additional productivity surge via biophysical processes that are poorly understood. Commercial landings and angler reports provide some evidence that such a spike has been occurring in the aftermath of the 2005 hurricanes.

Because of economic constraints, many of the state's shrimp harvesters that were not damaged by Katrina and Rita remained in port immediately following the storms. According to numerous news reports, some fishermen found it too expensive to fish given the prohibitive cost of fuel, declining dockside prices, and the paucity of available buyers. For vessels with a more efficient cost structure, however, the post-storm environment has been very productive. These operating vessels, have more than made up for harvesting capacity lost due to the hurricanes. According to market news compiled by NMFS, landings of shrimp in the first half of 2006 are up substantially for most of the northern Gulf, and Louisiana landings were 47 percent above the 5-year average for the same period (NMFS 2006). Clearly, economically-viable vessels have overcome the impediments of high fuel costs and low dockside prices, although profit for these vessels may be relatively low compared to earlier years. Anecdotal evidence suggests that a similar spike has occurred in recreational fisheries. Reports of spotted sea trout and red drum catches[9] were above average for the last quarter of 2005, and have remained strong throughout 2006 (Brooks 2005, Crawford 2006, Burkhead 2006).

[9] Recreational fishing reports do not typically differentiate between total catch and catch per unit effort.

Any post-hurricane increases in the total harvest and/or catch per unit effort (CPUE) for a commercial or recreational species are likely due to a combination of economic and biological factors, including changes in effort, reduced competition for a fixed resource, enhanced larval transport, and detrital fertilization. The final assessment of post-Katrina and Rita productivity in will be borne out in future fisheries-independent sampling conducted by the LDWF.

Initial Damage Assessments and Recovery Efforts

Because of their physical location and dependence on the marine environment, commercial and recreational fishing sectors in Louisiana received a disproportional economic impact from the hurricanes of 2005. Most of the state's fishing infrastructure was located on, or very near, the Gulf of Mexico and thus more heavily impacted than other sectors of the state economy. The severity of the disaster in Louisiana and surrounding states led U.S. Commerce Secretary Carlos Gutierrez to declare a formal fishing failure and fishing resource disaster for the Gulf of Mexico on September 9, 2005 (for hurricane Katrina) and October 4, 2005 (for hurricane Rita). These declarations authorized the U.S. Department of Commerce to request emergency assistance funds from Congress and to make those funds available for disaster assessment and recovery efforts targeting fishing communities.

In an effort to coordinate hurricane-related fisheries damage assessment and recovery, commercial and recreational fishing representatives united in February 2006 to form the Louisiana Fishing Community Recovery Coalition (LFCRC). This coalition was led by the Louisiana Departments of Wildlife and Fisheries (LDWF), Economic Development (LDED), Health and Hospitals (LDHH), and the Louisiana Seafood Promotion and Marketing Board. Participants in the LFCRC included representatives from the seafood harvesting industry (shrimp, oyster, crab, menhaden, and commercial finfish), seafood dealers/processors, recreational fishing interests (charter boats and guide services) and several local governments. University assistance to the coalition was provided by the LSU Center for Natural Resource Economics and Policy (CNREP) and the Louisiana Sea Grant College Program. Initial meetings of the LFCRC resulted in a three-fold charge designed to guide coalition activities during the recovery process: 1) documenting the physical and economic impacts of storm-related damages; 2) developing requests to specific funding sources to assist in the recovery of commercial and recreational fishing sectors; and 3) recommending allocation mechanisms for financial aid that are sound and proportional to the physical and economic geography of storm damages. Each of these three objectives required development of an economically-sound estimate of the Katrina and Rita-related damages to fisheries harvest revenues and infrastructure losses. Preliminary estimates were developed in late 2005 immediately after the two storms and used in support of initial requests for emergency aid and support (LSU AgCenter 2005, LDWF 2005_a; $LDWF_b$).

In January 2006, NOAA commissioned an independent assessment of the economic damages resulting from hurricanes Katrina and Rita in Louisiana. Given the level of destruction experienced in Louisiana from both Katrina and Rita, the wide geographic extent of the damage, and continuing depopulated status of the affected areas, traditional survey methods could not be systematically or comprehensively executed. Because of these limitations, the Louisiana assessment was limited to a revenue-based approach, somewhat similar to the approach used in the rapid assessments developed by LDWF and the LSU AgCenter immediately following the two storms.

In February 2006, assessments were developed using two methods which relied on highly aggregated revenue data and coast-wide assumptions of economic damage. The first method, a form of partial income capitalization, was derived from property appraisal techniques in which the value of a business' infrastructure is calculated as a function of the net income generated by that infrastructure[10]. The second method, a discounted loss approach, was similar to the first method except that net income and infrastructure losses were discounted over a five-year period under the assumption that the status of damage recovery cannot be reasonably estimated beyond that time frame.[11] The commercial components of that estimate were limited to infrastructure damage to commercial vessels, dealers, and processors in Louisiana and ranged from $272 million to $585 million (LFCRC 2006). Additional refinement was necessary in order to develop damage estimates that were more region-specific and proportional to the physical and economic geography of hurricane impacts along the Louisiana coast.

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[10] The Appraisal of Rural Property, American Institute of Real Estate Appraisers, ISBN: 0-911780-56-4, 11th Edition. Appraisal Institute, Chicago, 1983.

[11] *Handbook for Estimating the Socio-economic and Environmental Effects of Disasters*, United Nations Economic Commission for Latin America and the Caribbean (ECLAC) and the International Bank of Reconstruction and Development (The World Bank), 2003.
http://www.eclac.cl/publicaciones/Mexico/5/LCMEXG5/lcmexg5i_VOLUME_Ia.pdf

SECTION 3:
REGIONAL ORGANIZATION OF THE STUDY

The hurricanes of 2005 produced damage across the entire length of Louisiana's 20,000 square mile coastal zone. Initial assessments conducted in early September 2005 following Hurricane Katrina indicated that tremendous damage had occurred to coastal fishing communities in the parishes of Plaquemines, Orleans, and St. Bernard, with additional devastation along the southern and north shores of Lake Pontchartrain. Because of the sheer size and magnitude of Katrina, damages from the storm center extended more than 100 miles westward towards the central coastal region. This damage was exacerbated less than one month later by the northwesterly track of Hurricane Rita, which pushed a large storm surge over the central coast before devastating fishing communities in southwestern Louisiana near the Texas border.

Because of the large geographic scale of these impacts, a regional approach was utilized for assessing the economic damages to coastal fisheries infrastructure. The use this regional approach allowed for more detailed assessment of fisheries infrastructure damages within the physical sub-basins and political parish boundaries of coastal Louisiana. Four regions were defined for the purposes of this report: Region 1, the parishes bordering the southeastern and northern shores of Lake Pontchartrain; Region 2, the coastal parishes of southeastern Louisiana; Region 3, the coastal parishes of south-central Louisiana; and Region 4, the coastal parishes of southwestern Louisiana (Figure 3.1). The remainder of this section provides baseline information on the known pre-storm fisheries infrastructure in these regions.

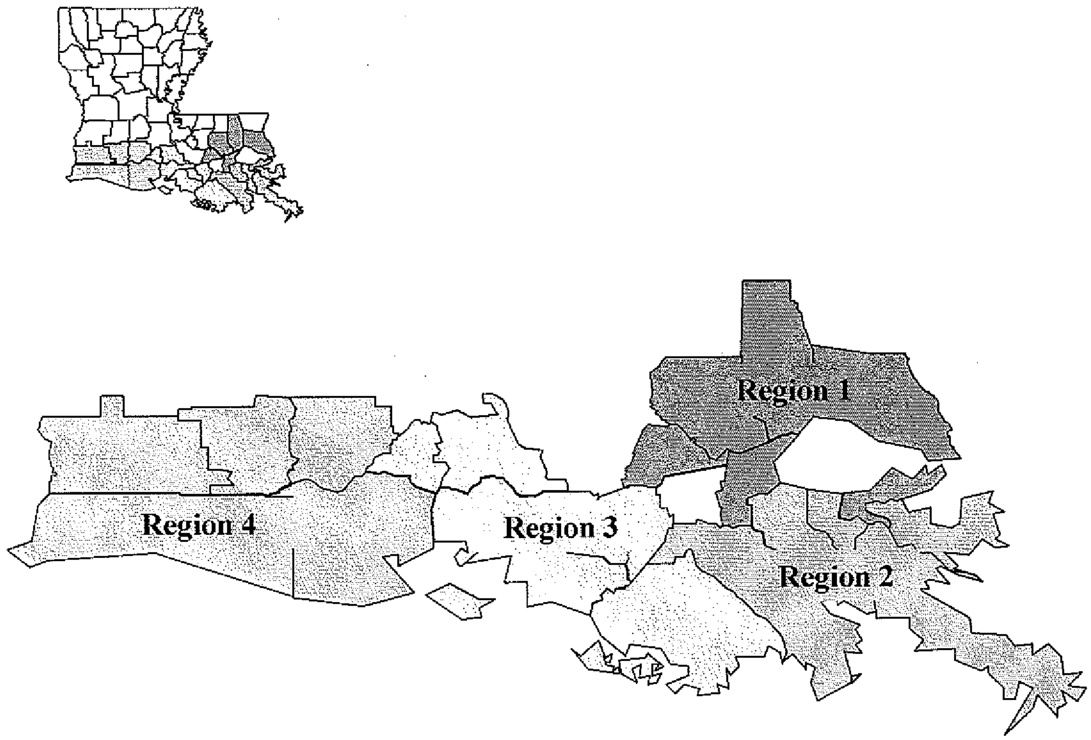

Figure 3.1. Coastal regions utilized for the assessment of economic damages to fisheries infrastructure from Hurricanes Katina and Rita

Region 1 – Lake Pontchartrain and Maurepas Basins

Region 1 encompassed the basins of Lakes Pontchartrain and Maurepas, including the parishes of Orleans, St. Tammany, Tangipahoa, Livingston, Assumption, and St. John (Figure 3.2). Table 3.1 provides demographic information on the region's fisheries sector. Region 1 was the most heavily populated area of Louisiana, and residents of Orleans Parish alone comprised more than a tenth (10.85 percent) of the state's pre-Katrina population. In 2004, there were 107,316 residential fishing licenses sold, with the majority of these (41,047) purchased in St. Tammany Parish. Although Region 1 had the highest number of recreational vessels (52,472), commercial fishing infrastructure was not extensive relative to other coastal regions. According to LDWF records, there were 1,701 licensed commercial fishermen in the region in 2004, and 980 active[12] fishing vessels were recorded as selling to 129 dealers. Of the six processors in Region 1 during 2004, five were located in Orleans Parish.

Table 3.2 provides a review of the average landings in Region 1 for the years 2002-2004. Landing values are depicted for 169 commercial fisheries aggregated under 5 broad species-related categories (i.e. shrimp, crab, oysters, freshwater finfish, and saltwater finfish).[13] Region 1 had the least amount of commercial fishing activity of the state's four coastal regions, with the average annual value of commercial fisheries landings being $9,852,118. This amount constitutes only 3.6% of the average annual value of the statewide Louisiana's fisheries landings for this time period. The crab fishery was the most prominent commercial sector of this region, averaging $4,384,694 in revenues annually, or approximately 14 percent of the average annual value of crabs harvested in Louisiana during this time period.

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[12] Active vessels and dealers refer to those which appeared in LDWF licensing and revenue tracking data for 2004.
[13] See Appendix A for a complete list of these species and additional information on aggregation schemes.

Figure 3.2. Coastal Parishes of Region 1

Table 3.1 Fishing community demographics for coastal parishes of Region 1

	Population[1] Level	Recreational[2] Licenses	Recreational[3] Vessels	Commercial[4] Licenses	Commercial[5] Vessels	Commercial[6] Dealers	Commercial[7] Processors
Region 1							
Ascension	76,627	14,532	7,732	123	46	6	0
Livingston	91,814	16,370	10,249	175	82	9	0
Orleans	484,674	12,753	7,139	475	212	33	5
St. John	43,044	7,624	2,497	204	145	10	0
St. Tammany	191,268	41,047	18,128	487	324	39	0
Tangipahoa	100,588	14,990	6,727	237	171	32	1
R1 Subtotals	**988,015**	**107,316**	**52,472**	**1,701**	**980**	**129**	**6**
Percent of LA	**22.1%**	**14.5%**	**16.2%**	**10.1%**	**11.0%**	**11.4%**	**5.3%**

Notes:

1 *U.S. Census Data (2000)*

2 *LDWF basic and saltwater fishing licenses sold in 2004. Not equivalent to number of anglers*

3 *LDWF Recreational Boat registrations (2004)*

4 *Resident Commercial Fishermen License Sales (Horst & Holloway 2000)*

5 *Commercial vessel registrations (LDWF 2004)*

6 *Commercial Dealers (LDWF Trip Ticket data 2004)*

7 *Commercial Processors (NMFS processor survey data, 2004)*

Table 3.2 Average annual landings values for major species by coastal parish in Region 1
Source: LDWF trip ticket data, average annual values 2002-2004**

	Shrimp[1] Value	Crabs[2] Value	Oyster[3] Value	SW Fish[4] Value	FW Fish[5] Value	Total[1-5] Value
Region 1						
Ascension	*	$29,691	*	$1,732,087	$110,802	$1,872,579
Livingston	*	$62,531	*	*	*	$62,531
Orleans	$1,597,127	$940,287	$1,011,020	$450,009	$5,473	$4,003,916
St. John	*	$56,405	*	*	*	$92,017
St. Tammany	$136,657	$1,819,697	$335,530	*	*	$2,291,885
Tangipahoa	*	$1,476,082	*	*	$36,668	$1,519,813
R1 Subtotals	**$1,757,477**	**$4,384,694**	**$1,362,842**	**$2,183,256**	**$163,849**	**$9,852,118**
Percent of LA	**1.3%**	**14.0%**	**4.2%**	**3.5%**	**2.6%**	**3.6%**

Notes:

1 *Aggregated data for 9 species of shrimp, average annual value 2002-2004 (see Appendix 1)*

2 *Aggregated data for 2 species of crab, average annual value 2002-2004 (see Appendix 1)*

3 *Eastern oyster (Crassostrea virginica), average annual value 2002-2004*

4 *Aggregated data for 131 species of saltwater finfish, including menhaden, average annual value 2002-2004 (see Appendix 1)*

5 *Aggregated data for 26 species of freshwater finfish, including turtles and wild crawfish, average annual value (see Appendix 1)*

* *Data omitted because of confidentiality*

** *LDWF Trip Ticket data are estimates only and data are subject to corrections*

Region 2 – Chandeleur, Breton, Barataria, and Lower Mississippi Basins

Region 2 encompassed the coastal basins of Chandeleur, Breton, and Barataria, as well as the deltaic coastal region surrounding the Lower Mississippi River. Region 2 parishes include St. Bernard, Plaquemines, Jefferson, St. Charles, and Lafourche (Figure 3.3). Table 3.3 provides demographic information on the region's fisheries sector. Region 2 was the second most populated area of Louisiana, and boasted the highest amount of recreational fishing licenses sold (175,234) in 2004. The largest number of these recreational fishing licenses (89,564) was purchased in Jefferson Parish, which also had the largest number of recreational fishing vessels (22,097) registered in 2004. Region 2 was the most involved in Louisiana's 2004 commercial fishing industry, accounting for 37.4 percent (6,297) of the commercial fishing licenses sold, 47.3 percent (4,205) of the active fishing vessels, 30.5 percent (345) of the active dealers, and 19.3 percent (22) of the seafood processors.

Table 3.4 provides data on the average annual landings in Region 2 for the years 2002-2004. During this period, ports within the region accounted for two-thirds (67.5%) of the state's oyster harvest, more than half (53.7%) the total shrimp catch, and nearly half of the state's total landings of crabs (46.8%) and saltwater finfish (45.6%). Region 2 was also home to the number one fishing port by volume in the coterminous U.S., as the port of Empire-Venice led the nation in landings with approximately 400 million pounds of fisheries harvested. Most of these landings could be attributed to menhaden (*Brevoortia spp.*), and, in fact average annual menhaden landings constituted approximately 85 percent of the volume of all fisheries harvested in Louisiana during 1994-2004 time period (NMFS 2005).

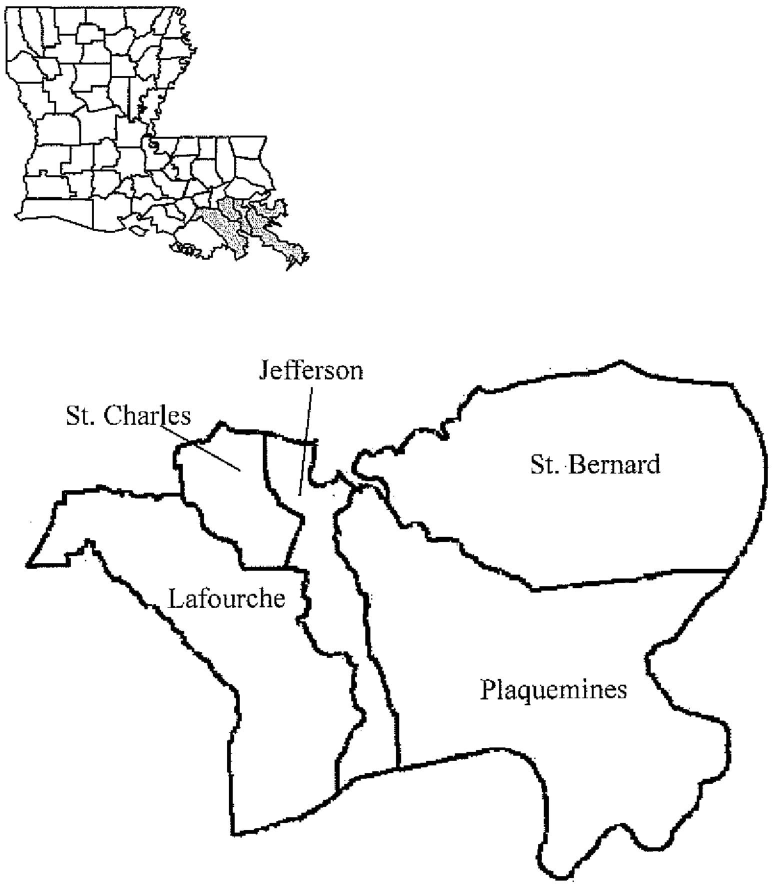

Figure 3.3. Coastal Parishes of Region 2

Table 3.3 Fishing community demographics for coastal parishes of Region 2

	Population[1] Level	Recreational[2] Licenses	Recreational[3] Vessels	Commercial[4] Licenses	Commercial[5] Vessels	Commercial[6] Dealers	Commercial[7] Processors
Region 2							
Jefferson	455,466	89,564	22,097	1,910	1,218	94	3
Lafourche	89,974	40,655	11,682	1,788	945	95	13
Plaquemines	26,757	15,254	4,090	1,155	1,102	69	1
St. Bernard	67,229	20,232	5,395	1,007	649	47	2
St. Charles	48,072	9,529	4,444	437	291	40	3
R2 Subtotals	**687,498**	**175,234**	**47,708**	**6,297**	**4,205**	**345**	**22**
Percent of LA	**15.4%**	**23.7%**	**14.7%**	**37.4%**	**47.3%**	**30.5%**	**19.3%**

Notes:

1 *U.S. Census Data (2000)*

2 *LDWF basic and saltwater fishing licenses sold in 2004. Not equivalent to number of anglers*

3 *LDWF Recreational Boat registrations (2004)*

4 *Resident Commercial Fishermen License Sales (Horst & Holloway 2000)*

5 *Commercial vessel registrations (LDWF 2004)*

6 *Commercial Dealers (LDWF Trip Ticket data 2004)*

7 *Commercial Processors (NMFS processor survey data, 2004)*

Table 3.4 Average annual landings values for major species by coastal parish in Region 2
Source: LDWF trip ticket data, average annual values 2002-2004**

	Shrimp[1] Value	Crabs[2] Value	Oyster[3] Value	SW Fish[4] Value	FW Fish[5] Value	Total[1-5] Value
Region 2						
Jefferson	$21,201,000	$2,098,533	$317,348	$1,723,966	$231,083	$25,571,931
Lafourche	$21,202,448	$5,738,926	*	$4,539,886	*	$31,821,057
Plaquemines	$28,732,935	$1,106,758	$9,435,927	$21,525,630	*	$60,859,261
St. Bernard	$2,805,287	$3,612,553	$11,907,449	*	*	$18,898,114
St. Charles	*	$2,097,121	*	*	$200,786	$2,319,505
R2 Subtotals	**$73,961,246**	**$14,653,892**	**$21,957,340**	**$28,306,636**	**$590,755**	**$139,469,868**
Percent of LA	**53.7%**	**46.8%**	**67.5%**	**45.6%**	**9.2%**	**51.6%**

Notes:

1 *Aggregated data for 9 species of shrimp, average annual value 2002-2004 (see Appendix 1)*

2 *Aggregated data for 2 species of crab, average annual value 2002-2004 (see Appendix 1)*

3 *Eastern oyster (Crassostrea virginica), average annual value 2002-2004*

4 *Aggregated data for 131 species of saltwater finfish, including menhaden, average annual value 2002-2004 (see Appendix 1)*

5 *Aggregated data for 26 species of freshwater finfish, including turtles and wild crawfish, average annual value (see Appendix 1)*

* *Data omitted because of confidentiality*

** *LDWF Trip Ticket data are estimates only and data are subject to correction*

Region 3 – Timbalier, Terrebonne, and Atchafalaya Basins

Region 3 encompassed the coastal basins of Timbalier and Terrebonne, and both the coastal and inland regions of the Atchafalaya Basin. Region 3 parishes include Terrebonne, Assumption, St. Mary, St. Martin, Iberia, and Lafayette (Figure 3.4). Table 3.5 provides demographic information on the region's fisheries sector. Region 3 had a population of 493,743, with approximately 60 percent of those residents living in the parishes of Terrebonne and Lafayette. In 2004, the region accounted for the second highest number of resident recreational fishing licenses sold (130,714) and the second highest number of recreational vessels registered (50,631). Indicators of commercial fishing activity in the region included the purchase of 28.4 percent (4,782) of the state's commercial fishing licenses, the porting of 30.2 percent (2,689) of the state's active fishing vessels, the presence of 29.3 percent (332) of the active dealers, and 52.6 percent (60) of the state's seafood processors.

Table 3.6 provides data on the average annual landings in Region 3 for the years 2002-2004. During this period, approximately half (45.3%) of the average annual landings value for the region came from shrimp. Of the $28,683,908 in average annual shrimp landings, approximately 94 percent came from ports in Terrebonne parish, a parish which also had the highest number of seafood processors statewide (28). Region 3 also accounted for the vast majority (80.8%) of the average annual value of freshwater fishes harvested in the study area zone. Approximately 32 of the 60 processors in Region 3 are primarily associated with the freshwater fisheries of the 929 square-mile Atchafalaya Basin. While these fisheries aggregate more than 26 freshwater species, wild crawfish (*Procambarus spp*) are the largest component on a value-basis. According to NMFS (2005), the value of wild crawfish harvest in 2004 was $4.8 million, or 93 percent of the freshwater landings of Region 3

Figure 3.4. Coastal Parishes of Region 3

Table 3.5 Fishing community demographics for coastal parishes of Region 3

	Population[1] Level	Recreational[2] Licenses	Recreational[3] Vessels	Commercial[4] Licenses	Commercial[5] Vessels	Commercial[6] Dealers	Commercial[7] Processors
Region 3							
Assumption	23,388	5,263	3,364	474	88	22	2
Iberia	73,266	16,678	7,451	396	302	41	2
Lafayette	190,503	31,008	13,308	212	88	12	4
St. Martin	48,583	11,639	4,589	349	81	43	18
St. Mary	53,500	17,598	7,638	872	563	80	6
Terrebonne	104,503	48,528	14,281	2,479	1,567	134	28
R3 Subtotals	**493,743**	**130,714**	**50,631**	**4,782**	**2,689**	**332**	**60**
Percent of LA	**11.0%**	**17.7%**	**15.6%**	**28.4%**	**30.2%**	**29.3%**	**52.6%**

Notes:

1 *U.S. Census Data (2000)*

2 *LDWF basic and saltwater fishing licenses sold in 2004. Not equivalent to number of anglers*

3 *LDWF Recreational Boat registrations (2004)*

4 *Resident Commercial Fishermen License Sales (Horst & Holloway 2000)*

5 *Commercial vessel registrations (LDWF 2004)*

6 *Commercial Dealers (LDWF Trip Ticket data 2004)*

7 *Commercial Processors (NMFS processor survey data, 2004)*

Table 3.6 Average annual landings values for major species by coastal parish in Region 3
Source: LDWF trip ticket data, average annual values 2002-2004**

	Shrimp[1] Value	Crabs[2] Value	Oyster[3] Value	SW Fish[4] Value	FW Fish[5] Value	Total[1-5] Value
Region 3						
Assumption	$28,742	$290,780	*	*	$1,449,017	$1,778,892
Iberia	$563,744	$2,168,929	$3,332,089	$67,651	$280,849	$6,413,262
Lafayette	*	$166,740	*	*	$68,416	$390,311
St. Mary	$1,396,682	*	*	$1,446,618	$1,745,302	$5,238,607
St. Martin	*	*	*	*	$2,017,537	$2,173,783
Terrebonne	$26,643,370	$5,899,713	$4,995,906	$8,848,145	$206,694	$46,593,828
R3 Subtotals	**$28,683,908**	**$10,668,992**	**$8,338,620**	**$10,403,528**	**$5,186,048**	**$62,588,684**
Percent of LA	**20.8%**	**34.0%**	**25.6%**	**16.7%**	**80.8%**	**23.4%**

Notes:

1 *Aggregated data for 9 species of shrimp, average annual value 2002-2004 (see Appendix 1)*

2 *Aggregated data for 2 species of crab, average annual value 2002-2004 (see Appendix 1)*

3 *Eastern oyster (Crassostrea virginica), average annual value 2002-2004*

4 *Aggregated data for 131 species of saltwater finfish, including menhaden, average annual value 2002-2004 (see Appendix 1)*

5 *Aggregated data for 26 species of freshwater finfish, including turtles and wild crawfish, average annual value (see Appendix 1)*

* *Data omitted because of confidentiality*

** *LDWF Trip Ticket data are estimates only and data are subject to correction*

Region 4 – Teche-Vermillion, Mermentau, and Calcasieu Basins

Region 4 encompassed the basins of the Teche-Vermillion, Mermentau, and Calcasieu Rivers, including the parishes of Vermilion, Acadia, Jefferson Davis, Calcasieu, and Cameron (Figure 3.5). Table 3.7 provides demographic information on the region's fisheries sector. With 342,171 residents, Region 4 was the least populated of all four coastal regions, with approximately half (53%) of these residing in Calcasieu Parish, primarily within the communities of Lake Charles and Sulphur. Correspondingly, approximately half of the sales of resident recreational fishing licenses (46,881) and more than half the recreational vessels registered (16,182) in Region 4 were in Calcasieu Parish. Indicators of commercial fishing activity in the region included 10 percent (1,675) of the state's commercial fishing licenses sold, 7.4% (656) of the state's active fishing vessels, 14.1 percent (160) of the state's active dealers, and 10.5 percent (12) of the state's seafood processors.

Table 3.7 describes the average annual landings in Region 4 for the years 2002-2004. During this period, more than half (58%) of the average annual landings value for the entire region came from shrimp harvesting. Of the $33,334,198 in average annual shrimp landings, approximately 70 percent was sold in Vermillion Parish to seafood dealers in towns such as Abbeville and Delcambre. Vermilion Parish also dominated the regional harvest of saltwater finfish, accounting for 91 percent of regional landings. As seen with respect to Region 2, the majority of landings in this category are derived from the harvest of menhaden. The town of Intracoastal City in Region 4 was the location of one of only three remaining commercial processors of menhaden on the Louisiana coast.

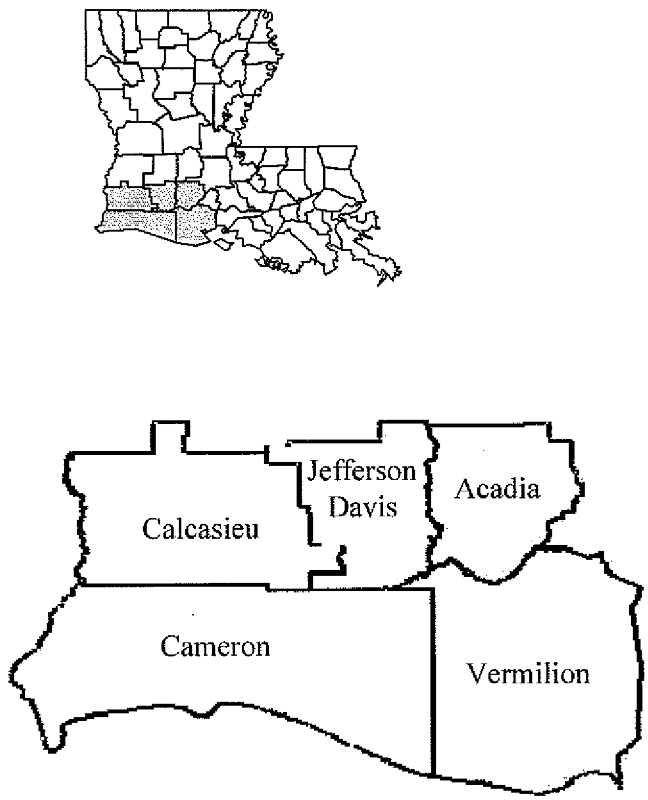

Figure 3.5 Coastal Parishes of Region 4

Table 3.7 Fishing community demographics for coastal parishes of Region 4

	Population[1] Level	Recreational[2] Licenses	Recreational[3] Vessels	Commercial[4] Licenses	Commercial[5] Vessels	Commercial[6] Dealers	Commercial[7] Processors
Region 4							
Acadia	58,861	10,832	3,573	132	56	8	1
Calcasieu	183,577	46,881	16,182	442	103	19	0
Cameron	9,991	7,698	1,460	419	252	62	4
Jeff Davis	31,435	6,431	2,518	148	39	7	0
Vermillion	58,307	20,646	5,391	534	206	64	7
R1 Subtotals	**342,171**	**92,488**	**29,124**	**1,675**	**656**	**160**	**12**
Percent of LA	**7.7%**	**12.5%**	**9.0%**	**10.0%**	**7.4%**	**14.1%**	**10.5%**

Notes:

1 *U.S. Census Data (2000)*

2 *LDWF basic and saltwater fishing licenses sold in 2004. Not equivalent to number of anglers*

3 *LDWF Recreational Boat registrations (2004)*

4 *Resident Commercial Fishermen License Sales (Horst & Holloway 2000)*

5 *Commercial vessel registrations (LDWF 2004)*

6 *Commercial Dealers (LDWF Trip Ticket data 2004)*

7 *Commercial Processors (NMFS processor survey data, 2004)*

Table 3.8 Average annual landings values for major species by coastal parish in Region 4
Source: LDWF trip ticket data, average annual values 2002-2004**

	Shrimp[1] Value	Crabs[2] Value	Oyster[3] Value	SW Fish[4] Value	FW Fish[5] Value	Total[1-5] Value
Region 4						
Acadia	*	*	*	*	*	$11,662
Calcasieu	$6,376,427	$156,430	*	*	$29,510	$6,564,420
Cameron	$3,672,919	$1,097,527	$265,727	$1,880,261	*	$6,934,992
Jeff Davis	*	*	*	*	*	$47,586
Vermillion	$23,242,715	$374,155	$590,252	$19,347,376	$420,937	$43,975,435
R4 Subtotals	**$33,334,198**	**$1,635,189**	**$857,278**	**$21,228,393**	**$479,037**	**$57,534,095**
Percent of LA	**24.2%**	**5.2%**	**2.6%**	**34.2%**	**7.5%**	**21.3%**

Notes:

1 *Aggregated data for 9 species of shrimp, average annual value 2002-2004 (see Appendix 1)*

2 *Aggregated data for 2 species of crab, average annual value 2002-2004 (see Appendix 1)*

3 *Eastern oyster (Crassostrea virginica), average annual value 2002-2004*

4 *Aggregated data for 131 species of saltwater finfish, including menhaden, average annual value 2002-2004 (see Appendix 1)*

5 *Aggregated data for 26 species of freshwater finfish, including turtles and wild crawfish, average annual value (see Appendix 1)*

* *Data omitted because of confidentiality*

** *LDWF Trip Ticket data are estimates only and data are subject to correction*

SECTION 4:
DATA AND METHODS

Five sources of information were used to estimate the economic damages to fisheries infrastructure in Regions 1 through 4. These sources included: 1) commercial revenue records, 2) registration and license data, 3) vessel sales data, 4) storm surge modeling, and 5) field observations. Revenue and sales data provided the basis for pre-storm value appraisals based on business income and assets, respectively. License and registration data were used to characterize and map fisheries infrastructure, and to indicate its geographic proximity to maximum storm surge heights. Finally, field observations provided the data necessary to develop a damage model in which economic losses could be expressed as a function of surge height for a given area. A more detailed description of these data and methods is provided below.

Commercial Revenue

Since 1999, the LDWF has maintained "trip ticket" records which capture information on dealers, commercial harvestors, area fished, trip length, species landed, quantity landed, and prices received. This geographically specific data, in conjunction with ground-truth observations and other physical data, can be used to infer where fisheries infrastructure existed prior to the storms, its economic value, and the corresponding levels of economic damages to that infrastructure caused by the hurricanes.

Trip ticket data for Louisiana were obtained from the NMFS Southeast Fisheries Science Center in June 2006. More than 2.5 million transaction records were acquired for the years 2002 – 2004. The data included transactions for 11,213 commercial fishing vessels (federal and state), 1,133 seafood dealers. Data for 114 seafood processors was obtained from a NMFS end-of the-year survey of seafood processing and wholesaling establishments.

Registration and Licenses

Commercial fishing license and vessel registration data were obtained from the LDWF in July 2006. Geographic Information System (GIS) software (ArcMap ver. 9.0 ESRI Inc.) was used to geo-code the majority of this infrastructure data where the appropriate information was available in the records. The remaining records were processed using a publicly-available website that can be used to generate latitude and longitude coordinates from physical addresses.[14] The resulting GIS layers depict the best available estimate of the geographic location of 10,140 Louisiana vessels, dealers, and processors prior to Hurricane Katrina (Figure 4.1).

Vessel Sales

As described in Section 2, preliminary estimates of fisheries infrastructure damage in Louisiana were initially calculated using an income capitalization procedure and discounted loss method. A third method, relying on market data, was later employed specifically to estimate the pre-storm value of commercial and recreational fishing vessels. A comprehensive review of fishing industry websites and back-issues of various commercial and recreational trade publications generated data on the asking prices[15] for individual fishing vessels and their characteristics. Data on nearly 600 commercial and recreational fishing vessels was collected through this method and incorporated into a multiple linear regression framework. The resulting model was used to estimate the value of all vessels based on their age, length, hull material, and means of propulsion.

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14 Geo-coding proved to be problematic with ArcMap for several addresses. The remaining locations were batch-processed at the following website: www.stevemorse.org/jcal/latlon.php , Converting Addresses to/from Latitude/Longitude in One Step, by Stephen P. Morse,

15 Actual sales price should be somewhat lower than asking price in most markets that depend on negotiation for the final sale. As a result, using the asking price in this study would be expected to generate an upper bound on the value of vessels lost due to the storms.

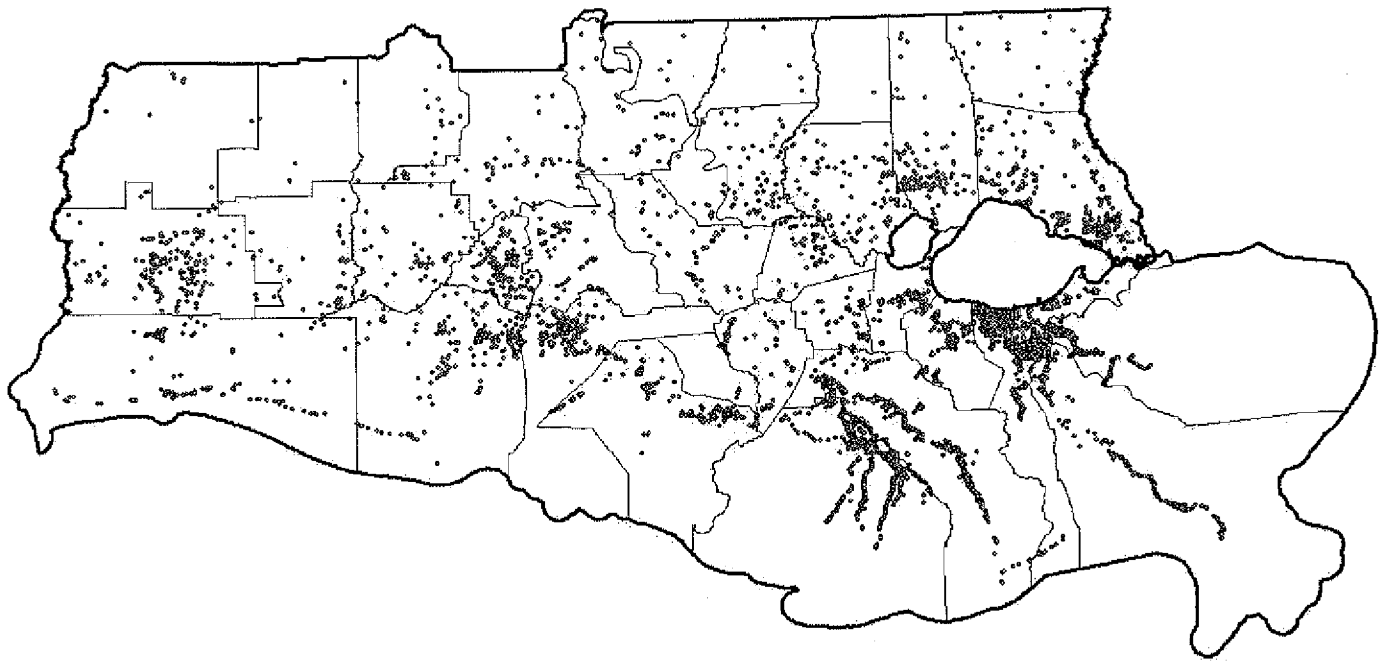

Figure 4.1 Pre-storm Location of Louisiana Fisheries Infrastructure
Geo-coded from LDWF License Records (commercial vessels, dealers, and processors)

Biophysical Data

Acquisition of disaggregated trip ticket data provided the site-specific, firm-level information required for a more accurate assessment of the fisheries infrastructure in the path of Hurricanes Katrina and Rita. In addition to this information, some form of physical data related to each storm was required to develop refined assumptions about infrastructure damage and its relationship to storm severity.

In the case of hurricanes, economic damage is primarily the result of wind speed and water heights, with coastal storm surge being one of the more critical determinants. For the past five years, the LSU Hurricane Center has used a modified version of the ADCIRC Coastal Circulation Model to predict maximum flood and surge levels associated specific storm events. Applied to surge modeling, ADCIRC incorporates data generated by the National Weather Service on storm trajectory and storm magnitude and combines that information with detailed data on coastal bathymetry and elevation (ADCIRC Development Group 2006).

In May 2006, spatial and numerical data regarding maximum water levels for hurricanes Katrina and Rita were obtained from the LSU Hurricane Center. These data were the product of multiple ADCIRC model runs conducted prior to landfall. The iterative refinement of model forecast, combined with post-storm hind-casting, produced a detailed depiction of the maximum flood heights across coastal Louisiana for Hurricanes Katrina and Rita. Maximum water level records were developed through this process for more than 500,000 coastal Louisiana locations (i.e. simulation nodes). Figures 4.2 and 4.3 graphically depict the maximum water levels at each of these nodes for hurricanes Katrina and Rita.

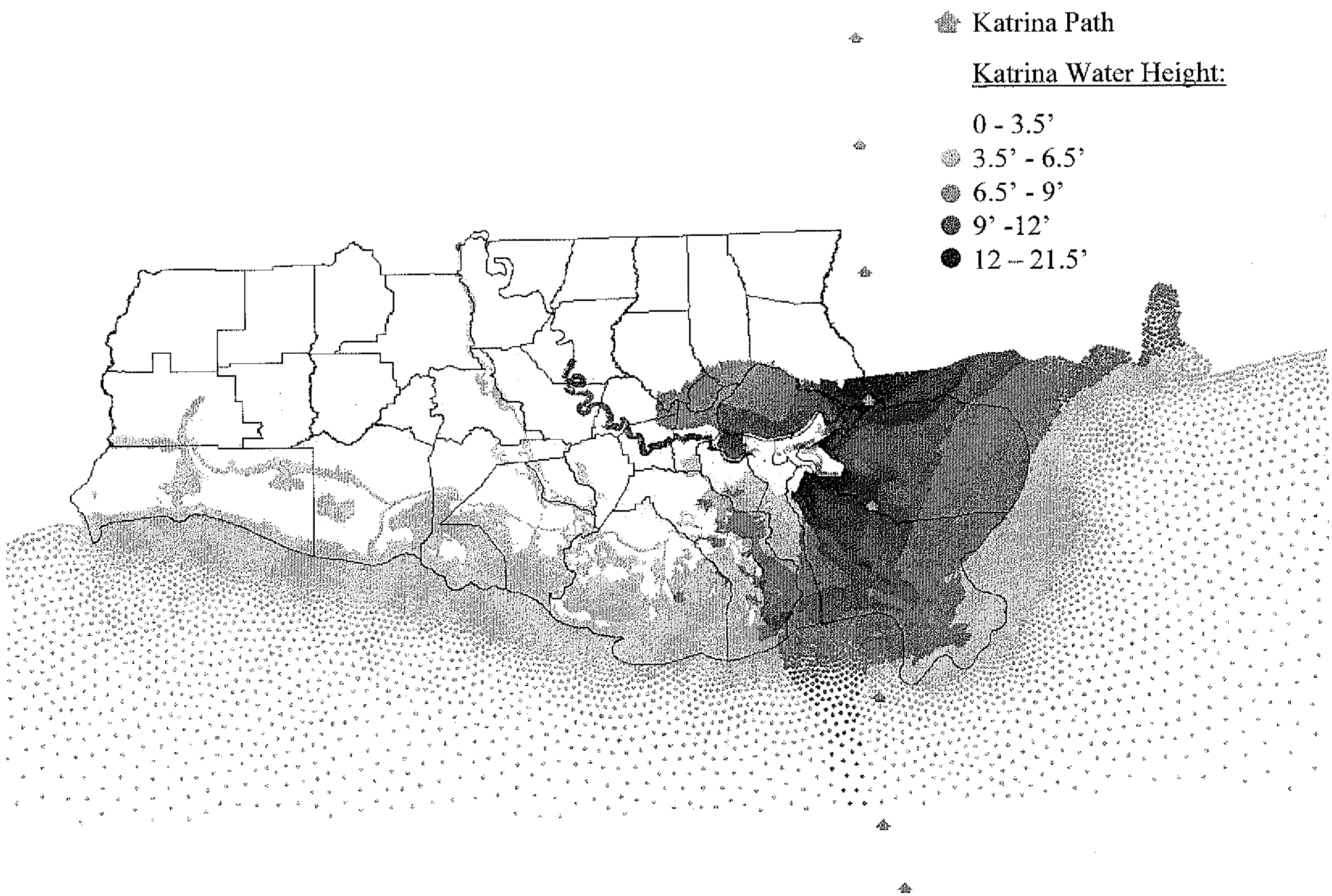

Figure 4.2 Maximum Water Levels for Hurricane Katrina derived from ADCIRC modeling conducted by the LSU Hurricane Center.

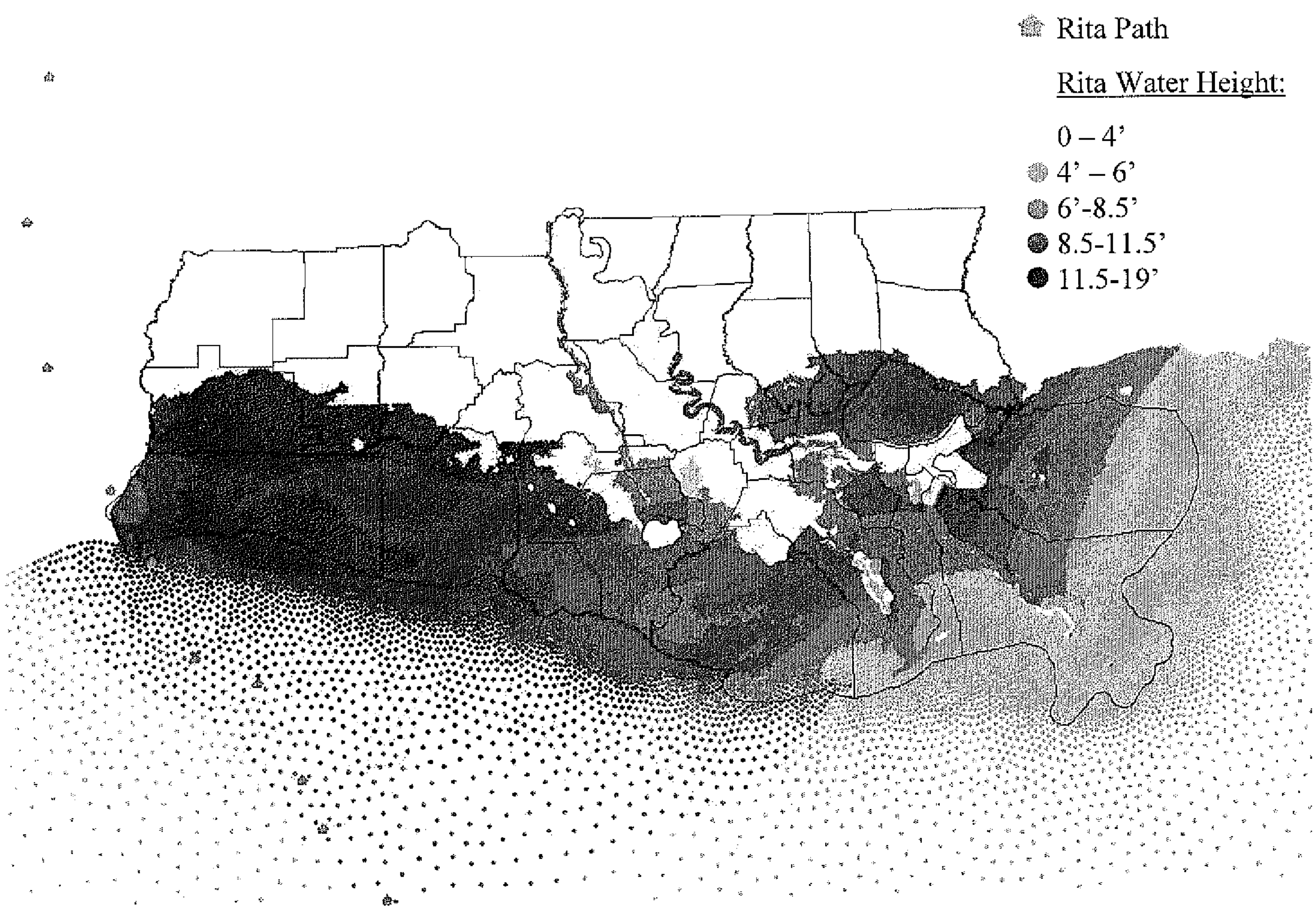

Figure 4.3 Maximum Water Levels for Hurricane Rita derived from ADCIRC modeling conducted by the LSU Hurricane Center.

Ground-Truthing

A template was developed for field observations that would measure, among other things, the percent of infrastructure that was lost due to the storms and the estimated dollar amount of that damage at specific locations. This Hurricane Damage Assessment Template (HDAT) consisted of 10 basic fields of information (Table 4.1). Cooperators located in each of the four coastal regions were asked to complete a pre-determined number of HDAT estimates. Sampling protocols were developed to be representative of the pre-Katrina geographic and economic distribution of fisheries infrastructure in each region and the geographic position of that infrastructure in relation to storm trajectories.

Spatial Integration

Using GIS software (ESRI Arc Map 9.0), a one-mile grid size was created for each of the 21 coastal parishes located in Regions 1 through 4. This grid was integrated with geo-coded coordinates of the 10,140 individual vessels, dealers, and processors obtained from LDWF license and registration data. Point data representing maximum storm surge heights, obtained from hind-cast adjusted ADCIRC simulations for Katrina and Rita, were then overlaid onto the grid. Figure 4.4 illustrates the integration of the grid and infrastructure data for Hurricane Katrina.

Because simulation nodes are not evenly distributed within ADCIRC, the number of maximum wave height observations varied considerably (0 to 31 per grid) depending on location. In cases where more than one observation was available, maximum storm surge (wave) height (MWH) was calculated by taking an arithmetic mean of the combined observations for Katrina and Rita. This average approach was considered the most conservative method for developing damage estimations within each 1 mile grid.

Table 4.1 Information in the Hurricane Damage Assessment Template (HDAT).

1	**Physical location of Infrastructure** - Latitude and longitude coordinates obtained from mapping software or handheld gps.
2	**Commercial vessel** – categorization by primary commercial activity
3	**Seafood buyer** – categorization by primary commercial activity
4	**Seafood processor** - categorization by primary commercial activity
5	**Primary species group** – Either shrimp, crab, oyster, marine or freshwater finfish.
6	**Secondary species group** - Either shrimp, crab, oyster, marine or freshwater finfish.
7	**Pre-Katrina Market Value of Business** - a reasonable estimate of what this business could have sold for on the open market prior to the 2005 hurricanes. This is not an estimate of the total amount of money someone has invested in the business.
8	**Estimated Business Damages** - an estimate of the total dollar cost of physical infrastructure damages caused to this business by the 2005 hurricanes. This estimate includes damages to things like buildings, equipment, vehicles, vessels, and inventory. It does not include estimates of revenue loss.
9	**Damages Covered by Insurance** - an estimate of the percentage (%) of damages estimated in Q4 that were covered by insurance.
10	**Lost Business Income for 2005** - an estimate of the percentage (%) of gross sales revenue that was lost in 2005 because of Hurricanes Katrina and Rita.
11	**Lost Business Income for 2006** - an estimate of the percentage (%) of gross sales revenue that you project will be lost in 2006 because of Hurricanes Katrina and Rita.
12	**Lost Business Income for 2007** - an estimate of the percentage (%) of gross sales revenue that you project will be lost in 2007 because of Hurricanes Katrina and Rita.

Note: Losses for 10-12 above should be based on the average annual sales that this business would have experienced prior to the 2005 hurricane season

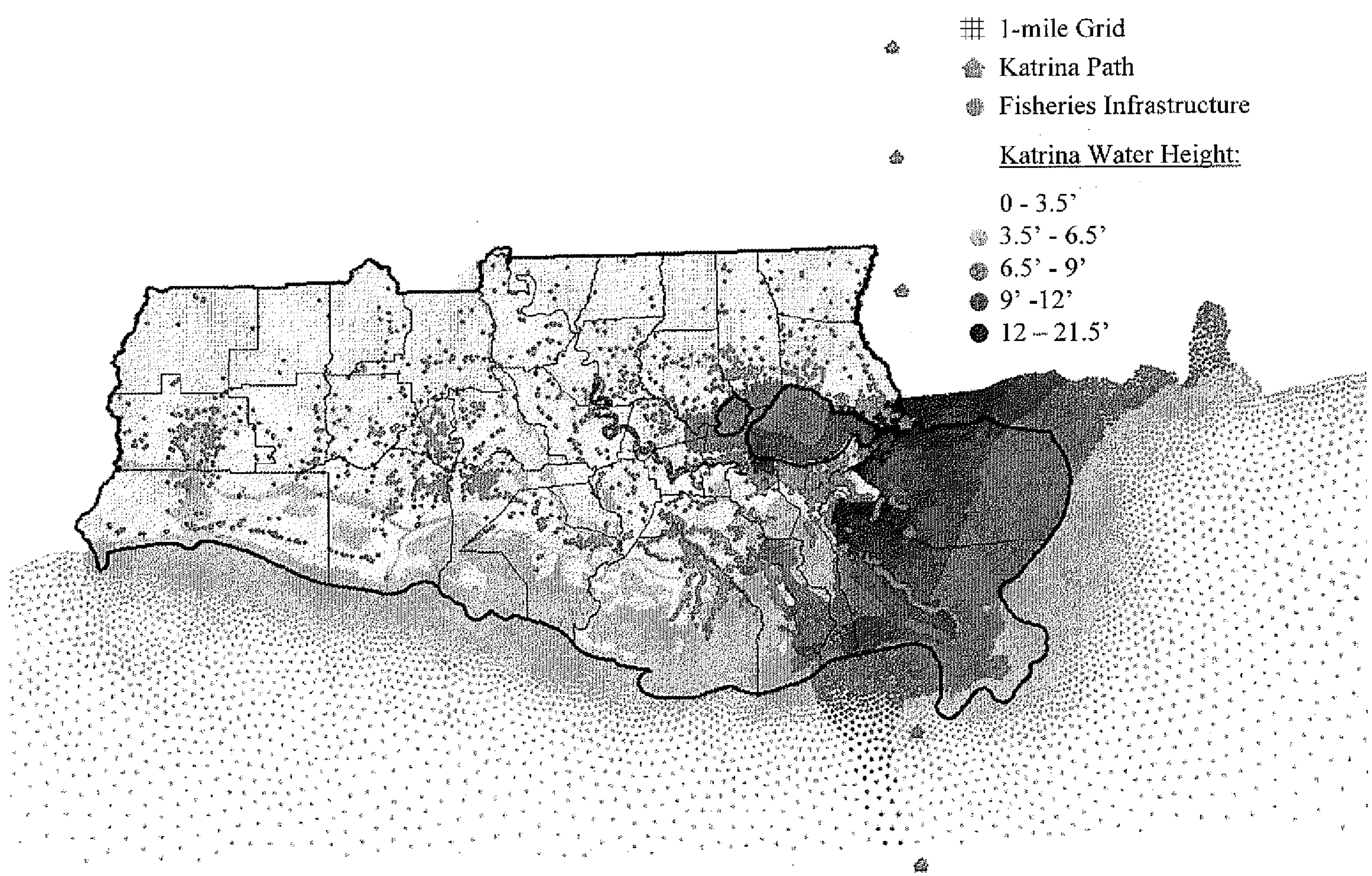

Figure 4.4 Integration of 1-Mile grid, Fisheries Infrastructure, and Maximum Water Levels for Hurricane Katrina

For grids where no observations were available, MWH was estimated using a nearest-neighbor estimation routine. But, because the computational requirements proved to be prohibitive when attempting to calculate MWH for each square mile of the Louisiana coastal zone, MWH was determined only for those grids that contained, or were adjacent to, geo-coded fisheries infrastructure. Combining all of the above information layers produced a map of the pre-Katrina location of fixed infrastructure in relation to storm surge height.

Statistical and Economic Assessment

Data obtained from the HDAT was used to develop an economic damage function in which direct damages were statistically related to geographically-specific surge heights. Subsequent analysis used the damage function to estimate storm impacts on all non-sampled infrastructure sites in coastal Louisiana, thereby allowing the calculation of aggregate storm impacts.

As an example, developing an estimate of direct damages to the commercial and recreational fleet required two distinct pieces of information – an accounting of the number of vessels lost or damaged during the storms, and a measure of the market value of each of the lost vessels. Given that no comprehensive listing of lost or damaged vessels was compiled post-storm, the loss of vessels was estimated by comparing the presence of vessels in trip-ticket data during the 8 month period following the storms with the same period from the previous year. A vessel that was absent in the post-storm period was assumed lost, and valued by its physical characteristics by employing a price regression estimated using data collected from the major commercial used-vessel marketing trade publications and websites. The loss of recreational vessels was similarly estimated using market-based price data from non-commercial marketing publications and state-maintained databases of recreational vessels and their characteristics. Loss estimates were developed separately for each of the 4 coastal regions in Louisiana and then aggregated.

SECTION 5:
REGIONAL AND STATEWIDE ECONOMIC LOSSES

The economic impacts of hurricanes Katrina and Rita on the Louisiana fishing industry were first estimated in a disaggregated context and then compiled to generate overall losses due to the storms. This section of the report details the specifics of the disaggregate analysis by industry sector.

Estimating Dealer and Processor Losses

Description of Dealer and Processor Responses

A total of 116 individuals and firms responded to the HDAT with usable information, including 101 seafood dealers and 15 seafood processors (Table 5.1). This represents approximately 11.5 percent of the original sample population that was constructed from lists of firms permitted by the State of Louisiana. While the response rate was adequate overall for state-level statistical inference, it was dominated by responses from Region 4 in southwest Louisiana, followed by Region 1 in the Lake Pontchartrain basin of southeast Louisiana. Specific reasons for the asymmetric response rates across regions were not completely clear, although there was substantial reluctance on the part of dealers and processors in Region 2 to providing economic information about their business, and Region 3 was not directly impacted by either hurricane.

When comparing responses across the state, Regions 2 and 4 clearly received the brunt of the physical impact from the hurricanes (as measured by estimated maximum wave height, see Table 5.2). Interestingly, processors in all regions on average experienced substantially lower maximum wave heights than did dealers. This may be explained, at least in part, by the fact that

Table 5.1. Regional distribution of permitted seafood dealers and processors responding to the 2006 Hurricane Disaster Assessment Template (HDAT) in Louisiana.

	Dealers [a]		Processors [b]	
	Number	**Percent** [c]	**Number**	**Percent** [c]
Region 1 [d]	12	9.6	2	40.0
Region 2 [e]	8	2.4	0	0.0
Region 3 [f]	9	2.8	8	16.3
Region 4 [g]	72	43.4	5	83.3
Total	101	10.8	15	20.3

[a] As permitted by the State of Louisiana.
[b] As permitted by the State of Louisiana; firms appearing in both the dealer and processor permit database were included in the processor level of the analysis.
[c] Represents the responding percent of permitted firms in the region.
[d] Includes the following parishes: Livingston, Orleans, St. Tammany, Tangipahoa, Ascension, St. John
[e] Includes the following parishes: Jefferson, Lafourche, Plaquemines, St. Bernard, St. Charles
[f] Includes the following parishes: Assumption, Iberia, Lafayette, St. Martin, St. Mary, Terrebonne
[g] Includes the following parishes: Acadia, Calcasieu, Cameron, Jefferson Davis, Vermilion

Table 5.2. Comparison by region of selected responses to the 2006 Hurricane Disaster Assessment Template (HDAT) in Louisiana.

Impact Measure	Dealers[a] Mean	Dealers[a] S.D.[c]	Processors[b] Mean	Processors[b] S.D.[c]
Maximum Wave Height (feet)[d]				
Region 1	4.5	5.3	2.9	0.6
Region 2	10.6	0.8	n.a.	n.a.
Region 3	5.4	4.3	5.1	3.2
Region 4	12.3	2.8	9.3	5.2
Pre-hurricane Value of Business ($)				
Region 1	686,667	573,127	1,262,500	1,750,089
Region 2	2,914,286	2,940,764	n.a.	n.a.
Region 3	625,000	631,325	1,192,857	1,314,163
Region 4	330,348	812,180	15,500,000	20,161,845
Damage to Business Value (%)				
Region 1	43.8	49.8	3.0	4.2
Region 2	38.6	32.0	n.a.	n.a.
Region 3	21.0	35.6	4.0	4.8
Region 4	71.5	35.2	30.1	30.8
Insurance Coverage (%)				
Region 1	8.6	16.1	22.5	31.8
Region 2	25.4	26.6	n.a.	n.a.
Region 3	14.4	29.6	28.8	36.4
Region 4	2.2	7.6	25.0	27.8
Expected Lost Income in 2005 (%)				
Region 1	54.6	36.9	30.0	7.1
Region 2	36.4	16.0	n.a.	n.a.
Region 3	53.9	26.5	34.4	26.4
Region 4	57.7	36.5	26.2	5.2
Expected Lost Income in 2006 (%)				
Region 1	49.8	39.2	12.5	17.7
Region 2	53.9	30.2	n.a.	n.a.
Region 3	27.8	14.2	28.1	26.9
Region 4	69.3	34.3	25.3	18.4
Expected Lost Income in 2007 (%)				
Region 1	40.9	43.2	7.5	10.6
Region 2	30.0	29.9	n.a.	n.a.
Region 3	11.1	10.5	16.3	22.0
Region 4	64.0	37.1	6.7	11.6

[a] As permitted by the State of Louisiana.

[b] As permitted by the State of Louisiana; firms appearing in both the dealer and processor permit database were included in the processor level of the analysis.

[c] Standard deviation of the mean.

[d] As estimated from the ADCIRC model.

dealers tend to be located either at or very close to the port facilities used by fishermen, whereas processors generally have more flexibility in siting their facilities. In terms of estimated damage to the value of their business, dealers in Region 4 were the most heavily impacted (average 71.5 percent loss), followed by dealers in Region 1 and 2 (average 43.8 and 38.6 percent, respectively). Processors, meanwhile, reported substantially lower levels of damage to their businesses, with the maximum average losses of 30.8 percent occurring in Region 4. Insurance coverage for these losses were generally minimal for both dealers and processors, especially in Regions 1 and 4 where the greatest percent damage was incurred.

Another important facet of the hurricanes' impact to consider is the potential affect on future revenues of dealers and processors. Projected 2005 revenue losses from the HDAT were relatively consistent across regions, with dealers estimating not quite twice the income loss that processors expected to experienced (Table 5.2). This consistency degenerated for 2006 and 2007 projections, however, with Region 2 and 3 dealers expecting a much more rapid recovery than Region 1 and, in particular, Region 4. Processors generally expected to recover faster than dealers, with the possible exception of those in Region 3. Of particular importance is the fact that these responses represented only expectations on the part of the respondents and not realized income losses. In fact, a comparison of respondent business revenues from the pre-storm period of September 2004 through April 2005 with the post-storm period of September 2005 through April 2006 indicated that dealers and processors overestimated expected income losses.[16] Responding dealers and processors that appeared in the trip-ticket data,[17] who on average expected to lose 55 to 62 confirmed for the industry overall by comparing total landings data in pre- and post-storm periods. As an example, shrimp landings in Louisiana for the January

[16] Estimated from respondent trip-ticket data for the given period.
[17] A total of 77 of the responding dealers and processors (66.4 percent) appeared in the trip-ticket data either before or before and after the storms.

through September 2006 period were estimated at 61.2 million pounds, 85 percent higher than the same period in 2005[18] and 26 percent above the previous 4-year average.[19] Similarly, menhaden harvests landed in Louisiana increased 6.8 percent in the first 9 months of 2006 as compared with 2005, although the total landings were 3.8 percent lower than the 2001-2005 average.[20] The fact that the operations of the responding dealers and processors recovered so quickly after the storm is evidence of the industry's resilience, flexibility, and general reliance on inputs other than built-capital.

Given the lack of statistical significance between regions in Table 5.2, the responses to impact measures were aggregated for the entire coastal region and used in subsequent calculations.[21] Overall, mean pre-storm business value for dealers and processors was $694,220 and $6,312,500, respectively (Table 5.3). Median business value for dealers and processors were $200,000 and $1,000,000, respectively, suggesting the highly skewed nature of the response data for this item.[22] Mean estimated damage to business value ranged from 11.9 percent for processors to 61.6 percent for dealers, while insurance coverage ranged from a mean of 5.9 percent for dealers to 26.7 percent for processors. Expected lost income due to this damage in the coming years ranged from 53.1 to 62.1 percent for dealers and 12.7 to 31.1 percent for processors. As previously noted, however, validation of these estimates against trip ticket data suggests that they were significantly overstated by respondents.

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[18] Due to data reporting problems caused by the storms, the 2005 time period does not include September 2005.

[19] U.S. National Marine Fisheries Service Market News, http://www.st.nmfs.gov/st1/market_news/doc45.txt, last accessed on October 28, 2006.

[20] U.S. National Marine Fisheries Service Market News, http://www.st.nmfs.gov/st1/market_news/doc77.txt, last accessed on October 28, 2006.

[21] The general implications of this aggregation will be to overestimate the impacts of the storms, as Region 4, which had the majority of responses, also tended to report the largest levels of impacts measured. One exception to this is in the pre-hurricane value of dealer businesses, as Region 2 reported much higher values than any other region. Given the limited responses from Region 2, the aggregate mean dealer values from all regions combined likely better represent the true mean in Region 2.

[22] Subsequent calculations in this analysis are accomplished using the mean value responses stratified by size class of the business (as discussed below), and as a result they will tend to overestimate the impact of the storm on dealers and processors.

Table 5.3. Descriptive statistics of permitted seafood dealer and processor responses in all regions to the 2006 Hurricane Disaster Assessment Template (HDAT) in Louisiana.

	Dealers [a]			Processors [b]		
Impact Measure	**Mean**	**S.D.[c]**	**Median**	**Mean**	**S.D.[c]**	**Median**
Pre-hurricane Value of Business ($)	694,220	1,390,032	200,000	6,312,500	13,289,545	1,000,000
Damage to Business Value (%)	61.6	40.2	77.5	11.9	20.3	6.0
Insurance Coverage for Damage (%)	5.9	15.4	0.0	26.7	31.0	20.0
Estimated Lost Income in 2005 (%)	55.3	34.9	40.0	31.1	22.8	30.0
Estimated Lost Income in 2006 (%)	62.1	35.4	60.0	25.1	22.8	22.5
Estimated Lost Income in 2007 (%)	53.1	39.5	50.0	12.7	18.3	0.0

[a] As licensed by the State of Louisiana.
[b] As licensed by the State of Louisiana; firms appearing in both the dealer and processor license database were included in the processor level of the analysis.
[c] Standard deviation of the mean.

Linking Water Levels to Business Damage

Using the ADCIRC model estimates of maximum water level heights experienced in systematic geographic cells across coastal Louisiana for hurricanes Katrina and Rita, maximum water levels experienced at the specific locations of all 1,013 dealers and processors permitted in Regions 1 through 4 were calculated via interpolation and nearest-neighbor techniques. The HDAT respondents were then used in a regression framework[23] to link the maximum water level experienced to the reported percent of business damage for dealers and processors. Specifically, this relationship took the form:

$$Damage = (\beta_1 + proc \cdot \beta_3) \cdot MaxWave + (\beta_2 + proc \cdot \beta_4) \cdot MaxWave^2 \qquad 5.1$$

where *Damage* is the percent damage to business value; *proc* is 1 if the respondent was a processor, zero otherwise; *MaxWave* is the estimated maximum wave height experienced at the business site; and β_1 through β_4 are the estimated parameters. Thus, two different relationships were estimated, one for dealers and one for processors, based on the intuition that dealers and processors in coastal Louisiana typically have very different capital investments in their businesses, resulting in different structures and equipment that has differential levels of susceptibility to storm surges. Results of the estimation are presented in Table 5.4, where it can be seen that all parameters were statistically significant at the traditional α-level of 0.05, with the exception of β_4, which nonetheless can be considered marginally significant.

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[23] Given that the percent damage is censored by zero and 100 percent, a two-limit probit estimator without intercept was used in developing the relationship (SAS QLIM Procedure). In this particular application, the dropping of an intercept term allowed the enforcement of the *ad hoc* regularity condition that damage could only be positive and could only occur if there was flooding. Because the two-limit probit estimator imposes restrictions on the data used in estimation, conventional measures of goodness-of-fit cannot be calculated. The log-likelihood value of -251.6 suggested a statistically significant model, as did the high Akaike Information and Schwatz Criterion (Table 5.4). In addition, an ordinary least squares (OLS) estimate of the relationship yielded an adjusted R-square of 0.89 and parameter estimates that were very similar to the two-limit probit model. Although these latter estimates were generated using a conceptually incorrect estimator, taken with the information generated by the two-limit probit model they indicate that use of the model is justified in terms of statistical fit to the data and robustness to incorrect estimators.

Table 5.4. Statistical results from the two-limit probit estimation of percent business value damage for respondents to the Louisiana HDAT.

Variable	Parameter Estimate	Standard Error of the Estimate	t-Value	Approx. Pr > |t|
MaxWave	16.0317	3.8734	4.14	< 0.0001
$MaxWave^2$	-0.6289	0.2992	-2.10	0.0356
procMaxWave	-21.5984	10.4225	-2.07	0.0382
$procMaxWave^2$	1.5034	0.9628	1.56	0.1184
sigma	44.6502	5.6069	7.96	< 0.0001

N = 96 Log Likelihood = -251.60 Akaike Criterion = 513.2
Schwarz Criterion = 526.0

The above estimated relationship is graphically depicted in Figure 5.1. In general, the estimated relationships for dealers and processors fall within the bounds of maximum and minimum expected flood damage to coastal businesses found in previous USACE studies.[24] Of particular note is the differences in expected damage to dealers and processors in coastal Louisiana given identical maximum water heights. Damage to dealers was estimated to occur even at low water levels, and increase rapidly (but at a decreasing rate) until 100 percent damage was reached at approximately 11 feet maximum water height. This relationship was very similar to the maximum expected damage curve derived from the USACE studies. In contrast, significant business value damage to processors was not expected to occur until water levels reached approximately 6 feet, after which damage increased rapidly until 100 percent damage was experienced at approximately 15 feet maximum water height. The processor damage curve was functionally different than either the USACE curves or the estimated curve for dealers, although it is not clear what characteristics about processor infrastructure might have led to this result.

Once estimated from respondent data, the damage curves depicted in Figure 5.1 were used to impute damage levels to all other processors in the original sample population based on their ADCIRC estimated maximum water heights experienced. This approach allows for damage estimates to be estimated for all dealers and processors without having to resort to a complete census of the population, and it has at its core actual respondent measures of damage

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[24] As part of the *2002 U.S. Army Corp of Engineers' Dredge Material Management Plan and Environmental Impact Statement, McNary Reservoir and Lower Snake River Reservoir,* the consulting firm Northwest Economic Associates incorporated various water depth to damage data tables that were extracted from USACE studies of previous flood and storm surge events in Galveston, Texas and the Pearl River Basin, Mississippi. The maximum, minimum, and mean damage curves in Figure 5.1 were calculated by using these data tables and the values reported for coastal businesses that were most closely related to the type of infrastructure used by Louisiana dealers and processors. Specifically, these included damages to piers, groceries, food warehouses, food processors, and boat stalls. These USACE studies can be found at http://www.nww.usace.army.mil/dmmp/dmmp_appc.htm, http://www.nww.usace.army.mil/dmmp/att_ca.htm, and http://www.nww.usace.army.mil/dmmp/att_cb.htm (sites last accessed November 9, 2006).

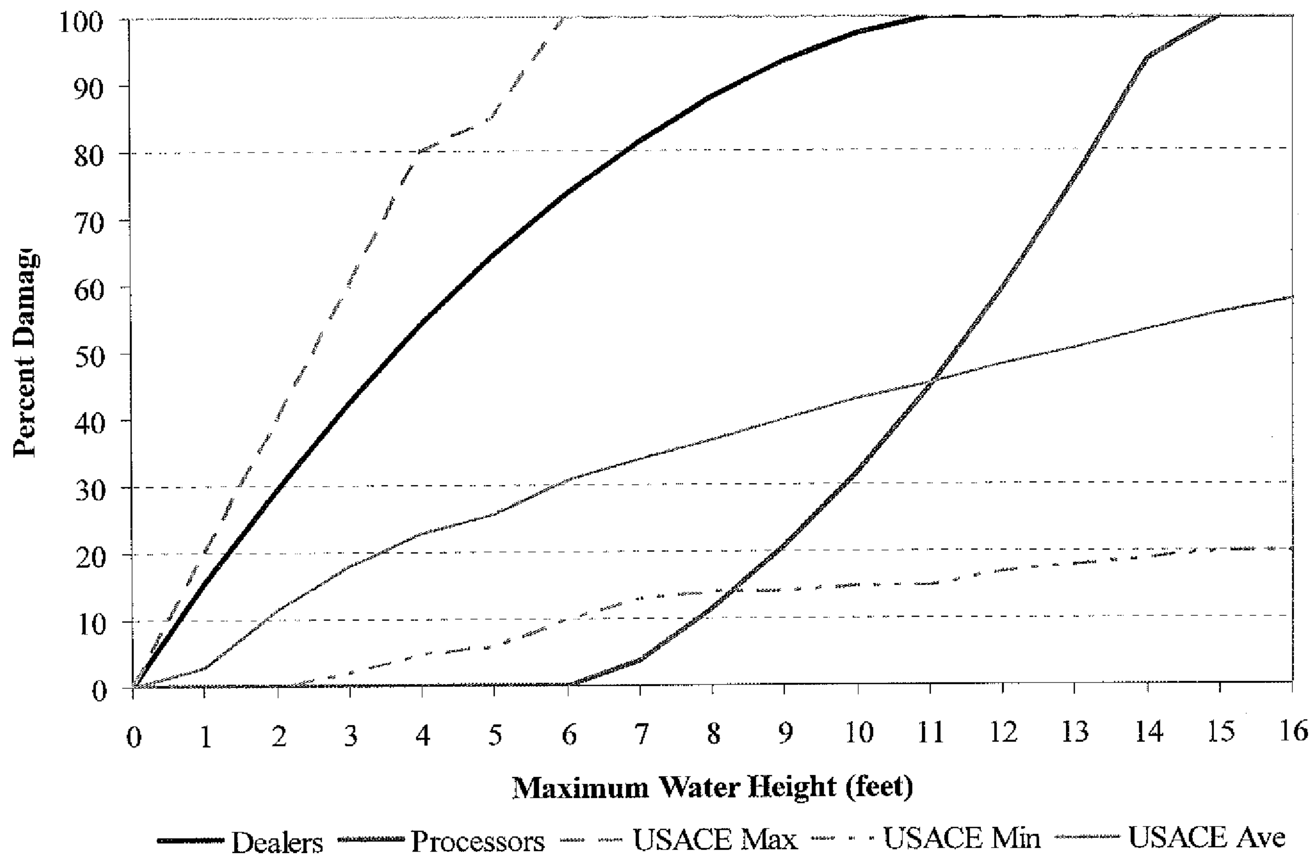

Figure 5.1. Comparison of estimated percent business damage models with U.S. Corp of Engineer (USACE)summary data on flood damage to water height relationships.

based on similar storm experiences. While errors would be expected in estimating any specific businesses damage levels using this approach,[25] it should yield a reasonable aggregate estimate of percent damage to all dealers and processors, and do so in a way that takes into account the geographic variability in storm experiences associated with hurricanes Katrina and Rita.

Calculating the Economic Value of Dealer and Processor Damages

Having estimated the maximum wave height experienced by each permitted dealer and processor, and from that using the estimated damage curves to calculate the percent lost business value for each firm, it remains to determine the economic value of that percentage loss. The approach taken in this study was to use the HDAT respondents' pre-storm annual gross revenues, as estimated from the trip ticket data, to stratify the sample into three business size classes – greater than $100,000 revenue annually, $25,000 to $100,000 revenue annually, and less than $25,000 annually. Using these size classes, the mean pre-storm value of the businesses were estimated from the HDAT responses (Table 5.5). As expected, reported mean pre-storm business values decreased with decreasing revenue size, from a high of over $7 million for businesses with more than $100,000 in annual revenues to $238,000 for businesses with less than $25,000 in annual revenues. It was these mean pre-storm business values, along with the estimated percent damage to business value, which determined the economic value of the losses experienced by dealers and processors due to hurricanes Katrina and Rita.

[25] These errors result from both the differences between actual water level heights and those estimated by the ADCIRC model interpolations, and from the fact that the estimated water height, percent business damage curves are regression based and thus represent average damage levels at any given water height. As a result, errors in estimating a specific businesses damage may be positive or negative, with an expectation of a zero error in aggregate. Another way to address this problem would have been to use a frontier curve of the estimated water height, percent business damage relationship, an approach that would generate all positive errors in estimating the actual damage experienced (i.e., overestimate the damage for all dealers and processors). This latter approach, however, would ultimately lead to excessive economic damage estimates given that the aggregation of reported percent damages by respondents across regions was already assumed to generate an overestimate of the true damage experienced.

Table 5.5. Pre-storm business values stratified by revenue size classes as reported by Louisiana HDAT respondents.

		Pre-Storm Business Value ($)			
Annual Revenues	Number	Mean	Minimum	Maximum	Median
>$100,000	14	7,328,571	500,000	40,000,000	1,550,000
$25,000 - $100,000	40	623,607	25,000	5,000,000	250,000
<$25,000	25	238,200	15,000	2,000,000	80,000

Table 5.6. Estimates of the Total Economic Losses Experienced by Coastal Louisiana Seafood Dealers and Processors Due to Hurricances Katrina and Rita.

Coastal Area	Estimated Losses in the Market Value of Dealer Businesses [a]	Estimated Losses in the Market Value of Processor Businesses [b]	Totals
Region 1	$5,359,541	$792,716	$6,152,257
Region 2	$48,359,012	$5,760,351	$54,119,363
Region 3	$29,457,307	$25,541,192	$54,998,499
Region 4	$20,346,326	$31,741,883	$52,088,209
Total	$103,522,186	$63,836,142	$167,358,328

[a] Calculated from direct responses from affected dealers and imputed to the entire population of dealers using the percent damage by wave height relationships (see body of text for further explanation).
[b] Calculated from direct responses from affected processors and imputed to the entire population of processors using the percent damage by wave height relationships (see body of text for further explanation).

Table 5.6 presents regional and statewide summary of the total calculated business value losses experienced by dealers and processors.[26] For dealers, the largest losses occurred in Region 2 ($48,359,012), followed by Region 3 ($29,457,307) and Region 4 ($20,346,326). Relative to the others, Region 1 dealers were lightly impacted by hurricane Katrina and Rita, experiencing $5,359,541 in losses. Taken together, dealers in the four coastal regions were estimated to have incurred $103,522,186 in business value losses due to the storms. Processor losses to the storms took on a somewhat different geographic pattern than did dealer losses (Table 5.6). Region 4 processors accounted for $31,741,883 in business losses, followed closely by Region 3 with $25,541,192 in storm-related losses. Processors in Region 1 and 2 – with $792,716 and $5,760,351 in losses, respectively – had substantially lower damage due primarily to the fact that relatively few processors were located in those regions. Taken together, processors across the coast were estimated to have experienced $63,836,142 in losses to their market value. Combining dealer and processor losses together resulted in estimated damages of $6,152,257 for Region 1, $54,119,363 for Region 2, $52,088,209 for Region 3, and $52,088,209 for Region 4. Thus, with the exception of Region 1, damages to the dealer and processor sectors of the Louisiana seafood industry were fairly evenly distributed geographically. Coast-wide, total dealer and processor damages totaled to $167,358,328. For comparison purposes, these losses are approximately 29 percent of the total annual revenue generated by the dealers and processors in Louisiana.[27]

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[26] Regional specificity in this table was possible because each dealer and processor can be located geographically given the state license files, and the ADCIRC interpolations of experience storm surges, and thus estimated percent damage, were also geographically specific. These geographically specific percent damages, however, were multiplied by the coast-wide estimates of pre-storm business value by revenue size class. Thus, the regional estimates does not account for the variability in actual economic damage between regions that arises from regional differences in pre-storm business values.

[27] While the estimated business value losses and the annual revenue values as reported in LDWF trip ticket and NMFS processor data are not directly related to each other, business infrastructure losses should affect future revenue streams that can be generated by the industry. The extent of that effect, and how long it persists, will

Estimating Commercial Fishermen Losses

Estimating losses to commercial harvesting sector of Louisiana's seafood industry was approached in two different ways. Conceptually, the impacts of a natural disaster should be measured through the changes in the physical infrastructure used to support economic activity. From that perspective, the most direct way to measure the hurricanes' impacts would be through measures of damage to the fishing fleet. But, the harvesting sector also includes the input suppliers to the fishermen, who provide everything from the gear to ice to fuel. Directly measuring changes to supplier infrastructure is difficult, in part because there are few sources that could be used to comprehensively identify these firms, and also because these suppliers tend to provide inputs to a number of sectors, only one which is the commercial fishermen.[28] Some of the impacts on this supplier group might be discerned, however, if the effects of the hurricanes are measured in terms of lost revenues to the harvesting sector as these revenues are partly used to pay suppliers.[29] Both approaches were employed in this study in order to get a better idea on the magnitude of the storm impacts.

Estimating Damages to the Fleet

Developing an estimate of direct damages to the commercial fleet required two distinct pieces of information – an accounting of the number of vessels lost or damaged during the storms, and a measure of the market value of each of the lost vessels. To our knowledge, no

depend on industry flexibility, the importance of the infrastructure as an input, and the ability to replace the built capital after it has been damaged.

[28] The most obvious example would be suppliers of fuel to the commercial fishermen, a group that also tends to supply fuel to the recreational industry and to other, non-fishing, uses.

[29] Included in these suppliers would be the mortgagers and builders/sellers of vessels, debts to whom must be paid from revenues. As a result, impacts measured as infrastructure damage (i.e., lost and damaged vessels) are also captured when measuring lost revenues to the harvesting sector. This requires that the two measures be viewed separately, with perhaps the fleet loss viewed as a lower bound and the revenue loss viewed as an upper bound on the damages experienced by the sector.

comprehensive listing of lost or damaged vessels was compiled post-storm,[30] requiring indirect methods for estimating the numbers. In terms of the number of vessels lost or damaged, one way to estimate the number is through the trip ticket data, where reporting vessels can be tracked through time. As for market value of these vessels, a relationship needed to be developed that would link a vessel's characteristics to its potential market price.

Using the trip ticket data, vessels[31] reporting landings during the pre-storm September 2004 through April 2005 time period were compared with the vessels reporting landings during the post-storm September 2005 through April 2006 time period.[32] Pre-storm, 6,402 vessels reported landings in the 8-month period indicated. Post-storm, only 2,997 of these vessels reported in the 8-month period, suggesting that 3,405 vessels were either completely lost during the storms or damaged to an extent that they were unable to return to fishing by the following year.[33] Of these lost vessels, 2,112 could be linked to either state or U.S. Coast Guard records that contained detailed information about their characteristics and thus could be valued using a market price relationship.[34] The remaining 1,293 vessels can be valued at the mean vessels value for the 2,112 vessels under the assumption that, on average, they exhibited the same vessels characteristics.

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[30] The U.S. Coast Guard kept partial records of vessels that were salvaged in their operations, but these records appear to have been inconsistently kept and, in any case, were almost exclusively vessels that had come to block navigable waterways after the storms (for which the Coast Guard had responsibility for clearing). In fact, anecdotal evidence and personal observation indicates that many vessels still lie abandoned in marshes and land-based collection points, making them for all intents and purposes lost to the industry.

[31] These vessels included both federally registered offshore vessels and those that were state registered for inshore fishing.

[32] This 8-month time period was chosen for comparison because it represented the most complete trip ticket data available post-storm at the time of the analysis.

[33] In actuality, the post-storm reporting fleet size totaled 3,985 vessels, suggesting that as many as 988 vessels (3,985 post-storm vessels minus the 2,997 surviving vessels of the pre-storm fleet) that were not there before the storms entered the Louisiana fleet (at least for the 8-month period examined). For the purposes of this analysis, the potential off-setting effects of these new vessels on fleet infrastructure losses were not considered.

[34] These characteristics include registered address and homeport information, thus allowing a regional analysis of the vessels losses.

Determining a relationship between commercial vessel characteristics and value required market data. Issues of trade publications that are often used for marketing used vessels were canvassed to collected data on asking prices for vessels and their characteristics.[35] With this approach, information on 108 vessel offers[36] were collected and analyzed in a regression framework using the following functional relationship:

$$\ln(price) = \alpha + \beta_1 \cdot \ln(length) + \beta_2 \cdot year + \beta_3 \cdot metal + \beta_4 \cdot glass + \beta_5 \cdot inboard \qquad 5.2$$

where *price* is the offer price for the vessel; *length* is vessel length in feet; *year* is the year the vessel was constructed; *metal* is 1 if the vessel hull was steel or aluminum, zero otherwise; *glass* is 1 if the vessel hull was fiberglass, zero otherwise; and *inboard* is 1 if vessel propulsion was via inboard motor, zero otherwise (for those with outboard propulsion). In this specification, binary variables describing vessels constructed of wood were dropped from the specification (as required to allow estimation).

The sample of vessels for sale was slightly older than all registered vessels, but they were substantially larger (almost twice as large) compared all registered vessels (Table 5.7). In addition, the sampled vessels were less likely to be constructed of fiberglass compared to all registered vessels, and they were much more likely to use inboard propulsion. Given the relative magnitudes of the parameter estimates from the commercial vessel market value estimations, this information suggests that the statistical price relationship may overestimate the value of lost commercial vessels depending on to what extent lost vessels have characteristics more similar to the average registered commercial vessel rather than the average vessel for sale.

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[35] The primary source for c data was the trade publication *Boat & Harbors: The Commercial Marine Marketplace*, which can be accessed online at http://www.boats-and-harbors.com/ (last accessed November 10, 2006).

[36] Actual market value of the vessel will be determined by their sale price, not the offer price. The lack of sale price data, however, required the use of the offer data. Because the offer price is usually greater than the sales price, the relationship developed with this method will likely overestimate the value of the lost vessels.

Results of this regression analysis were highly significant, with both the overall model and all the individual parameters being statistically significant and the estimated parameters having the expected signs (in the cases of length and year built, as there were no *a priori* expectations of signs on the other variables) (Table 5.8). As can be seen in Figure 5.2, overall the estimated regression was a good predictor of vessel value, with the exception that highest priced vessels tended to be under-predicted.

The values of each of the 2,112 vessels apparently lost due to the storms were estimated using the above price relationship. Taken together, the 2,112 vessels were valued at $95,407,488 for an average of $45,174 per vessel. This average was then used to calculate the value of the 1,293 vessels that did not have enough characteristics data in either state or federal registries to value using the price relationship. Including these vessels, the calculated value of the lost fleet totaled $153,817,470. A regional breakdown of this infrastructure loss is detailed in Table 5.9. Region 2 by far experienced the largest loss in vessels, totaling $104,595,880, whereas the losses in Regions 1, 3 and 4 each fell in the range of $15 million to a little over $17 million.

Table 5.7. Comparison of Characteristics for Commercial Vessels Offered for Sale versus Known Registered Commercial Vessels.

Characteristic	Mean	Median	Std. Error	Min	Max	Percent
Offered for Sale (n=108):						
Year Built	1986	1987	1.08	1950	2006	
Length (feet)	49	45	2.09	14	90	
Percent Constructed of Fiberglass						49.1
Percent Constructed of Metal						31.5
Percent with Inboard Propulsion						88.0
Registered (n=6,402):						
Year Built	1990	1989	0.13	1924	2006	
Length (feet)	25	24	0.11	12	79	
Percent Constructed of Fiberglass						60.7
Percent Constructed of Metal						33.8
Percent Using Inboard Propulsion						45.5

Table 5.8. Statistical results from the federal and state registered commercial vessel market value estimations.

Variable	Parameter Estimate	Standard Error of the Estimate	t-Value	Approx. Pr > |t|
Intercept	-62.1046	10.2169	-6.08	< 0.0001
Ln(vessel length) (feet)	2.3564	0.1380	17.08	< 0.0001
Year Built	0.0317	0.0051	6.20	< 0.0001
Metal Hull (0,1)	0.5474	0.1788	3.06	0.0028
Fiberglass Hull (0,1)	0.6997	0.1597	4.38	< 0.0001
Inboard Propulsion (0,1)	0.5367	0.2023	2.65	0.0092
N = 108	F = 139.882	Approx. (Pr > F) < 0.0001	Adjusted R-square = 0.8665	

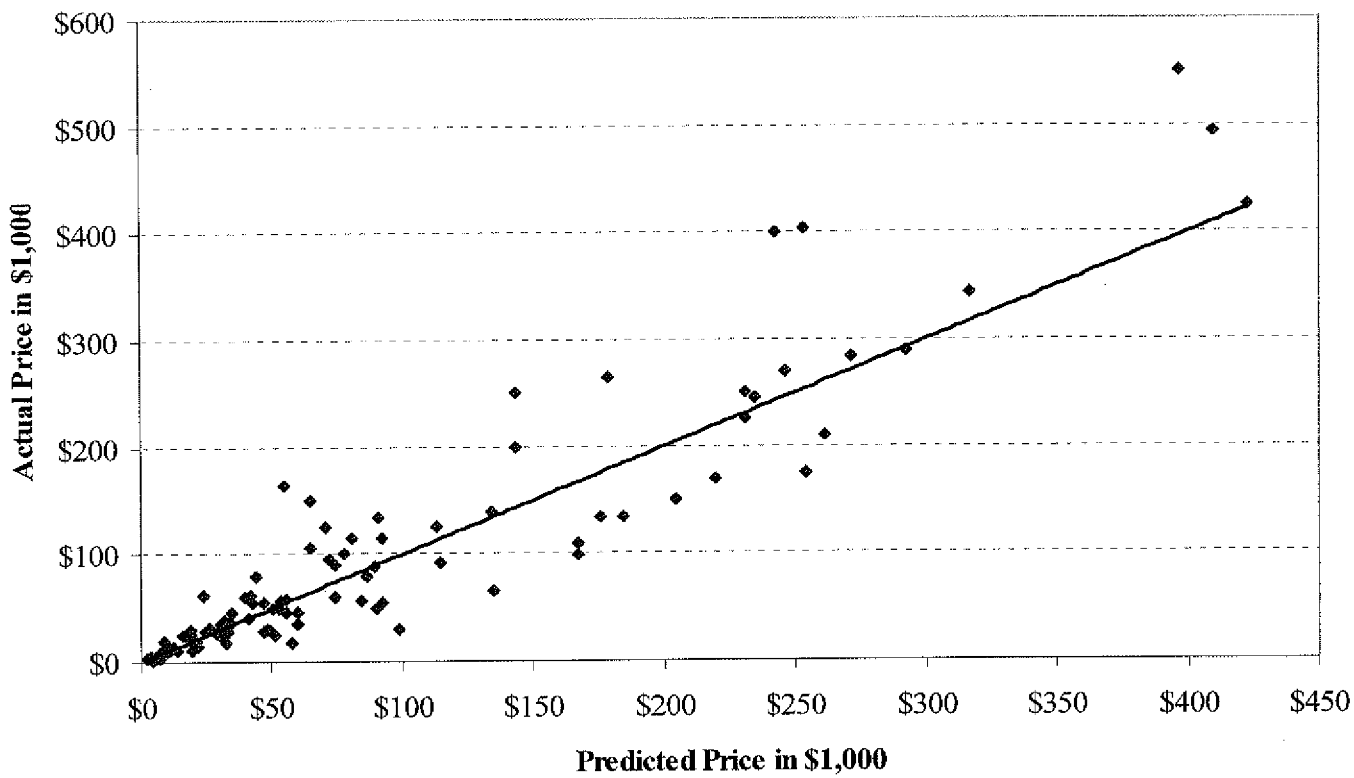

Figure 5.2. Comparison of observed versus predicted market value for commercial vessels in Louisiana.

Table 5.9. Two Alternative Estimates of the Total Economic Losses Experienced by Louisiana's Commercial Fishermen Due to Hurricanes Katrina and Rita.

Coastal Area	Estimated Total Market Value of Lost Commercial Fishing Vessels [a]	Estimated Discounted Total Revenue Loss (in 2005 dollars) [b]						
		2005	2006	2007	2008	2009	2010 [c]	Total
Region 1	$17,227,557	$1,150,419	$1,989,687	$1,140,447	$429,172	$0	$0	$4,709,724
Region 2	$104,595,880	$28,662,737	$44,812,154	$20,033,222	$0	$0	$0	$93,508,113
Region 3	$16,612,287	$11,561,132	$16,955,772	$6,712,989	$0	$0	$0	$35,229,893
Region 4	$15,381,747	$13,092,982	$23,273,457	$14,287,612	$6,743,215	$452,447	$0	$57,849,714
Total	$153,817,471							$191,297,444 [d]

[a] Calculated using trip ticket data and comparing the vessels reporting pre-storm during the period September 2004 through April 2005 with those vessels reporting post-storm during the period September 2005 through April 2006. Those vessels reporting in the first period, but not the second, were assumed to have been lost to the fishery due to the storm. Market values for these vessels were then estimated using the commercial vessel market price relationships (presented elsewhere).

[b] Calculated using dealer estimates of percentage business losses incurred in 2005 and the forecasted percentage business losses for 2006 and 2007 adjusted by the observed business activity in the trip-ticket data and a discount rate of 10 percent (see body of text for further explanation). Note that the values are generated from the trip ticket data and represent the amount paid by dealers to fishermen for product. Losses for 2008-2010 were estimated by straight-line interpolation from the projected declines between 2006 and 2007, yielding a result that conforms to published guidance that suggests limiting disaster loss calculations to a 5 year time horizon (United Nations, Economic Commission for Latin America and the Caribbean 2003).

[c] Given the extrapolation and discounting methods, years beyond 2010 had zero values for losses in all regions. Current data collection for Louisiana fisheries indicates that recovery (in terms of landings) is occurring at a faster rate than projected by dealers (perhaps due to entry into the fishery by vessels from regions not impacted by the storms and from accelerated repair activities), suggesting that these revenue losses are an overestimate.

[d] Theoretically, the value of a fisherman's' business is determined by discounted future net revenues. Given that this value represents the discounted future gross revenues, it should be thought of as an upper bound on the actual losses to the fishermen.

Estimating Lost Revenue to the Harvesting Sector

Discounted total revenue figures accruing to the harvesting sector and below can be estimated over a period of years from the trip ticket data, which in principle records all landings sold through dealers in Louisiana,[37] and by employing the forecasted percentage business losses reported by dealers and processors in the HDAT. These estimates, detailed in Table 5.9, indicate that although expected losses in 2005 totaled nearly $55 million across all regions, revenue losses were expected to peak in 2006 at slightly over $87 million. Recovery in the years following 2006 was forecasted by dealers to vary by region, but in all cases they were expected to be back to normal by 2010. On a region specific basis, Region 2 was expected to incur the largest losses ($93.5 million), followed by Region 4 ($57.8 million) and Region 3 ($35.2 million). Relative to the other regions, the losses in Region 1 were expected to be minor ($4.7 million). Over all, the estimated discounted total revenue loss to the harvesting sector and its input suppliers was $191,297,444. This value is approximately $37.5 million more than the direct estimated fleet infrastructure losses, an amount that can be taken as an estimated of the revenue that is passed from harvesters to their suppliers.[38]

[37] Not necessarily included in the trip ticket data would be landings that are direct marketed by fishermen to consumers, restaurants, or non-reporting dealers/wholesalers. The extent of this alternative marketing channel, however, is believed to be small relative to the reported data.

[38] Under certain assumptions, the market value of a vessel would be equal to the total discounted net revenue that the vessel is capable of generating over time. As a result, the difference between the harvesters' total revenue and their vessel value represents various costs incurred in harvesting, which in this case we simply refer to as revenue to the input suppliers.

Estimating Recreational Sector Losses

Similar to the commercial fleet, developing an estimate of direct damages to the recreational fleet required two distinct pieces of information – a measure of the market value of each lost vessel and an accounting of the number of vessels lost or damaged during the storms.[39] To our knowledge, only one comprehensive estimate of lost or damaged Louisiana recreational vessels was compiled post-storm, and that was as part of a Gulf-wide study conducted by National Association of Charterboat Operators (Walker et al. 2006). In this study, Louisiana was estimated to have lost approximately 21 percent of its charter fleet, with an additional 20 percent damaged but where repairs were anticipated. Lacking better data, the former value was used to estimate the total number of recreational vessels lost by multiplying by the total number of recreational vessels registered in the four coastal regions, resulting in an estimated loss of 17,108 boats to hurricanes Katrina and Rita.[40] As for the market value of these vessels, a relationship needed to be developed that would link a boat's characteristics to its potential market price.

Determining a relationship between recreation boat characteristics and value required market data. Issues of trade publications that are often used for marketing used vessels were canvassed to collected data on asking prices for vessels and their characteristics.[41] With this

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[39] Damage to the recreational sector would also be expected to include marina and other infrastructure losses. The National Association of Charterboat Operator study (Walker et al. 2006) estimated that 46 Louisiana marinas were damaged in the storms, with 4 being put out of business permanently and the rest subject to repair. Their report, however, gives no estimate of the economic value of these marinas, nor any information about their characteristics. Given time constraints, difficulties in data collection, and the focus on the commercial sector, no estimates were generated of marina and allied business damage for this study.

[40] State of Louisiana registration records for recreational vessels indicate that 81,467 boats were registered in the coastal parishes of Regions 1 through Region 4, or nearly 52 percent of the fleet. Of course, many of these boats can be trailered and thus it unknown exactly how many were exposed to the conditions experienced by the generally larger charterboats. For the purposes of this study all were considered at risk, and thus the loss values generated are best considered upper bound estimates.

[41] The primary source for this data was the recreational boating site www.Boats.com (last accessed November 14, 2006), where there is an active market for both new and used recreational vessels in the United States. For the purposes of this study, information on used boats offered for sale in Louisiana were collected across a wide variety of vessel types and sizes.

approach, information on 491 vessel offers[42] were collected and analyzed in a regression framework using the following functional relationship:

$$\ln(price) = \alpha + \beta_1 \cdot \ln(length) + \beta_2 \cdot year + \beta_3 \cdot outboard + \beta_4 \cdot inboard + \beta_5 \cdot metal + \beta_6 \cdot glass \qquad 5.3$$

where *price* is the offer price for the vessel; *length* is vessel length in feet; *year* is the year the vessel was constructed; *outboard* is 1 if vessel propulsion was via outboard motor, zero otherwise; *inboard* is 1 if vessel propulsion was via inboard motor, zero otherwise; *metal* is 1 if the vessel hull was steel or aluminum, zero otherwise; and *glass* is 1 if the vessel hull was fiberglass. In this specification, binary variables describing vessels constructed of wood or using other propulsion (sail, oars, etc.) were dropped from the specification (as required to allow estimation).

The sample of vessels for sale were, on average, 4 years newer than all registered vessels, and they were substantially larger compared all registered vessels (Table 5.10). In addition, the sampled vessels were much more likely to be constructed of fiberglass instead of metal compared to all registered vessels, and they were much more likely to use inboard propulsion. Given the relative magnitudes of the parameter estimates from the vessel market value estimations, this information suggests that the statistical price relationship may overestimate the value of lost recreational vessels depending on to what extent lost vessels have characteristics more similar to the average registered recreational vessel rather than the average vessel for sale.

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42 Actual market value of the vessel will be determined by their sale price, not the offer price. The lack of sale price data, however, required the use of the offer data. Because the offer price is usually greater than the sales price, the relationship developed with this method will likely overestimate the value of the lost vessels.

Table 5.10. Comparison of Characteristics for Recreational Vessels Offered for Sale versus Known Registered Recreational Vessels.

Characteristic	Mean	Median	Std. Error	Min	Max	Percent
Offered for Sale (n=491):						
Year Built	1992	1995	0.47	1947	2006	
Length (feet)	29	27	0.44	10	72	
Percent Constructed of Fiberglass						87.4
Percent Constructed of Metal						12.3
Percent with Inboard Propulsion						44.3
Percent with Outboard Propulsion						41.1
Registered (n=81,467):						
Year Built	1988	1990	0.03	1900	2005	
Length (feet)	16	16	0.01	6	82	
Percent Constructed of Fiberglass						45.4
Percent Constructed of Metal						51.8
Percent Using Inboard Propulsion						7.5
Percent with Outboard Propulsion						84.0

Results of this regression analysis were highly significant, with both the overall model and all the individual parameters being statistically significant and the estimated parameters having the expected signs (in the cases of length and year built, as there were no *a priori* expectations of signs on the other variables) (Table 5.11). As can be seen in Figure 5.3, overall the estimated regression was a good predictor of vessel value, with the dispersion around the predicted value increasing as the value of vessels increased.[43]

The values of each of the 81,467 boats registered in the coastal regions were estimated using the above price relationship and information contained in the state registration database. Overall, the estimated market value of these boats was approximately $1.07 billion, for an average value of slightly more than $13,093 per boat. Using the calculated number of boats lost (17,108) to the storms, the estimated total recreational fleet losses is estimated to be $224,004,486 (Table 5.12). Region 2 was estimated to have experienced the largest loss of recreational vessels, totaling $78,049,621. Regions 1 and 3 were each estimated to have lost slightly less than $61 million in recreational vessels, while Region 4 was estimated to have lost slightly more than $24 million in vessels.

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[43] In part, this increasing dispersion is likely a function of thinner markets for higher priced vessels, and thus a lack of commonly accepted metrics among sellers for determining their offer prices.

Table 5.11. Statistical results from the state registered recreational vessel market value estimations.

Variable	Parameter Estimate	Standard Error of the Estimate	t-Value	Approx. Pr > |t|
Intercept	-94.8594	5.0179	-18.90	< 0.0001
Ln(vessel length) (feet)	3.8665	0.1297	29.81	< 0.0001
Year Built	0.0457	0.0025	18.34	< 0.0001
Outboard (0,1)	0.2547	0.0930	2.74	0.0064
Inboard (0,1)	0.2292	0.0815	2.81	0.0051
Metal (0,1)	0.8639	0.4940	1.75	0.0810
Fiberglass (0,1)	1.3322	0.4895	2.72	0.0067
N = 491	F = 467.034	Approx. (Pr > F) < 0.0001	Adjusted R-square = 0.8716	

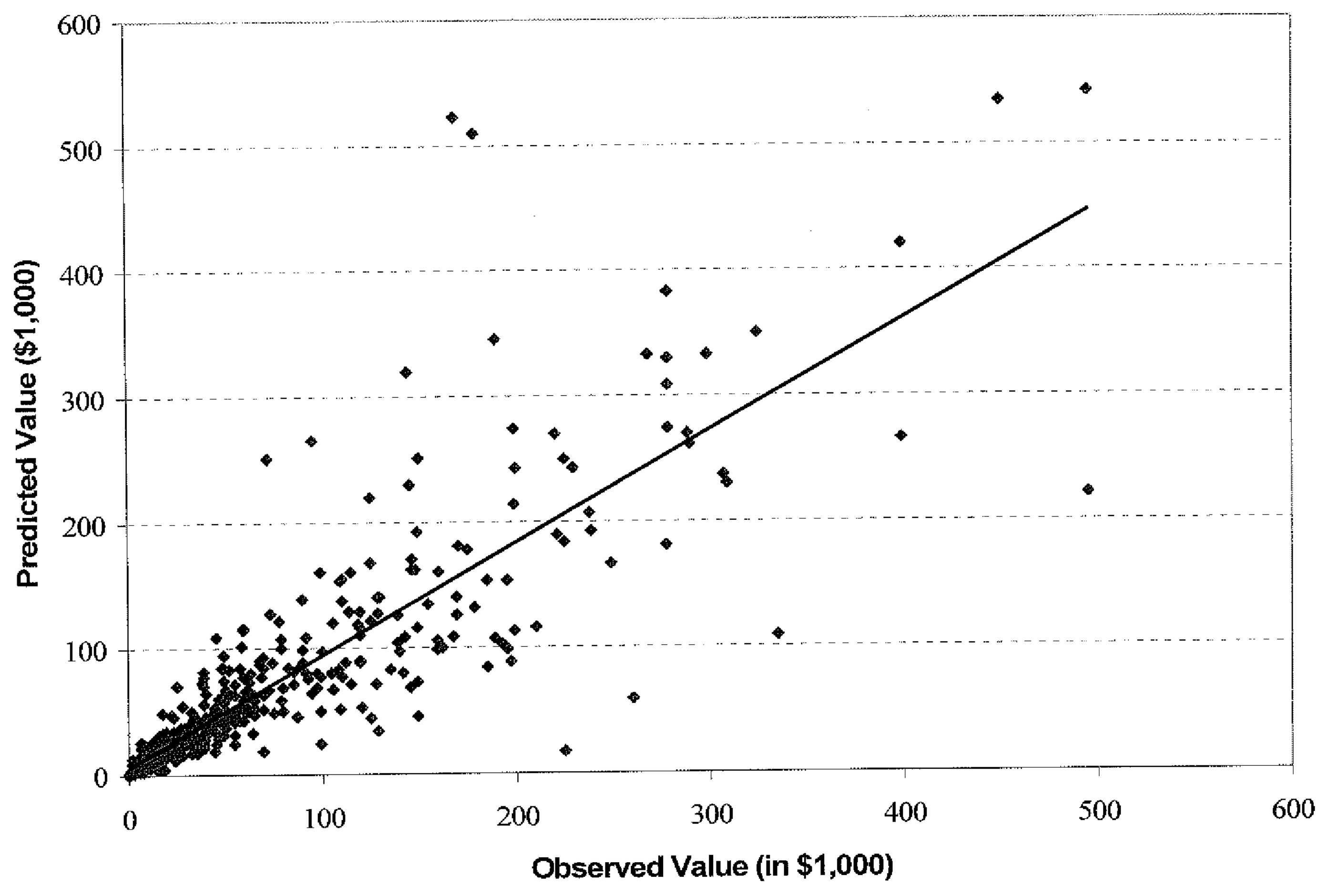

Figure 5.3. Comparison of observed versus predicted market value for recreational fishing vessels in Louisiana.

Table 5.12. Estimates of the Vessel Losses Experienced by the Louisiana Recreational Fishing Industry Due to Hurricanes Katrina and Rita.

Coastal Area	Number of Registered Vessels	Estimated Total Market Value of Lost Recreational Fishing Vessels [a]
Region 1	21,712	$60,945,259
Region 2	23,397	$78,049,621
Region 3	24,747	$60,873,018
Region 4	11,611	$24,136,588
Total	81,467[b]	$224,004,486

[a] Calculated using the estimated 21 percent of charter boats lost and damaged during the hurricanes (Walker et al. 2006) as applied to all recreational vessels in the affected coastal parishes and the estimated recreational vessel market value relationship (presented elsewhere).
[b] These vessels in the coastal regions amounted to 51.6 percent of the 157,943 registered recreational vessels in the state of Louisiana.

SECTION 6
SUMMARY AND IMPLICATIONS

Hurricanes Katrina and Rita severely damaged the infrastructure and livelihoods of commercial and recreational fishers along the northern Gulf of Mexico, with the majority of this damage occurring within the Louisiana coastal zone. Rapid assessments of the economic damage were widely published in the popular media and used as the basis for proposed recovery efforts even though many of the initial estimates were inconsistent with established economic procedures for damage assessment following natural disasters. As part of an ongoing effort to assist coastal states in the acquisition and distribution of federal aid during the recovery process, this study provides a more detailed examination of fisheries infrastructure damage using new estimates that were generated from both established and novel procedures for quantifying damage from natural disasters. Because of the large geographic scale of the impacts in Louisiana, a regional approach was developed in order to characterize damages within the physical sub-basins and political parish boundaries of coastal Louisiana. Four regions were defined for the purposes of damage assessment in this report: Region 1, the parishes bordering the southeastern and northern shores of Lake Pontchartrain; Region 2, the coastal parishes of southeastern Louisiana; Region 3, the coastal parishes of south-central Louisiana; and Region 4, the coastal parishes of southwestern Louisiana.

Regional and Sector Findings

As might be expected given the storm tracks detailed in Figures 4.2 and 4.3, regions 2 and 4 received the bulk of the physical impact from the hurricanes (see estimated maximum wave heights in Table 5.2). Consequently, these two regions had the highest levels of economic damage, with total fisheries damages at $225,677,097 and $134,074,511, respectively, compared to damages of $151,101,410 for Region 3 and $71,807,240 for Region 1 (Table 6.1). Damages to recreational and commercial vessels accounted for the majority of the losses in each region, with these two vessel categories combined producing 75 percent of the total estimated damages to fisheries infrastructure in coastal Louisiana. At the same time, dealers in Region 4 were the most heavily impacted of the shore-based fishing industries, on average experiencing a 71.5 percent loss in their business. Compared to Region 4's level of damage, dealers in Region 1 and 2 were less severely affected, averaging 43.8 and 38.6 percent losses, respectively. Processors, which are typically located further inland, reported substantially lower levels of damage to their businesses, with maximum average losses of 30.8 percent occurring in Region 4. Insurance coverage for these losses was generally minimal for both dealers and processors, especially in Regions 1 and 4 where the greatest percent damage was incurred. In addition to the direct, immediate losses caused by the hurricanes, dealers and processors would be expected to have losses in post-storm revenues for some indeterminate period of time both due to infrastructure losses in their businesses and losses incurred by suppliers and upstream marketers/retailers. The expectation of continuing losses in 2005 after the storms was relatively consistent across regions, with dealers estimating not quite twice the income loss that processors expected to experience. With respect to projected losses in 2006 and 2007, however, Region 2 and 3 dealers expected a more rapid recovery than Region 1 and, in particular, Region 4. Overall, processors expected to recover faster than dealers everywhere except in Region 3.

Table 6.1 Regional Economic Losses for Coastal Louisiana Fisheries Sectors resulting from Hurricanes Katrina and Rita.

Coastal	Commercial	Commercial	Commercial Fishermen		Recreational	Total
Area	Dealer [a]	Processor [b]	Vessels [c]	Revenue [d]	Vessels [e]	Losses [f]
Region 1	$5,359,541	$792,716	$17,227,557	$4,709,724	$60,945,259	$71,807,240
Region 2	$48,359,012	$5,760,351	$104,559,880	$93,508,113	$78,049,621	$225,677,097
Region 3	$29,457,307	$25,541,192	$16,612,287	$35,229,893	$60,873,018	$151,101,410
Region 4	$20,346,326	$31,741,883	$15,381,247	$57,849,714	$24,136,588	$134,074,511
Total	$103,522,186	$63,836,142	$153,780,971	$191,297,444	$224,004,486	$582,660,258

[a] Estimated losses in the market value of a dealer business

[b] Estimated losses in the market value of a processor business

[c] Estimated market value of lost commercial fishing vessels

[d] Estimated discounted total revenue losses of commercial fishermen through 2010 (in 2005 dollars)

[e] Estimated market value of lost recreational fishing vessels

[f] Total of a, b, d, and e

Of particular importance is the fact that these responses represented only expectations on the part of the respondents and not realized income losses. In fact, a comparison of respondent business revenues from the pre-storm period of September 2004 through April 2005 with the post-storm period of September 2005 through April 2006 indicated that dealers and processors overestimated expected income losses. Responding dealers and processors that appeared in the trip-ticket data, who on average expected to lose 55 to 62 percent of their income in 2005 and 2006, lost on average only 15 percent of their business revenues over the 8 month period following the storm. This minimal revenue loss can be confirmed for the industry overall by comparing total landings data in pre- and post-storm periods. As an example, shrimp landings in Louisiana for the January through September 2006 period were estimated at 61.2 million pounds, 85 percent higher than the same period in 2005 and 26 percent above the previous 4-year average. Similarly, menhaden harvests landed in Louisiana increased 6.8 percent in the first 9 months of 2006 as compared with 2005, although the total landings were 3.8 percent lower than the 2001-2005 average. The fact that the operations of the responding dealers and processors recovered so quickly after the storm is evidence of the industry's resilience, flexibility, reliance on inputs other than built-capital, and geographic dispersion.

Comparison to Other States

It is important to note that the damage estimates in this study, and the methods used to obtain them, were substantially different than the assessments developed for the states of Mississippi and Alabama (Posadas 2007 and Chang et al. 2006). As Table 6.2 indicates, the $582 million in Louisiana damages were almost twice the reported damages in coastal Mississippi ($293 million) and more than four times the level of damages in Alabama ($112 million). The proportionally higher damages reported in Louisiana are a function of two factors.

Table 6.2 Fisheries Infrastructure Damages in Louisiana, Mississippi, and Alabama from Hurricanes Katrina and Rita in 2005

State	Commercial Vessels	Seafood Dealers	Seafood Processors	Recreational Vessels	State Total	Final Total*
Louisiana	$191,297,444	$103,522,186	$63,836,142	$223,247,097	$581,902,869	$581,902,869
Mississippi[1]	$35,296,545	$77,827,681	$21,313,205	$159,000,000	$293,437,431	$293,437,431
Alabama*[2]	$25,355,000	$18,641,500	$18,641,500	$13,253,000	$75,891,000	$112,250,000
Totals	$251,948,989	$199,991,367	$103,790,847	$395,500,097	$951,231,300	$987,590,300

* Estimates from AL included additional impacts (e.g. lost wages and inventory) not included in the assessments conducted in LA and MS.

[1] Posadas 2007

[2] Chang et al. 2006

First, pre-storm Louisiana had a much larger commercial fishing infrastructure, with Louisiana's commercial vessels and ports accounting for approximately 41 percent of the northern Gulf landings by value in 2004.[44] By comparison, ports in Mississippi and Alabama together accounted for only 12 percent of these annual landings by value. Thus, for any given storm event, the amount of fisheries infrastructure at risk of damage is considerably greater in coastal Louisiana that in neighboring states. Secondly, damage to fishing infrastructure from Hurricane Rita was limited almost exclusively to Louisiana. While surge damages from Rita exacerbated the damages caused by Katrina in the vicinity of New Orleans and the Pontchartrain basin, Rita's impact increased in severity towards the southwestern coastal parishes where there was a heavy concentration of fisheries infrastructure. Because of these factors, Louisiana experienced nearly 60 percent of the $987,590,300 in damages for the three state (Alabama, Mississippi, and Louisiana) region, an amount that is likely to be a conservatively estimated given the lack of data to estimate losses to coastal marinas and other ancillary support sectors. Variation in methods between the three state reports means that the actual values are not fully comparable. The methods used in the present study provide a degree of geographically-specificity not found in the Mississippi and Alabama studies, and do not include estimates for ancillary industries (e.g., damages to marinas and bait shops), nor estimates of economic impact at the retail level.

The Potential Impacts of Disaster Recovery Funding

The disaster declarations issued by Secretary Gutierrez in late 2005 initiated a sequence of events that resulted in federal relief funds for fisheries recovery activities. One stipulation of that assistance was that the Secretary must first "determine that the activity will not expand the commercial fishery failure in that fishery or into other fisheries or other geographical regions"

[44] See Section 1 of this report for more details.

(CFDA 2006). The extent to which federal disaster aid might either mitigate or compound the existing crisis depends largely on how "failure" is defined. Clearly, the storms' impact on infrastructure led to individual failures for an unprecedented number of fishermen and small businesses. It is also true, however, that many of those businesses were already on the brink of failure because of various market forces. In contrast, the biological fisheries have proven to be resilient to the storms, with stocks and harvests for many species now significantly higher than pre-storm levels. Long-term habitat implications aside, the fisheries resource has not failed beyond the impacts to oyster reefs directly in the path of the two storms, which in part rationalizes the targeting of much of the proposed spending at oyster reef restoration. But, for many in the shrimp fishery, hurricanes Katrina and Rita will mark a point beyond which it may be impossible to recover given current market forces. For those that do continue in the industry, federal aid may ultimately worsen their current competitive advantage by allowing marginally profitable participants to reenter the industry. For this reason, and to address externalities associated with bycatch, effort-reduction programs were featured in many of the initial aid packages. Those initiatives failed to receive adequate support because of their perceived high cost and opposition from the commercial sector to attempts at limiting effort.

Even with the challenges of the last two years, Louisiana continues to be a leader in U.S. fisheries production. The response to the damage inflicted by the storms has included establishment of a Louisiana fisheries recovery coalition, ongoing refinement of economic damage assessments, and the eventual authorization of millions of dollars in federal aid. How the institutional and industry responses will evolve over the next few years is unpredictable, as the storms reduced fishing capacity in the Louisiana commercial fleet to a level that no effort-reduction program could have ever achieved in such a short period of time. Whether this post-storm capacity level will become the new equilibrium, however, is dependent on a number of factors, including dockside prices, fuel costs, post-storm fisheries abundance, and the speed and channels through which federal disaster funding is ultimately disbursed.

Future Research

The damage model developed in this study represents a novel combination of primary and secondary data that could be used in the future for more accurate assessment of fisheries infrastructure damages in the wake of a tropical storm or hurricanes. And while the methods outlined in this particular application resulted in coast-wide estimates that were similar to more rapid assessment techniques, the strength of this approach lies in the ability to provide damage assessments on a geographically-specific basis. The extent to which this model can provide such localized estimates on a rapid basis depends on a number of factors, including: 1) the amount of time required to obtain disaggregated trip ticket data; 2) the degree of access to commercial and recreational vessel databases; and 3) the availability of current market data on commercial and recreational fishing vessel sales. Field observations and storm surge data may not always be necessary for rapid, localized damage assessment using the techniques of this study. While such data were initially needed to establish a functional relationship between surge height and economic damage, the damage curves estimated in this study may prove sufficient in situations where rapid, localized assessments are needed. As an example of this forward application of damage relationships, this study used, in addition to its own estimated damage curves, relationships developed for earlier storm events in the northern Gulf of Mexico (see Figure 5.1). Transferred use of damage relationships from previous studies may be especially beneficial in situations where rapid and accurate assessments are needed but traditional surveying methods are infeasible because of dispersed coastal populations. Nevertheless, the damage model estimated in this study was developed with a relatively small number of HDAT observations. Additional field observations in Louisiana would further refine the functional relationship between economic damage and storm surge height. Such refinement could be obtained in the following months and years by conducting follow-up interviews with commercial and recreational fishermen. Such a follow-up study would collect additional HDAT estimates by canvassing a larger and more representative sample of the coastal Louisiana fishing community.

There are several examples in which the lack of geographic specificity in fisheries data limits the ability to develop rapid and reliable damages estimates. One significant limitation is that the spatial designation of fisheries infrastructure is usually obtained from geo-coded street addresses. This process is complicated by the fact that some seafood dealer and processor operations use a post-office box address. Thus, it is sometimes impossible to determine from public records how much distance exists between the address of a fishing-related enterprise and the actual location of the given infrastructure. This constraint is further compounded in the case of commercial fishermen, where the actual street addresses are often different from the pre-storm location of the fishing vessel. Furthermore, there is no standard method available to estimate the post-storm location of commercial and recreational fishing vessels. Some combination of existing techniques (e.g., field observation, vessel monitoring systems, or remote sensing through satellite photography) would likely be required to inventory the location and condition of fishing vessels before after major storms.

Finally, there are a number of fisheries-related sectors for which no revenue data, sales data, or physical address data exists in an easily accessible format. In this study, the lack of such data precluded the estimation of damages for fisheries-related businesses such as marinas, ice houses, and bait dealers. This limitation, taken with the constraints cited above, suggest that a periodic survey of Louisiana's coastal fishing infrastructure is warranted. Properly implemented, such a survey would yield a more detailed database useful for the development of improved damage estimates after future storms.

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APPENDIX:
List of Commercial Species Landed by Category

LDWF Trip Ticket Data 2002-2004

No.	COMMON NAME	SCIENTIFIC NAME
	SHRIMP	
1	Palaemonetes	*Palaemonetes*
2	SHRIMP, ATLANIC SEABOB	*Xiphopenaeus kroyeri*
3	SHRIMP, NORTHERN BROWN	*Penaeus aztecus*
4	SHRIMP, NORTHERN PINK	*Penaeus duorarum*
5	SHRIMP, NORTHERN WHITE	*Penaeus setiferus*
6	SHRIMP, ROUGHNECK	*Trachypenaeus*
7	SHRIMP, ROYAL RED	*Pleoticus robustus*
8	SHRIMP,FW	*Macrobrachium*
9	SHRIMP,ROCK	*Sicyonia*
	CRAB	
10	CRAB, BLUE	*Callinectes sapidus*
11	CRAB, FLORIDA STONE	*Menippe mercenaria*
	OYSTER	
12	OYSTER, EASTERN	*Crassostrea virginica*
	SALTWATER FISHERIES	
13	ALBACORE	*Thunnus alalunga*
14	AMBERJACK, GREATER	*Seriola dumerili*
15	AMBERJACK, LESSER	*Seriola fasciata*
16	BARRACUDAS	*Sphyraenidae*
17	BASS, BLACK SEA	*Centropristis striata*
18	BASS, LONGTAIL	*Hemanthias leptus*
19	BIGEYE	*Priacanthidae*
20	BIGEYE	*Priacanthus arenatus*
21	BLUEFISH	*Pomatomus saltatrix*
22	BROTULA, BEARDED	*Brotula barbata*
23	BULLEYE	*Cookeolus japonicus*
24	CATFISH, GAFFTOPSAIL	*Bagre marinus*

25	CATFISH, HARDHEAD	*Arius felis*
26	COBIA	*Rachycentron canadum*
27	CODLINGS	*Urophycis*
28	COOTER, RIVER	*Pseudemys concinna*
29	CREOLE-FISH	*Paranthias furcifer*
30	CROAKER, ATLANTIC	*Micropogonias undulatus*
31	DOLPHINFISH	*Coryphaena*
32	DRIFTFISH, BLACK	*Hyperoglyphe bythites*
33	DRUM, BLACK	*Pogonias cromis*
34	EEL, CONGER	*Conger oceanicus*
35	ESCOLAR	*Lepidocybium flavobrunneum*
36	FLAG, SPANISH	*Gonioplectrus hispanus*
37	FLOUNDER	*Paralichthys*
38	GAG	*Mycteroperca microlepis*
39	GOOSEFISH	*Lophius americanus*
40	GROUPER, BLACK	*Mycteroperca bonaci*
41	GROUPER, MARBLED	*Epinephelus inermis*
42	GROUPER, MISTY	*Epinephelus mystacinus*
43	GROUPER, RED	*Epinephelus morio*
44	GROUPER, SNOWY	*Epinephelus niveatus*
45	GROUPER, WARSAW	*Epinephelus nigritus*
46	GROUPER, YELLOWEDGE	*Epinephelus flavolimbatus*
47	GROUPER, YELLOWFIN	*Mycteroperca venenosa*
48	GROUPER, YELLOWMOUTH	*Mycteroperca interstitialis*
49	GRUNTS	*Haemulidae*
50	HERRINGS	*Clupeidae*
51	HIND, RED	*Epinephelus guttatus*
52	HIND, ROCK	*Epinephelus adscensionis*
53	HIND, SPECKLED	*Epinephelus drummondhayi*
54	JACK, ALMACO	*Seriola rivoliana*
55	JACK, BAR	*Caranx ruber*
56	JACK, BLACK	*Caranx lugubris*
57	JACK, CREVALLE	*Caranx hippos*
58	JACK, HORSE-EYE	*Caranx latus*
59	JELLYFISH	*Scyphozoa*
60	MACKEREL, KING	*Scomberomorus cavalla*
61	MACKEREL, SPANISH	*Scomberomorus maculatus*
62	MAKO, LONGFIN	*Isurus paucus*
63	MAKO, SHORTFIN	*Isurus oxyrinchus*
64	MENHADENS	*Brevoortia*
65	MULLET, STRIPED	*Mugil cephalus*

66	OILFISH	*Ruvettus pretiosus*
67	OPAH	*Lampris guttatus*
68	PARROTFISHES	*Scaridae*
69	PINFISH	*Lagodon rhomboides*
70	POMPANO, AFRICAN	*Alectis ciliaris*
71	POMPANO, FLORIDA	*Trachinotus carolinus*
72	PORBEAGLE	*Lamna nasus*
73	PORGY, JOLTHEAD	*Calamus bajonado*
74	PORGY, KNOBBED	*Calamus nodosus*
75	PORGY, RED	*Pagrus pagrus*
76	PORGY, WHITEBONE	*Calamus leucosteus*
77	PUFFERS	*Tetraodontidae*
78	RAYS	*Rajiformes*
79	RUDDERFISH	*Kyphosidae*
80	RUDDERFISH, BANDED	*Seriola zonata*
81	RUDDERFISHES	*Kyphosus*
82	RUNNER, BLUE	*Caranx crysos*
83	RUNNER, RAINBOW	*Elagatis bipinnulata*
84	SCAMP	*Mycteroperca phenax*
85	SCORPIONFISH, LONGSNOUT	*Pontinus castor*
86	SCORPIONFISH, SPINYCHEEK	*Neomerinthe hemingwayi*
87	SCORPIONFISH, SPOTTED	*Scorpaena plumieri*
88	SCORPIONFISHES	*Scorpaenidae*
89	SEATROUT, SAND	*Cynoscion arenarius*
90	SEATROUT, SPOTTED	*Cynoscion nebulosus*
91	SHARK	*Chondrichthyes*
92	SHARK, BLACKNOSE	*Carcharhinus acronotus*
93	SHARK, BLACKTIP	*Carcharhinus limbatus*
94	SHARK, BLUE	*Prionace glauca*
95	SHARK, BULL	*Carcharhinus leucas*
96	SHARK, DUSKY	*Carcharhinus obscurus*
97	SHARK, LEMON	*Negaprion brevirostris*
98	SHARK, NIGHT	*Carcharhinus signatus*
99	SHARK, SANDBAR	*Carcharhinus plumbeus*
100	SHARK, SPINNER	*Carcharhinus brevipinna*
101	SHARK, THRESHER	*Alopias vulpinus*
102	SHARK, TIGER	*Galeocerdo cuvier*
103	SHARK,HAMMERHEAD	*Sphyrnidae*
104	SHARKS, DOGFISH	*Squalidae*
105	SHEEPSHEAD	*Archosargus probatocephalus*
106	SNAPPER, BLACK	*Apsilus dentatus*

107	SNAPPER, BLACKFIN	*Lutjanus buccanella*
108	SNAPPER, CUBERA	*Lutjanus cyanopterus*
109	SNAPPER, DOG	*Lutjanus jocu*
110	SNAPPER, GRAY	*Lutjanus griseus*
111	SNAPPER, LANE	*Lutjanus synagris*
112	SNAPPER, MAHOGANY	*Lutjanus mahogoni*
113	SNAPPER, MUTTON	*Lutjanus analis*
114	SNAPPER, QUEEN	*Etelis oculatus*
115	SNAPPER, RED	*Lutjanus campechanus*
116	SNAPPER, SILK	*Lutjanus vivanus*
117	SNAPPER, VERMILION	*Rhomboplites aurorubens*
118	SNAPPER, YELLOWTAIL	*Ocyurus chrysurus*
119	SOAPFISHES	*Rypticus*
120	SPADEFISH	*Ephippididae*
121	SPOT	*Leiostomus xanthurus*
122	SQUIDS	*Loliginidae*
123	SQUIRRELFISHES	*Holocentridae*
124	SWORDFISH	*Xiphias gladius*
125	TILEFISH	*Lopholatilus chamaeleonticeps*
126	TILEFISH, BLACKLINE	*Caulolatilus cyanops*
127	TILEFISH, BLUELINE	*Caulolatilus microps*
128	TILEFISH, GOLDFACE	*Caulolatilus chrysops*
129	TILEFISH, SAND	*Malacanthus plumieri*
130	TRIGGERFISH, GRAY	*Balistes capriscus*
131	TRIGGERFISH, OCEAN	*Canthidermis sufflamen*
132	TRIGGERFISH, QUEEN	*Balistes vetula*
133	TRIPLETAIL	*Lobotes surinamensis*
134	TUNA, BIGEYE	*Thunnus obesus*
135	TUNA, BLACKFIN	*Thunnus atlanticus*
136	TUNA, BLUEFIN	*Thunnus thynnus*
137	TUNA, SKIPJACK	*Euthynnus pelamis*
138	TUNA, YELLOWFIN	*Thunnus albacares*
139	TUNNY, LITTLE	*Euthynnus alletteratus*
140	WAHOO	*Acanthocybium solandri*
141	WENCHMAN	*Pristipomoides aquilonaris*
142	WHITING, KING	*Menticirrhus*

FRESHWATER FISHERIES

143	BOWFIN	*Amia calva*
144	BULLHEADS	*Ameiurus*
145	CARP, BIGHEAD	*Hypophthalmichthys nobilis*

146	CARP, COMMON	*Cyprinus carpio*
147	CARP, GRASS	*Ctenopharyngodon idella*
148	CARP, SILVER	*Hypophthalmichthys molitrix*
149	CATFISH, BLUE	*Ictalurus furcatus*
150	CATFISH, CHANNEL	*Ictalurus punctatus*
151	CATFISH, FLATHEAD	*Pylodictis olivaris*
152	DRUM, FRESHWATER	*Aplodinotus grunniens*
153	EEL, AMERICAN	*Anguilla rostrata*
154	FISHES, BONY	*Osteichthyes*
155	FISHES, BUFFALO	*Ictiobus*
156	FROGS	*Ranidae*
157	GAR, ALLIGATOR	*Atractosteus spatula*
158	GAR, LONGNOSE	*Lepisosteus osseus*
159	GAR, SHORTNOSE	*Lepisosteus platostomus*
160	GAR, SPOTTED	*Lepisosteus oculatus*
161	GARFISHES	*Lepisosteidae*
162	MINNOWS	*Cyprinidae*
163	Procambarus	*Procambarus*
164	SHAD, GIZZARD	*Dorosoma cepedianum*
165	SLIDER, COMMON	*Trachemys scripta*
166	TURTLE, ALLIGATOR SNAPPING	*Macroclemys temminckii*
167	TURTLES	*Anapsida*
168	TURTLES, N. A. SOFTSHELL	*Apalone*
169	TURTLES,SNAPPING	*Chelydra serpentina*

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