ESTIMATING THE ECONOMIC DAMAGE OF HURRICANES KATRINA AND RITA ON COMMERCIAL AND RECREATIONAL FISHING INDUSTRIES

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On the morning of August 29th, 2005, Southeast Louisiana was hit by the extreme winds and flood surge associated with Hurricane Katrina. Less than 3 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 post-storm recovery efforts focused on rapid assessments of the physical and economic impacts. In October 2005, infrastructure damage estimates were conducted by the Louisiana State University Agricultural Center (LSUAgCenter 2005) and the Louisiana Department of Wildlife and Fisheries (LDWF 2005). These estimates were developed using different methods and assumptions, and in some cases were inconsistent with established economic procedures for damage assessment following natural disasters. Despite a wide range of estimated damages (from $275 million to $2.5 billion), these preliminary reports were frequently cited in support of various emergency funding initiatives (Caffey et al. 2006).

In January 2006, the National Oceanic and Atmospheric Administration's Fisheries Services (NOAA Fisheries) requested that economists in Louisiana develop independent assessments of the economic damages to fisheries infrastructure resulting from hurricanes Katrina and Rita. The study was to provide 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. 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.

Study Area

The hurricanes of 2005 produced damage across the entire length of Louisiana's 20,000 square mile coastal zone. Initial assessments immediately 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.

Given the geographic scale and variability of impacts, this study assessed the economic damages to coastal fisheries infrastructure by region. This regional approach allowed for more detailed estimates of damages within the physical sub-basins and political parish boundaries of coastal Louisiana which, in principle, could allow for better targeting of recovery efforts. Four regions were defined for the purposes of this report (Figure 1): 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.

Tables 1 and 2 provide information on each region's fisheries sector. Overall, regions 2 and 3 accounted for the majority of commercial fishing activity in the state, producing on average nearly $203 million in landed value during the 2002 – 2004 time period, or 74 percent of the state's production. Region 4 was significantly involved in the production of specific product categories, producing over $54 million in shrimp and fin fish during the same time period. From a structural perspective, regions 2 and 3 together dominated the state's commercial fishing industry in terms of licenses, vessels, and the presence of dealers and processors. In terms of the importance of recreational fishing, region 1 was approximately equivalent to both region 2 and region 3 as measured by licenses and registered vessels. Region 4, in the southwestern part of the state, lagged behind the other regions with respect to recreational fishing, a fact that may in part be due to lower human population levels.

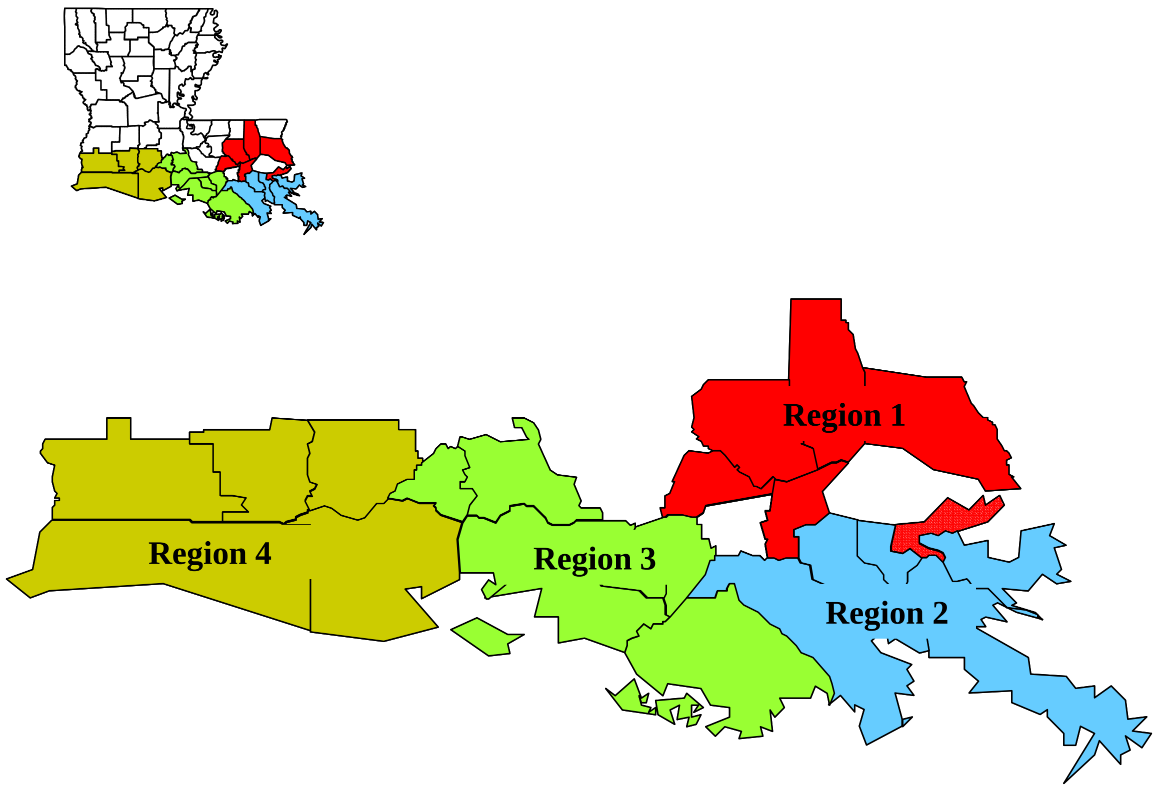

Figure 1. Coastal regions utilized for the assessment of economic damages to fisheries infrastructure from Hurricanes Katina and Rita.

Table 1. Population, license, vessel, dealer, and processor information for the Louisiana coastal regions in the study.

	Population[a] Level	Recreational[b] Licenses	Recreational[c] Vessels	Commercial[d] Licenses	Commercial[e] Vessels	Commercial[f] Dealers	Commercial[g] Processors
Region 1	988,015	107,316	52,472	1,701	980	129	6
% of state total	22.1	14.5	16.2	10.1	11.0	11.4	5.3
Region 2	687,498	175,234	47,708	6,297	4,205	345	22
% of state total	15.4	23.7	14.7	37.4	47.3	30.5	19.3
Region 3	493,743	130,714	50,631	4,782	2,689	332	60
% of state total	11.0	17.7	15.6	28.4	30.2	29.3	52.6
Region 4	342,171	92,488	29,124	1,675	656	160	12
% of state total	7.7	12.5	9.0	10.0	7.4	14.1	10.5

[a] U.S. Census Data (2000)
[b] LDWF Recreational Fishing Licenses (Basic and Saltwater 2004)
[c] LDWF Recreational Boat registrations (2004)
[d] Resident Commercial Fishermen License Sales (Horst & Holloway 2000)
[e] Commercial Vessels (2004)
[f] Commercial Dealers (2004)
[g] Commercial Processors (2004)

Table 2. Average annual landings values for major species by the Louisiana coastal regions in this study.[a]

	Shrimp[b] Value	Crabs[c] Value	Oyster[d] Value	SW Fish[e] Value	FW Fish[f] Value	Total Value
Region 1	$1,757,477	$4,384,694	$1,362,842	$2,183,256	$163,849	$9,852,118
% of state total	1.3	14.0	4.2	3.5	2.6	3.6
Region 2	$73,961,246	$14,653,892	$21,957,340	$28,306,636	$590,755	$139,469,868
% of state total	53.7	46.8	67.5	45.6	9.2	51.6
Region 3	$28,683,908	$10,668,992	$8,338,620	$10,403,528	$5,186,048	$63,281,095
% of state total	20.8	34.0	25.6	16.7	80.8	23.4
Region 4	$33,334,198	$1,635,189	$857,278	$21,228,393	$479,037	$57,534,095
% of state total	24.2	5.2	2.6	34.2	7.5	21.3

a Source: LDWF trip ticket data, average annual values 2002-2004. LDWF Trip Ticket data are estimates only and data are subject to change

b Aggregated data for 9 species of shrimp, average annual value 2002-2004

c Aggregated data for 2 species of crab, average annual value 2002-2004

d Eastern Oyster (Crassostrea virginica), average annual value 2002-2004

e Aggregated data for 131 species of saltwater finfish, including menhaden, average annual value 2002-2004

f Aggregated data for 26 species of freshwater finfish, including turtles and wild crawfish, average annual value

Data and Methods

Five sources of information were used to estimate the economic damages to fisheries infrastructure in Regions 1 – 4; 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 pre-storm values based on business income and assets, respectively. License and registration data were used to map fisheries infrastructure and to characterize 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" information on dealers, fishermen, 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, was used to help identify where fisheries infrastructure existed prior to the storms, determine its economic value, and estimate the corresponding levels of economic damages to that infrastructure caused by the hurricanes. Trip ticket data for Louisiana were obtained from the NOAA Fisheries Southeast Fisheries Science Center in June 2006. More than 2.5 million records were acquired for the years 2002 – 2004, including transactions data for 11,213 commercial fishing vessels (federal and state), 1,133 seafood dealers, and 114 seafood processors.

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. 9.2 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.[2] The resulting GIS layers depict the best available estimate of the geographic location of 10,140 vessels, dealers, and processors prior to Hurricane Katrina (Figure 2).

Vessel Sales

Preliminary estimates of fisheries infrastructure damage in the immediate aftermath of the storms utilized 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[3] for individual fishing vessels and their characteristics. Data on nearly 600 commercial and recreational fishing vessels was collected through this method and used in a hedonic regression to estimate the value of vessels based on their age, length, hull material, and means of propulsion.

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[2] Geo-coding records that lacked geographical latitude and longitude coordinates was accomplished using the following website: Converting Addresses to/from Latitude/Longitude in One Step, by Stephen P. Morse, www.stevemorse.org/jcal/latlon.php.

[3] 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.

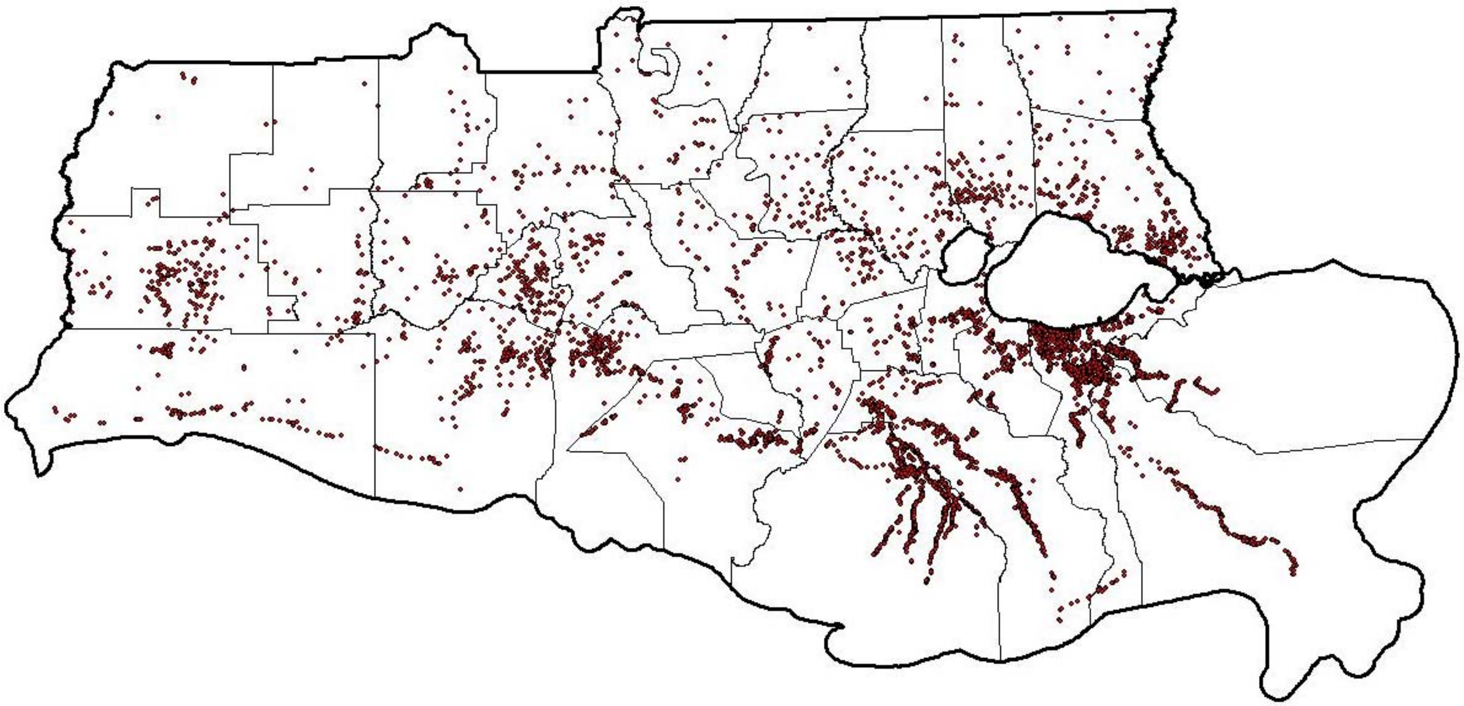

Figure 2. Pre-storm Location of Louisiana Fisheries Infrastructure Geo-coded from LDWF License Records (commercial vessels, dealers, and processors)

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 relationships between storm severity and infrastructure damage. In the case of hurricanes, economic damage is primarily the result of wind speed and water heights, with coastal storm surge often being the critical determinant. For the past five years, the Louisiana State University (LSU) Hurricane Center has used a modified version of the Advanced Circulation Model for Coastal Oceans, Inlets, Rivers and Floodplains (ADCIRC)[4] to predict maximum flood and surge levels associated with specific storm events. ADCIRC incorporates data generated by the U.S. National Weather Service on storm trajectory and storm magnitude and combines it with detailed data on coastal bathymetry and elevation to model surge heights at geographically specific locations (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 forecasts, 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 (simulation nodes). Figures 3

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[4] More information on the ADCIRC model can be found at the ADCIRC Development Group website: http://www.nd.edu/~adcirc/ .

and 4 graphically depict the maximum water levels at each of these nodes for hurricanes Katrina and Rita.

Ground-Truthing

Field observations were used to 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. The Hurricane Damage Assessment Template (HDAT) consisted of 10 basic fields of information (Table 3). Field personnel 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 ArcView 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.

Because simulation nodes are not evenly distributed within ADCIRC, the number of maximum wave height (MWH) calculations varied considerably by grid (from 0 to 31). In cases where more than one observation was available, MWH was calculated by taking an arithmetic mean of the combined observations for Katrina and Rita. For grids

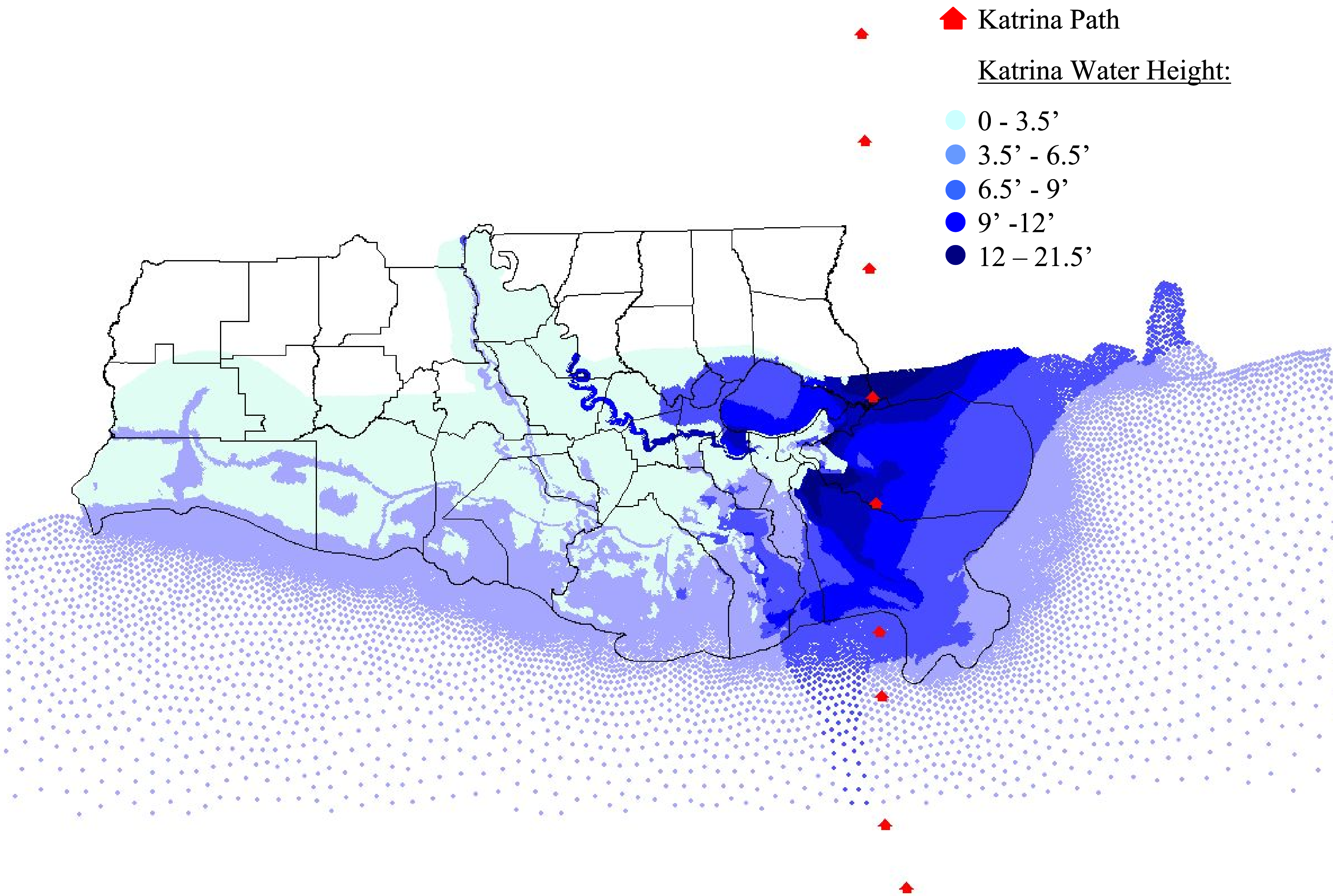

Figure 3. Maximum Water Levels for Hurricane Katrina derived from ADCIRC modeling by the LSU Hurricane Center.

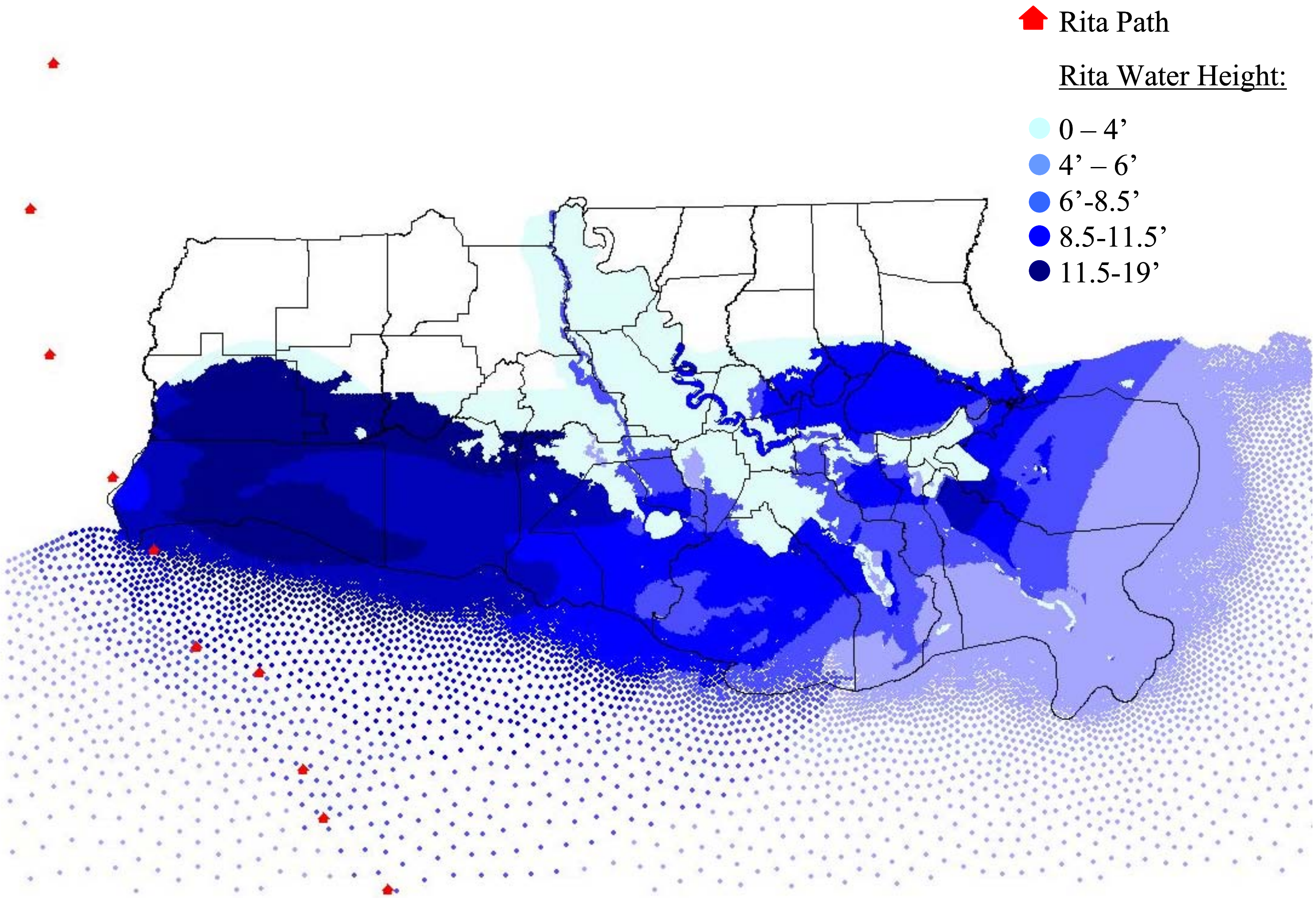

Figure 4. Maximum Water Levels for Hurricane Rita derived from ADCIRC modeling by the LSU Hurricane Center.

Table 3. Information in the Hurricane Damage Assessment Template (HDAT).

Physical location of Infrastructure - Latitude and longitude coordinates obtained from mapping software or handheld gps.

Commercial vessel – categorization by primary commercial activity

Seafood buyer – categorization by primary commercial activity

Seafood processor - categorization by primary commercial activity

Primary species group – Either shrimp, crab, oyster, marine or freshwater finfish.

Secondary species group - Either shrimp, crab, oyster, marine or freshwater finfish.

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.

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.

Damages Covered by Insurance - an estimate of the percentage (%) of damages estimated in Q4 that were covered by insurance.

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.

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.

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: Business income losses were based on the average annual sales experienced prior to the 2005 hurricane season.

where no observations were available, MWH was estimated using a nearest-neighbor estimation routine. Given the computational intensity of this approach, 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 were 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 using the hedonic regressions. The recreational vessels were similarly valued using a sector specific hedonic regression.

Results and Discussion

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

A total of 116 individuals and firms responded to the HDAT with usable information, including 101 seafood dealers and 15 seafood processors (Table 4). 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). 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 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 was 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. Project 2005 revenue losses were relatively consistent across regions, with dealers estimating not quite twice the income loss that processors expected to experienced (Table 5). 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.[5] Responding dealers and processors that appeared in the trip-ticket data,[6] who on average expected to lose 55 to 62 percent of their income in 2005 and 2006, lost on average only 15 percent[7] of their business revenues over the 8 month period following the storm. This minimal revenue

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5 Estimated from respondent trip-ticket data for the given period.

6 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.

7 Weighted by the pre-storm total value of their landings.

Table 4. 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. Comparison by region of selected responses to the 2006 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
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 % 2005 Income Loss					
	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 % 2006 Income Loss					
	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 % 2007 Income Loss					
	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.

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[8] and 26 percent above the previous 4-year average.[9] 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.[10] 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, the responses to impact measures were aggregated for the entire coastal region and used in subsequent calculations.[11] Overall, pre-storm business value for dealers and processors was $694,220 and $6,312,500, respectively (Table 6). 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.[12] 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.

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8 Do to data reporting problems caused by the storms, the 2005 time period does not include September 2005.

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

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

11 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.

12 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 6. 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 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.

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.

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[13] to link the maximum water level experienced to the reported percent of business damage for dealers and processors. Specifically, this relationship took the form

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

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

[13] 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). 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. 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.

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 7, 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.

The above estimated relationship is graphically depicted in Figure 5. 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.[14] Of particular note are 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,

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[14] 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.

Table 7. 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	

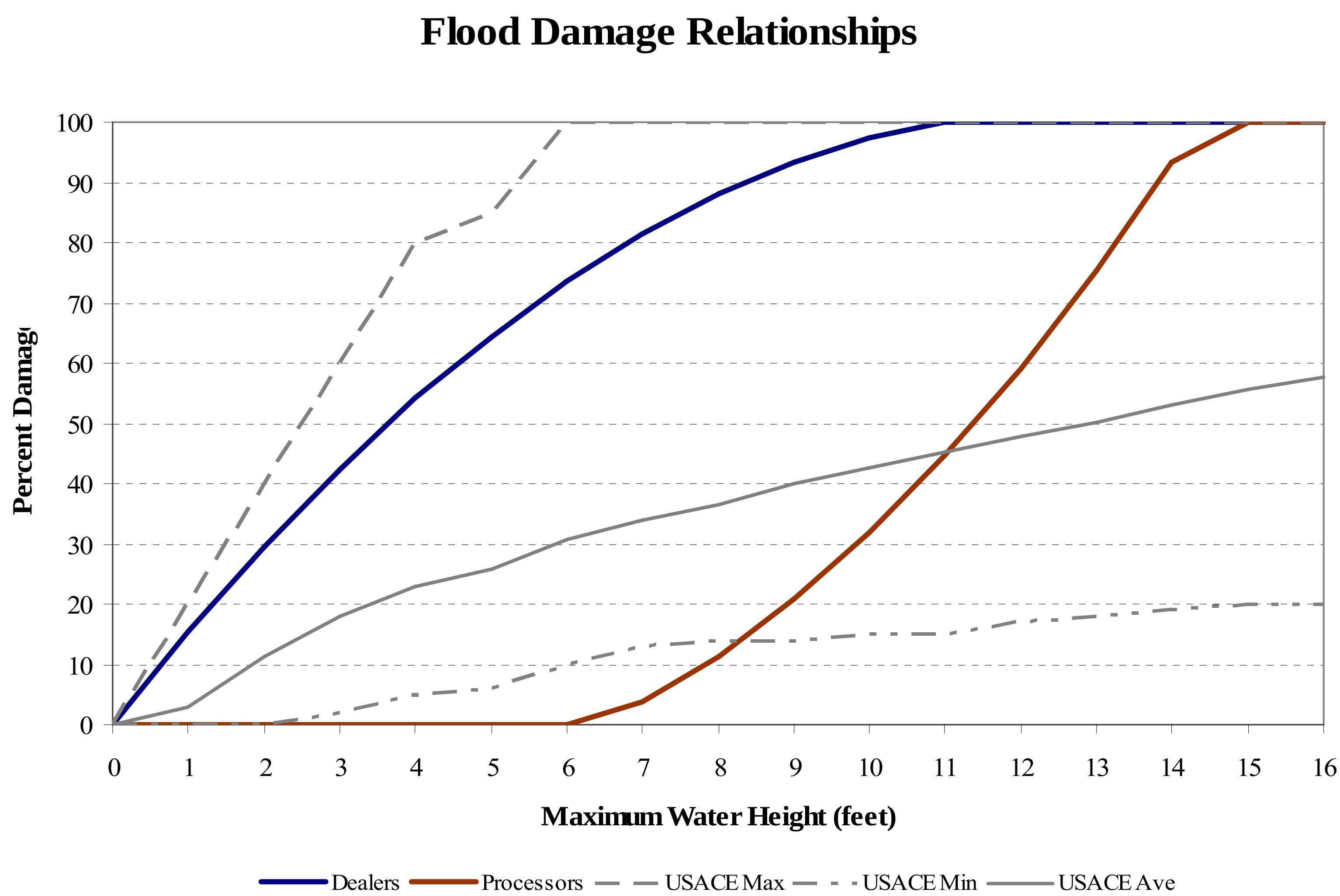

Figure 5. Comparison of estimated percent business damage models with U.S. Corp of Engineer (USACE)summary data on flood damage to water height relationships.

Once estimated from respondent data, the damage curves depicted in Figure 5 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 based on similar storm experiences. While errors would be expected in estimating any specific businesses damage levels using this approach,[15] 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,

[15] 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.

the mean pre-storm value of the businesses were estimated from the HDAT responses (Table 8). 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.

Table 9 presents regional and statewide summary of the total calculated business value losses experienced by dealers and processors.[16] 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 9). 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.

[16] Regional specificity in this table was possible because each dealer and processor can be located geographically given the state permit 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.

Table 8. Pre-storm business values stratified by revenue size classes as reported by Louisiana DAT respondents.

Annual Revenues	Number	Pre-Storm Business Value ($) 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 9. Estimates of the Total Economic Losses Experienced by Coastal Louisiana Seafood Dealers and Processors Due to Hurricanes 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).

Combining dealer and processor losses together resulted in estimated damages of $54,998,499 for Region 3, $54,119,363 for Region 2, $52,088,209 for Region 3, and $6,152,257 for Region 4. Thus, with the exception of Region 1, damages to the dealer and processor sectorsof 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.[17]

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.[18] 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

[17] While the estimated business value losses and the annual revenue values as reported in NMFS trip ticket and 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 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.

[18] 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.

to the harvesting sector as these revenues are partly used to pay suppliers.[19] 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 comprehensive listing of lost or damaged vessels was compiled post-storm,[20] 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[21] 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

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[19] 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.

[20] 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.

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

period.[22] 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.[23] 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.[24] 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.

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.[25] With this approach, information on 108 vessel offers[26] were collected and analyzed in a regression framework using the following functional relationship:

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

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[22] 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.

[23] 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.

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

[25] The primary source for this 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)

[26] 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.

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. Results of this regression analysis were highly significant, with both the overall model and all the individual parameters being statistically significant (Table 10). As can be seen in Figure 6, 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 11. 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.

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

Table 10. 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	

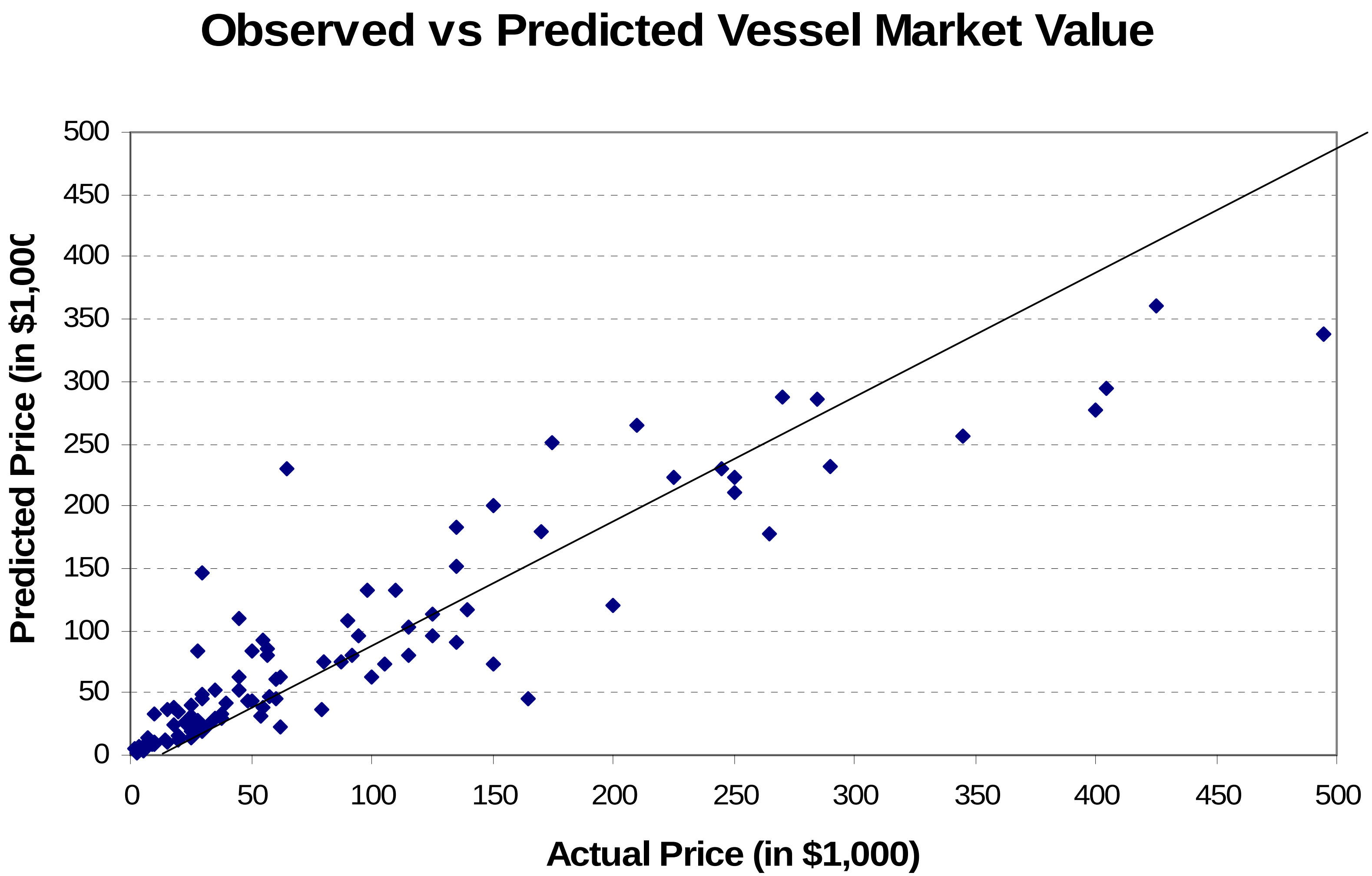

Figure 6. Comparison of observed versus predicted market value for commercial vessels in Louisiana.

Table 11. 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

landings sold through dealers in Louisiana,[27] and by employing the forecasted percentage business losses reported by dealers and processors in the HDAT. These estimates, detailed in Table 11, 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 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 directly estimated fleet infrastructure losses, an amount that can be taken as an estimated of the revenue that is passed from harvesters to their suppliers.[28]

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.[29] To our knowledge, only one comprehensive estimate of lost or

[27] 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.

[28] 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.

[29] 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

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.[30] 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.[31] With this approach, information on 491 vessel offers[32] were collected and analyzed in a regression framework using the following functional relationship:

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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.

[30] 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.

[31] 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.

[32] 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.

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

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. Results of this regression analysis were highly significant, with both the overall model and all the individual parameters being statistically significant (Table 12). As can be seen in Figure 7, 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.[33]

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 are estimated to be $224,004,486 (Table 13). 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.

[33] 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 12. 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	

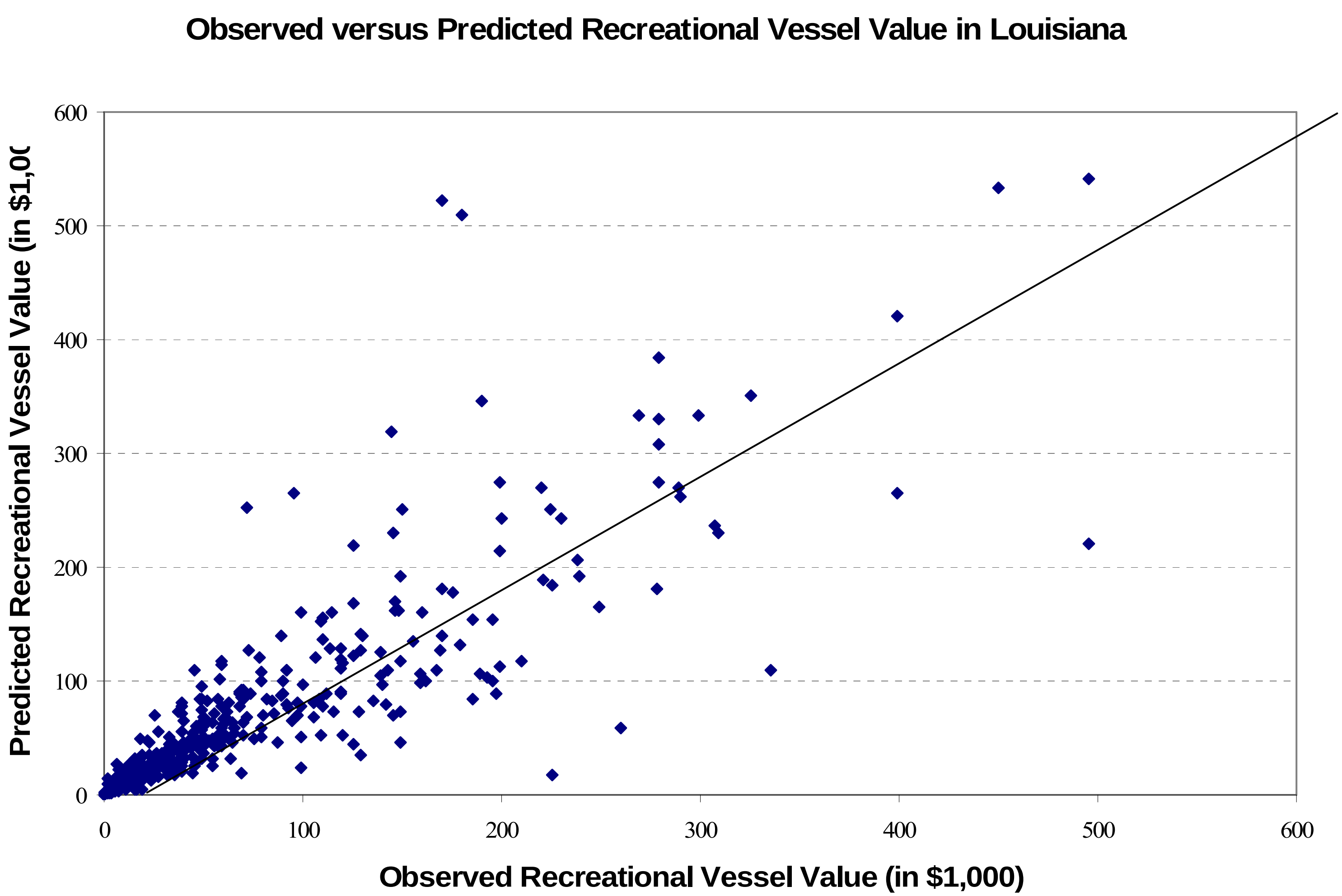

Figure 7. Comparison of observed versus predicted market value for recreational fishing vessels in Louisiana

Table 13. 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.

Summary and Conclusions

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 tracts detailed in Figures 3 and 4, regions 2 and 4 received the bulk of the physical impact from the hurricanes (see estimated maximum wave heights in Table 5). 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 14). 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 14. Regional Economic Losses for Coastal Louisiana Fisheries Sectors resulting from Hurricanes Katrina and Rita.

Coastal Area	Commercial Dealer [a]	Commercial Processor [b]	Commercial Fishermen Vessels [c]	Commercial Fishermen Revenue [d]	Recreational Vessels [e]	Total 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 15 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. First, pre-storm Louisiana had a much larger commercial fishing infrastructure, with Louisiana's commercial vessels and ports accounted for approximately 41percent of the northern Gulf landings by value in 2004.[34] 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.

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

Table 15. 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	$35,296,545	$77,827,681	$21,313,205	$159,000,000	$293,437,431	$293,437,431
Alabama*	$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.

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