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BOEM 2016-020

An Analysis of the Impacts of the *Deepwater Horizon* Oil Spill on the Gulf of Mexico Seafood Industry

U.S. Department of the Interior
Bureau of Ocean Energy Management
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CONTENTS

List of Tables

List of Figures

List of Acronyms

BOEM	U.S. Department of the Interior, Bureau of Ocean Energy Management
CGE	Computable General Equilibrium
DWH	Deepwater Horizon
EEZ	Exclusive Economic Zone
FDA	U.S. Food and Drug Administration
FEAM	Fishery Economic Assessment Model
FEUS	Fisheries Economics of the United States
GCCF	Gulf Coast Claims Facility
IFQ	Individual Fishing Quota
IMPLAN	IMpact analysis for PLANning
I/O	Input/Output
IQF	Individually Quick Frozen
ITC	International Trade Commission
NEFSC	Northeast Fisheries Science Center
NMFS	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PAHs	Polycyclic Aromatic Hydrocarbons
REMI	Regional Economic Modeling, Inc.
RIMS	Regional Input-Output Modeling System
SAM	Social Accounting Matrix
USNM	U.S. National Impact Model
VOO	Vessels of Opportunity

Summary

This study gathered various economic data to determine the structure of the seafood industry in the Gulf of Mexico, factors that affect the industry, and to estimate the economic impacts of the *Deepwater Horizon* (DWH) oil spill on the seafood industry. The research focuses on the structure of the seafood industry's supply chain, and how that structure may have changed as a result of the spill. The research in this study consists of two key components: a comprehensive examination of the factors that have affected the gross revenues of domestic commercial fishermen operating in the Gulf during and after the oil spill, and an economic impact model for the seafood supply chain in the five Gulf States (Alabama, West Florida, Louisiana, Mississippi, and Texas).

The study begins with a descriptive analysis of how the oil spill may have affected the seafood industry in the Gulf in both the short and long term. The geographic distributions of impacts are discussed in order to improve understanding of differences in economic effects across fisheries, states, and associated coastal communities. Potential longer-term effects of the oil spill on the Gulf ecosystem are reviewed at a more aggregate level, as are potential implications on the ecosystem at a fishery level. Concerns with seafood safety and implications for consumer perception and demand of seafood from the Gulf that have been raised in the literature are summarized. Initial adjustments in markets due to product shortages and food safety concerns are also summarized, and challenges faced by Gulf seafood producers trying to regain market share from import products and non-Gulf domestic producers are discussed. The temporary fisheries closures implemented by the federal government due to safety concerns are summarized spatially and temporally to allow direct comparison to changes in harvest patterns. Changes in the overall U.S. economy during the pre- and post-spill period are also noted and discussed, including the likelihood of positive exogenous effects on seafood demand during the damage period. This section of this report concludes with a summary of how these impacts were or were not able to be factored into the subsequent economic impact model developed for this study.

Background information on the fishing and seafood industries in the Gulf was presented by grouping species into the following categories: shrimp, blue crab, oysters, menhaden, reef fish, pelagic finfish, other crustaceans, bait, other shellfish, and miscellaneous finfish. Various secondary data sets were collected and merged to accomplish this task for the time period surrounding the oil spill, namely 2002–2013, and the data sets were examined for trends. The analysis used the same the eight-month "damage period" of May 2010 through December 2010 as defined by the Seafood Compensation Program Settlement Agreement (see Section 3.10) and is the period over which economic impacts to the Gulf seafood industry were estimated in this study. In addition, this study also used one of the "benchmark time periods" in the Seafood Compensation Program Settlement Agreement, that is, May to December of 2009. In addition to monthly landings by fishery and state during the damage and benchmark time periods, qualitative information was gathered outside of the damage period in order to explain some of the observed results. Types of additional information and data collected included product prices, sales, trade (i.e., imports and export information), financial information, employment/wage data, and regulatory information (e.g., permit data and fishing closures).

The fishing and seafood industry background sections of this report include a general overview of the fishing industry and the associated supply chain in the Gulf. The summaries by fishery include a review of the regulatory structure, harvest trends, and a discussion of typical trade routes and practices, as well as some general insights into how each species category was individually affected by the oil spill. The final section of the background chapter discusses the Seafood Compensation Program including how the program was designed to reach settlement amounts at the firm level.

The economic impact modeling section of this report begins with a literature review that was used to justify model selection and helped determine the model structure and design. As a result, a custom input-output model was selected and constructed for the analyses. The model traces the regional economic consequences of a change in product flows, such as occurred during and following the oil spill. The change in landed value (industry revenues) is assumed to be the initial impact of the spill and the loss is initially incurred by the harvest sector, one of five industry sectors explicitly modeled in the value chain: harvesters, dealers, processors, wholesale/distribution, and retail (includes both restaurants and markets). Model outputs for each sector included changes in the following four metrics of economic activity: (1) total sales, (2) value added (labor income, property income and indirect business taxes), (3) income (personal income from salaries and wages, and proprietors' income if self-employed), and (4) employment (number of full-time jobs). The changes are described and summarized below (following a discussion of the species) by looking specifically at the "total effects"; however, four types of impacts are estimated using multipliers (a means of extrapolation), namely: direct (change in expenditures by commercial fishermen), indirect (change in output of suppliers to commercial fishermen), induced (change in expenditures of employees affected), and total (sum of direct, indirect and induced effects). In summary, the *total effects* are used to quantify impacts incurred during the damage period because they are a measurement of short-term economic impacts. Any longer-term impacts are not captured in this modeling exercise.

An economic impact model developed for this project combined ten harvester sectors (ten commercial fisheries) taken from the U.S. National Economic Impact Model with custom supply chain sectors constructed using 2012 Impact Analysis for Planning (IMPLAN) data and recent cost and earnings data collected by the Gulf States Marine Fisheries Commission. The custom multipliers were combined with trade flow and margin data to create a backward-linked seafood supply chain model for each state and the entire Gulf region. The custom model was then used to examine the economic activity lost to the entire seafood supply chain from the oil spill under two scenarios. Those scenarios were the "market dynamic" scenario, in which 2009 landings data were compared to 2010 landings data (including the oil spill damage period) and reported prices were used, and the "market constant" scenario, in which landings in 2010 (including the oil spill damage period) were modeled by keeping prices fixed at 2009 levels. The estimated reduction in revenues to harvesters across the Gulf (i.e., the "loss" estimates) for the market dynamic scenario was $7.5 million, and the loss from the market constant scenario was $141.1 million; these are the figures that are inputted into the IMPLAN model in order to derive the estimated impacts across the value chain.

Table 1 summarizes the results of this impact modeling exercise by scenario at the Gulf wide level. Overall, the DWH oil spill was calculated to have reduced "total sales" between $51.7 and

$952.9 million. This reduction, in turn, reduced "value added" by $21.4 to $392.7 million, reduced "income" by $21.6 to $309.8 million, and reduced "jobs" by 740 to 9,315 jobs. The harvesting sector bore the brunt of those losses, losing $20.1 to $354.5 million in total sales, $7.9 to $137.8 million in value added, $11.9 to $126.3 million in income, and 449 to 3,809 jobs. The sector that experienced the lowest economic impacts was the dealer sector, losing $4.3 to $80.6 million in total sales, $887,000 to $16.8 million in value added, $652,000 to $12.3 million in income, and 28 to 527 jobs.

Table 1. Calculated Short-Run Economic Impacts of the DWH Oil Spill on the Gulf of Mexico Seafood Industry by Scenario and Sector

Sector	Impact Type	Market Dynamic (Total Impact)	Market Constant (Total Impact)
Harvester	Sales	-$20,114	-$354,512
	Value Added	-$7,932	-$137,782
	Income	-$11,858	-$126,268
	Employment	-449	-3,809
Dealer	Sales	-$4,261	-$80,644
	Value Added	-$887	-$16,792
	Income	-$652	-$12,338
	Employment	-28	-527
Processor	Sales	-$6,348	-$120,156
	Value Added	-$1,503	-$28,454
	Income	-$1,053	-$19,938
	Employment	-42	-798
Distributor	Sales	-$9,714	-$183,874
	Value Added	-$4,143	-$78,421
	Income	-$3,580	-$67,766
	Employment	-82	-1,543
Market	Sales	-$5,630	-$106,572
	Value Added	-$3,838	-$72,648
	Income	-$2,503	-$47,374
	Employment	-74	-1,391
Restaurant	Sales	-$5,662	-$107,171
	Value Added	-$3,095	-$58,581
	Income	-$1,908	-$36,106
	Employment	-66	-1,246
Total	Sales	-$51,729	-$952,929
	Value Added	-$21,399	-$392,678
	Income	-$21,554	-$309,791
	Employment	-740	-9,315

Note: Dollar Values are in Thousands of $US, Employment is in number of full time jobs

This modeling exercise demonstrated that the harvest sector had the least ability to adjust or adapt to the oil spill and was most impacted by the fishery closures. The market dynamic scenario incorporates the various external factors that occurred during the modeling horizon (most notably changes in prices). In particular, prices for most species were higher in the post-spill period. These higher prices were due to both spill-related and non-spill-related factors. This implies that the market dynamic scenario likely underestimates the negative economic impacts of the oil spill, while the market constant scenario likely overestimates the negative economic impacts of the oil spill. Consideration and use of these impact estimates requires a thorough understanding of what these results represent, especially to each sector in the value chain, and the limitations of the input data.

Although the aggregate economic impact estimates are informative, results by species and state provide a more robust and intuitive set of results. At the state level, losses were highest in Louisiana, Mississippi, and Alabama. In Texas and West Florida, losses were lower, and some species categories even saw positive economic effects as a result of the oil spill. Shrimp, oysters and menhaden (in that order) were the most impacted species categories. Blue crab, reef fish, and pelagic finfish were roughly tied for fourth. Although species-level impacts were apparent in most of the species categories, positive impacts were noted in various West Florida and Texas species categories. Certain impacts that presented counterintuitive results were investigated further, and in most cases, market events external to the oil spill were driving these results.

Overall, this study offers a robust range of impact estimates. However, definitive impact estimates derived solely by the oil spill will remain conjecture without further empirical examination of the complex cause and effect relationships that have influenced the revenues in these fisheries. We believe the results can be used to bookend impacts that have occurred in the short term, and should be a strong framework for any further studies that attempt to define impacts of the oil spill on the Gulf seafood industry. The model developed in this study can also be used to estimate the economic impacts to the Gulf seafood industry from various potential future events.

Chapter One: Introduction

1.1 Timeline of Events

The *Deepwater Horizon* oil spill in the Gulf of Mexico began on April 20, 2010 with a blowout and uncontrolled release of oil at the seafloor. It is now considered the largest marine oil spill in U.S. history. With respect to seafood, the effects of the spill began with fishery closures (i.e., harvest bans) and grew to concerns about seafood safety. This included concerns about bioaccumulation of oil in marine fishes and about public health being affected by the chemical dispersants that were used in response to the spill.

The short-term social and economic effects that occurred in the first 20 months after the oil spill were studied by others conducting research and interviews in the coastal communities of Louisiana, Mississippi, and Alabama (Austin et al. 2014). A priority in that project was recording impacts on the lives and businesses of participants in the commercial fishing industry. Information from interviews was put in context with existing historical and geographical socioeconomic data. A summary of the history of fishing methods, processing of various products, and government regulations was presented for shrimp, oysters, crabs, and finfish. External historical effects on the fishing industry were summarized, including changing fishing regulations, rising fuel prices, local hurricanes, and import competition. Impacts that occurred in the summer and fall months directly after the spill were described, including fisheries closures, the claims compensation process, the Vessels of Opportunity (VOO) program, and consumer perception issues. This information supplements this report and is referenced in the appropriate sections.

Table 2 shows a timeline of events during the spill (Austin et al. 2014). The timeline includes actions taken by several management authorities that occurred between April 20, 2010 and April 20, 2012. This timeline covers events specifically related to the seafood industry and events related to impacts of the oil spill.

Table 2. A Chronological Summary of the Deepwater Horizon Oil Spill and Response by BP and Management Authorities

Date	DWH Related Event
4/20/10	Approx. 9:50 p.m. CDT. An unexpected influx of hydrocarbons (a “kick”) escalated to a blowout on the *Deepwater Horizon* platform, just after the crew finished drilling the exploratory Macondo well. Gas that flowed onto the rig floor through a mud-gas vent line ignited in two separate explosions, eventually sinking the platform. The explosions killed 11 platform workers and injured 17 others; another 98 people survived without serious physical injury.
4/29/10	The U.S. Coast Guard designates the DWH spill a Spill of National Significance, establishing a National Incident Commander to coordinate nationwide response. Louisiana Governor Jindal declares State of Emergency in Louisiana. Louisiana Governor announces creation of VOO Program which will hire local

Date	DWH Related Event
	fishermen to help in oil clean up and landfall prevention.
4/30/10	Louisiana Department of Wildlife and Fisheries begins closing state waters and oyster grounds to fisheries. Governor Jindal orders the opening of Mississippi River fresh water diversions to try to prevent oil from penetrating into coastal marshes. The fresh water causes 80% mortality in nearby oyster beds by July.
5/2/10	First VOO task forces from Terrebonne and St. Bernard parishes, Louisiana reported working. The National Oceanic and Atmospheric Administration (NOAA) begins closing federal waters to fisheries, initially totaling 6,817 square miles (3% of Federal Gulf waters).
5/25/10	Federal Fishery Resource Disaster declared. NOAA Fisheries expands fishing closed area in Gulf to 22% of Federal Gulf waters.
6/1/10	Closure of portions of Mississippi state waters to commercial and recreational fishing.
6/2/10	Federal fisheries closure area reaches peak at 37% of federal Gulf waters normally open to fisheries.
6/4/10	NOAA reopens 16,000 square miles of the Gulf formerly closed to fishing.
6/13/10	The Florida Fish and Wildlife Conservation Commission announce partial closures of state waters to commercial and recreational fishing.
6/21/10	NOAA re-expands closed fishing areas, which now approach 36% of Gulf federal waters.
7/12/10	Commercial and recreational fisheries closures amount to 35% of the Gulf normally open to fishing.
7/15/10	Leaking well is successfully shut in for the first time, stopping flow of oil into the Gulf; BP begins well integrity test to determine how well leak is capped before permanent sealing is attempted.
7/29/10	Reopening of some Louisiana state waters to commercial fishing from the Mississippi River Delta to the Mississippi state line.
8/3/10	BP succeeds in sealing the well with concrete through the “static kill” procedure before the relief well’s completion.
8/4/10	Federal government issues report on DWH oil budget and environmental fates.
8/6/10	Mississippi Department of Marine Resources and Mississippi Department of Environmental Quality reopen state waters to finfish and shrimp fisheries.

Date	DWH Related Event
8/16/10	Alabama Department of Conservation and Natural Resources Marine Resources Division announce re-opening of all state waters closed to commercial and recreational fishing. Florida Fish and Wildlife Conservation Commission announce re-opening of closed state waters to fishing.
8/23/10	Gulf Coast Claims Facility (GCCF) officially takes over claims process from BP.
9/7/10	NOAA and U.S. Environmental Protection Agency announce that no dead zones have been observed or are expected as part of DWH oil spill.
9/15/10	BP officially halts VOO program in Florida, Alabama, and Mississippi. In these three states, the program spent $500 million and hired 3,500 vessels.
9/19/10	Admiral Allen announces oil spill is over after completion of relief well.
10/1/10	NOAA reopens 5,628 square miles of Gulf waters off Louisiana to fishing.
10/22/10	NOAA reopens 7,037 square miles of Gulf waters south of the Florida panhandle to commercial and recreational fishing.
10/23/10	BP announces $20 million in funding for seafood inspection and marketing to Florida state government.
11/1/10	BP announces $218 million grant to Louisiana state government for seafood testing and promotion ($48 million), tourism promotion ($30 million), and coastal restoration ($140 million).
11/8/10	Mississippi Department of Marine Resources opens some public oyster beds to tonging, and sets a 10 sack per vessel per day limit.
11/10/10	Louisiana Department of Wildlife and Fisheries reopens 98% of state waters to commercial fisheries by this date.
11/15/10	After harvesting on public oyster beds opened in October in Western Louisiana, harvesting reopens in Terrebonne and Lafourche parishes and most of Barataria Bay. Public oyster beds east of the Mississippi River in Louisiana remain closed.
11/24/10	NOAA temporarily re-closes 4,000 square miles of deep Gulf waters to shrimping for royal red shrimp after oil is brought up by some trawls.
1/31/11	GCCF releases Dr. John W. Tunnell’s report, prepared for the Facility, on oil spill effects on fisheries and recovery timelines.
2/2/11	NOAA reopens the waters closed to royal red shrimping the previous November.
3/24/11	Louisiana Department of Wildlife and Fisheries holds meeting on crab mortalities reported in coastal Louisiana in recent months.

Date	DWH Related Event
4/11/11	Louisiana Department of Wildlife and Fisheries orders reopening of commercial fishing in portions of state inside waters within the Mississippi River Delta that were previously closed due to spill impacts. Over 99% of state waters now open for fishing. BP awards $30 million tourism grant to Florida.
4/18-23/11	Louisiana Department of Wildlife and Fisheries opens some state inshore waters for special early shrimp season.
4/19/11	NOAA re-opens last federal Gulf Waters to fishing, those nearest to DWH site.
6/2/11	Oceana and other national environmental groups file notice to sue NOAA Fisheries for immediate closure of Gulf shrimp fishery because of concerns over large increases in sea turtle mortalities observed in the Gulf and claims of rising violations of turtle excluder devices requirements on shrimp trawls.
6/22/11	Louisiana Shrimp Association hosts rally at Louisiana State Capitol over GCCF compensation issues and environmentalist threat to sue over turtle excluder devices regulations, claiming the spill, not shrimpers, is at fault.
8/3/11	NOAA denies last of three separate petitions from environmental groups requesting emergency closures or restrictions on shrimping because of the large number of sea turtle deaths in the Gulf.
8/22/11	Louisiana Department of Wildlife and Fisheries opens Fall inshore shrimp season after a May inshore shrimp season of historically below-average total landings.
9/26/11	Study published in the Proceedings of the National Academy of Sciences reports biological changes found in juvenile killifish exposed to BP spill oil could signify trouble for the reproduction of coastal fish populations.
10/11	Gulf shrimpers report very poor white shrimp catches in Fall inshore season.
4/19/12	Institute for Southern Studies publishes two-year oil spill anniversary report detailing community non-profit initiatives, ongoing coastal land loss and lack of restoration funding, environmental health concerns following the spill including cleanup worker health issues, commercial fishers' experiences, and criticism of the proposed BP/PSC settlement (Sturgis 2012).

Source: Austin et al. (2014)

1.2 Study Objectives

The most immediate economic losses caused by the oil spill (other than to the oil industry) were to fisheries and the associated value chain. Though all aspects of fisheries and the value they generate should be examined, and some have–such as economic losses suffered by recreational fishermen (e.g., Alvarez et al. 2014)–this study focuses solely on commercial fisheries. Specifically, the broad objectives of this study were to:

- Improve understanding of the varied impacts of the oil spill on the individuals and firms that comprise the Gulf's seafood industry.

- Improve understanding of the structure of the Gulf's seafood industry and how this structure may have been altered as a result of the oil spill.

- Provide information that will be used to improve the nation's response to future oil spills as it relates to the Gulf's seafood industry.

To accomplish these objectives, this study conducted an economic impact analysis of changes in the value of harvested seafood across the Gulf. The intent of the analysis and of the methods selected to complete the analysis was to develop a model with broader application outside this study. Key considerations and criteria with respect to selecting the methods used included that it would:

- Capture the effects of the oil spill across the value chain (i.e., from the harvest sector through retail).

- Include the species and/or fisheries important to each of the five Gulf States.

- Use species/fisheries distinctions commonly used in the literature, available data, and definitions of the damage period from previous analysis.

- Develop a model that would have subsequent uses.

- Provide substantive discussion regarding nuances in the data (and estimated economic impacts) with respect to spatial, temporal and marketing differences across species/fisheries.

1.3 Building the Input/Output (I/O) Model

Economic impact metrics trace the flow of expenditures in a community or region. A change in final demand or, as in this case, a reduction in the domestic supply of seafood, changes those economic flows and reduces employment, incomes, and total sales in the region. In this study, the model assessed these changes in economic flows across multiple supply chain segments, numerous species categories, and the five Gulf States. After the model was built, estimates of the initial changes in domestic seafood supply (i.e., flow of expenditures) induced by the spill were needed to calculate the economic impacts to the Gulf States.

To estimate representative changes in seafood supply (in dollars), we examined the various factors (regulatory, biological, etc.) that affect supply of commercially important species and determined key species and groupings to be included in the impact analysis. To estimate representative changes in associated seafood revenues, we had to understand factors that affect price and, ultimately, fishery revenue (e.g., changes in import quantities and values, changes in consumer preferences reflected in a shift in demand, etc.) Although the scope of this research did not include an econometric analysis of these factors, a comprehensive qualitative analysis of these factors was completed to ground truth estimated changes in domestic dock-side landings and value with respect to the relative contribution of the oil spill.

The closures of fishing areas following the oil spill are summarized in Section 2.6, especially large-scale closures that should be directly observable by comparing landings with previous seasons. The basic premise of the model is that a change in landings (in volume and value) can be an adequate proxy to initiate the calculation of economic impacts. The landings data was obtained from National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) to use official estimates that have been used in previous analyses of impacts, and likely will be used in the future analyses of impacts (NOAA 2013). The reduction in economic activity (change in value of reduced landings) is used to calculate the associated economic impacts that ripple through the supply chain.

The change in landed value (industry revenues) represents the initial impact on the harvest sector, one of five industry sectors explicitly modeled in the value chain. The five industry sectors are harvesters, dealers, processors, wholesale/distribution, and retail (includes both restaurants and markets). Model outputs for each link in the supply chain included the following four metrics of economic activity (Kirkley 2011):

- **Total Sales** is the gross sales by businesses within the economic region affected by an activity.
- **Value Added** includes labor income plus rental and other property income and indirect business taxes.
- **Income** includes personal income (wages and salaries) and proprietors' income (income from self-employment).
- **Employment** is specified on the basis of full-time and part-time jobs. There is significant part-time and seasonal employment in commercial fishing and many other industries.

Impact multipliers can be separated into four types of impacts. The impact types from this model are presented as direct, indirect, induced, and total impacts (Kirkley 2011):

- **Direct** effects express the economic impacts in the sector in which the expenditure was initially made. For example, the direct income impact for the harvester sector would show the total income generated among harvesting employees and proprietors by demand for services from the harvesting sector. This direct impact would result from expenditures made by commercial fishermen.
- **Indirect** effects measure the economic impacts in the specific sectors providing goods and services to the directly affected sector. Indirect effects include the purchases of products by directly-affected harvesters from manufacturers and purchases of accounting services. These indirect impacts extend throughout the economy since each supplier purchases from other suppliers in turn. For example, the accounting firms who provide

services to the directly-affected harvesters would need to purchase office supplies and business equipment. Thus, the indirect output multiplier would represent the total output generated in the various supplier sectors resulting from demand for goods or services from the direct sector.

- **Induced** effects are the economic activity generated by personal consumption expenditures by employees in the directly and indirectly affected sectors, as harvesters, accountants, and other directly and indirectly affected employees spend their paychecks. These household purchases also have additional "indirect" and "induced" effects, all of which are defined as induced effects.

- **Total** effects are the sum of the direct, indirect and induced economic impacts. Total effects quantify the total impact (i.e., for total sales, value added, income or employment) throughout the economy created by demand for goods and services by the direct sector.

In summary, the economic impact analyses are based on measures of changes in economic activity, which, in this case, is a change in the dockside value (i.e., fishery revenue generated through catch landings) of commercially-landed marine fish and shellfish species in the Gulf following the oil spill. For consistency, changes in dockside value were measured using the reference periods set forth in the lawsuit settlement. According to the settlement, the "damage period" is defined as the period between May and December of 2010. This definition is important because it determines the period during which businesses (including fishermen and other supply chain participants) could claim compensation. Businesses could use any of the following three baseline reference periods, across the same months, in order to estimate a loss in dockside value or revenues loss: 2009, the average of 2008 and 2009, or the average of 2007, 2008, and 2009 (Settlement Agreement, 2012). Quantifying impacts during the damage period is a measurement of short-term economic impacts. Any longer-term impacts are not captured in this modeling exercise.

An alternative to using the official reported landings data over time collected by NMFS is to use the actual claims submitted and paid to firms that experienced losses. However, the data available in the public domain are aggregated in such a way that the extent to which they included all members of the industry is unknown (although they could be extrapolated based on average losses). In addition, the claims data has evolved over the post-spill period. For example, claims by commercial fishermen were calculated differently for shrimp, oyster, finfish, and blue crab/other seafood, as outlined in Exhibit 10: Seafood Compensation Program of the Settlement Agreement (2012). Seafood processors, dealers, and wholesalers were compensated under Exhibit 4: Business Economic Loss Claims of the Settlement Agreement (2012). Claims for these types of businesses were calculated based on revenue for a benchmark period in the years leading up to the oil spill, and a compensation period of three or more consecutive months between May and December 2010 (Settlement Agreement 2012). Though the eligibility requirements differed among commercial fishermen and other industry sectors, both business types had similar compensation frameworks. The difference in revenue between these periods was the first step in the compensation calculation. Claimants could also seek compensation for profits the claimant might have been expected to generate in 2010 in the absence of the spill based on the claimant's growth in revenue in January-April of 2010 relative to the benchmark period (Settlement Agreement 2012).

Another complication with using the claims data was that the settlement included only formulas for calculating the claims; the actual claims cannot be calculated from those formulas without confidential data, which is not available because of NMFS confidentiality rules and denial by the claims administrator. Therefore, claims data are not available by species category and state, as would be needed.

The settlement agreement divided all seafood landings into four categories: shrimp, oysters, finfish, and blue crab/other seafood. For this study, commercial fisheries in the Gulf were further disaggregated, given the availability of landings data and previous groupings created for an economic impact analysis by species/gear types (Kirkley 2011). The composition of the categories used in this study is summarized in Table 3.

Table 3. Composition of Species Categories for the Economic Impact Model

Fishery Groupings	Species Included
Shrimp	mantis shrimp, brown shrimp, tiger shrimp, pink shrimp, rock shrimp, royal shrimp, seabob shrimp, white shrimp
Blue Crab	blue crab
Oysters	eastern oyster
Menhaden	Gulf menhaden
Reef Fish	amberjack, grouper, hind, hogfish, rudderfish, scamp, snapper
Pelagic Finfish	barrelfish, driftfish, oilfish, swordfish, tuna, wahoo
Bait	ballyhoo, butterfish, herring, mullet, shad
Other Shellfish	quahog, octopus, squid
Other Crustaceans	Florida crab, crawfish, lobsters
Miscellaneous Finfish	barracudas, bass, bluefish, brotula, cobia, croaker, grunts, hake, jacks, kingfish, ladyfish, leatherjacket, lionfish, lookdown, mackerels, margate, mojarras, parrotfishes, permit, pigfish pinfish, pomfrets, pompanos, porgy, puffers, stingrays, rosefish, runner, sardine, scads, scorpionfish, scup, sea bass, sea catfishes, seatrout, sharks, sheepshead, spadefishes, spot, squirrelfishes, tilefish, triggerfish, tripletail, wenchman

Estimates of changes in dockside value have been examined for each of the fishery categories and the five Gulf states across the three baseline periods allowed in the Settlement Agreement (2012). Trying to determine changes in revenue streams is not an exact science. Based on the settlement documents, there were compelling reasons to allow fishermen to select from several baseline options for fairness or equity concerns. Estimates of revenue changes across all the three potential baselines from the settlement are detailed in Section 4.4.

One way to deal with different baselines is to examine upper and lower bounds on a series of different baselines. That is the strategy used here. Using 2009 as the baseline produces the lowest loss of revenues in aggregate across the Gulf. After review of the revenue data and consideration of the various factors external to the spill that may have influenced this revenue data, we determined that an additional scenario that holds external market effects constant would be advantageous. In doing this, we created an additional scenario where prices were held constant at 2009 levels to examine only the impact in reduced landings. After estimating revenue changes when holding prices constant, we found that holding 2009 prices constant presented the largest losses in harvester revenues relative to the spill year. As a result, 2009 was used for both the upper, holding prices constant, and the lower, allowing prices to change, bound estimates on the economic impacts of the spill. The scenario using 2009 as a baseline allowing prices to change will be called the Market Dynamic scenario and the scenario using 2009 data holding prices constant will be called the Market Constant scenario.

1.4 Overview of Study

Chapter Two provides a descriptive analysis of how the oil spill may have affected the Gulf seafood industry. It begins with the geographic distribution of impacts to improve understanding of spatial effects across fisheries, states and associated coastal communities. Potential longer-term effects of the oil spill on the Gulf ecosystem are reviewed at a higher aggregate level, as are potential implications at the fishery level. Concerns with seafood safety and implications on consumer perception and demand for Gulf seafood are reviewed through various sources of literature. Larger changes in the U.S. economy during the pre- and post-spill period are also noted and discussed with respect to likely positive exogenous effects on seafood demand during the damage period. Initial adjustments in markets due to product shortages and food safety concerns are summarized, and challenges faced by Gulf seafood producers trying to regain market share from import products and non-Gulf domestic producers are discussed. The temporary fisheries closures implemented by the federal government due to safety concerns are summarized spatially and temporally to allow direct comparison to changes in harvest patterns. Chapter Two concludes with a summary of how these impacts were or were not able to be factored into the subsequent economic impact model developed for this study.

Chapter Three outlines the fishing industry, the associated supply chain in the Gulf, and presents background data and detailed qualitative information on each species category. The fishery industry summaries include a review of the regulatory structure, harvest trends, and a discussion of typical trade routes and practices, and some general insights into how they were affected during the spill. Each species category is described in sub-chapters about the species and species groupings in the study. The final subchapter of the fishery industry background presents the Seafood Compensation Program and details how the program was applied to reach settlement amounts for the seafood industry participants.

Chapter Four introduces the modeling portion of the study. A review of the relevant impact modeling literature is outlined and a solid rationale for model choice and design is presented. Chapter Four also contains a discussion of model construction and an overview of the multipliers, trade flows, margins, and assumptions for the custom input-output impact model. The methodology behind the model, the model’s assumptions and the source of the data behind the customization of the model for this project are presented. Options for input data are reviewed and established based on the time periods established by the settlement. Two different market scenarios are developed (market dynamic and market constant) that estimate impacts based on the dockside value changes.

Chapter Five presents the overall results of the model scenarios by supply chain segment and gives a summary of which segments in the Gulf as whole were most impacted. It also presents species-level results by state for employment, sales, value added, and income for the two scenarios (Market Constant and Market Dynamic) used in the impact model. A summary of the results is presented and discussed relative to what could be drawn from earlier qualitative research in the study.

Chapter Six is a summary of the study and study conclusions. The study results are compared to previous studies, caveats are noted, and the intended uses and limitations of this study are reviewed.

The Appendix presents the custom multipliers that were developed based on the previous models and sources of literature referenced. These multipliers can serve as a basis for future analysis and impact model development.

Chapter Two: Factors Affecting Gulf Seafood Following the *Deepwater Horizon* Oil Spill

2.1 Overview of Factors

This chapter provides an overview of the likely impacts of the *Deepwater Horizon* oil spill on industry sectors within the Gulf of Mexico seafood supply chain. First, the geographic distribution of impacts relative to initial changes in landings as a result of the oil spill and historical accounts of community impacts provided by local publications are discussed. Then, potential longer-term impacts on the ecosystem and studies that begin to measure these impacts are presented. Examining these studies tells us that biological evidence is accruing, but attempting to measure the effects of uncertain long-run changes in stocks is beyond the scope of this study, as it falls outside the damage period. The effects of the oil spill on seafood safety and on consumer demand is discussed, including the results of studies that examined consumer perceptions following the oil spill. Changes in the overall U.S. economy during the key periods of this study are noted, and their relationship to seafood demand is discussed, including the effects of competition from imports and other domestic suppliers. The fishery closures implemented by the government to prevent harvesting in areas contaminated with oil are examined, since they correlate to changes in harvests during the spill.

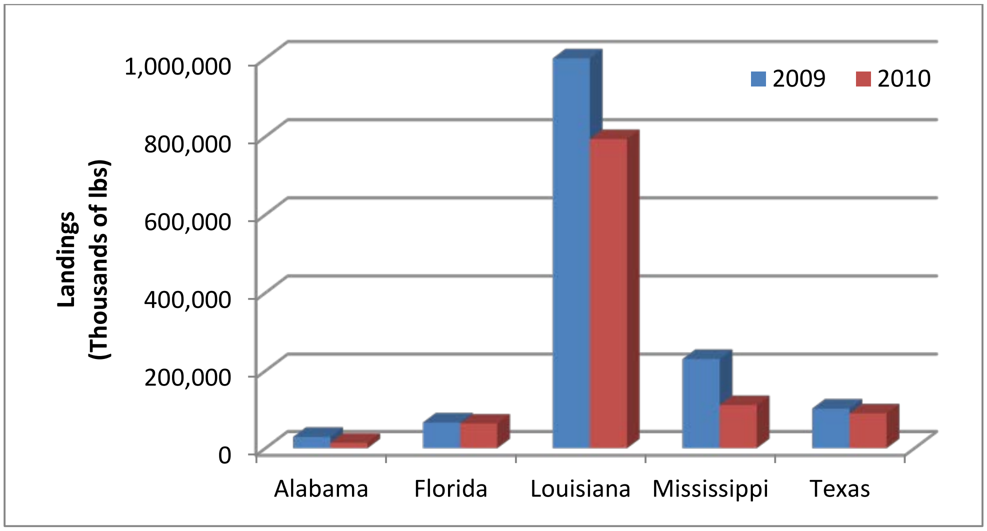
Landings for a given geographical area can be examined for a quick assessment of economic impacts. Though some impacts can be examined temporally and spatially in this analysis, various exogenous variables (both long term and short term) cannot be separated at this time and may not be measureable for years to come. The specific contribution of each potential cause of a change in landings is unknown and could have come from multiple sources, including the oil spill, use of dispersants, ecological changes, decrease in demand, etc. Also, the extent to which each of the potential causes is directly attributable to (or was caused by) the spill is debatable. Assessing economic impacts is further complicated by the fact that prices for Gulf seafood increased in 2011 (Burdeau and Reeves 2012). This section identifies the potential suite of confounding market factors, and to what extent they are captured in the resulting estimates of economic impacts modeled in this study.

2.2 Geographical Distribution of Impacts

The geographical distribution of impacts is important to recognize because of the spatial and temporal differences in several Gulf fisheries. Communities near the oil spill saw the highest impacts, because these communities included home ports to fishermen who traditionally participate in fisheries that are open from April through December (the damage period in 2010). Because of the complexity of the biological ecosystems and fishery management systems that encompass these fisheries across the five Gulf states, it is prudent to examine geographical differences in landings during the damage period compared to historical landings. In addition, documented impacts on local communities in the Gulf region add considerable qualitative evidence of key impacts by region.

Figure 1 shows the difference in landings of all commercial fisheries by state in 2010 compared to the landings during the 2009 baseline period used for this study. Though West Florida and

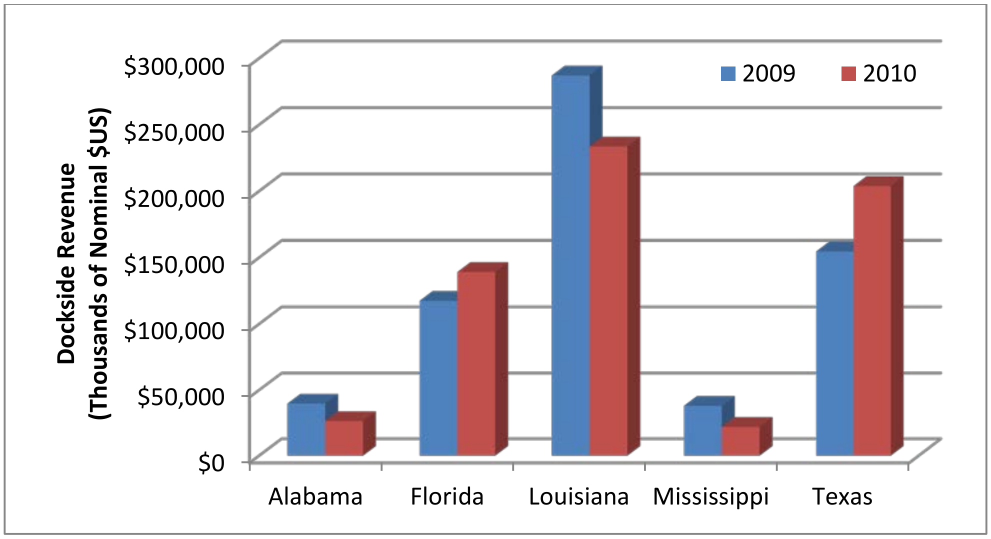
Texas appear to have had minimal changes in landings between 2009 and 2010, Alabama, Mississippi, and Louisiana experienced significant declines. The less apparent impacts in Texas and West Florida are believed to be partially because West Florida and Texas were farther from the spill than the other states.



Source: NMFS Commercial Landings Statistics

Figure 1. Comparison of State Level Landings from 2009 to 2010

Though a change in landings is helpful in terms of assessing changes in product flows, the value of those landings is equally important. Any changes in product value will directly affect the profitability of the harvest sector and other components of the value chain. Figure 2 shows another comparison of state-level data, but in dollar terms as opposed to pounds. This figure shows that Alabama, Louisiana, and Mississippi had lower dockside revenues in 2010 than they did in 2009. Even though West Florida and Texas may have landed nearly the same quantity of product as the previous year (Figure 1), their dockside revenue increased (Figure 2) because of the overall increases in market prices for seafood.



Source: NMFS Commercial Landings Statistics

Figure 2. Comparison of State Level Dockside Revenue from 2009 to 2010

Newspaper articles reported the possibility of greater long-term impacts in specific areas and described hard-hit areas struggling to recover, especially those specializing in the harvest of shrimp, crabs, and oysters. Louisiana was the focus because of the relatively high importance of seafood to the state's economy. Smith (2013), Burdeau and Reeves (2012), Johnson, Calkins and Fisk (2012), and Jamall (2012) all noted regional impacts two to three years after the oil spill, and described the impacts to fishermen and processors specifically. The results focus on declining shrimp, crab, and oyster landings, which are all important species to Louisiana's seafood industry.

Austin et al. (2014) focused on impacts in the coastal areas of Louisiana, Mississippi, and Alabama, stating that these areas were most directly affected by the spill. There was a particular focus on those in the shrimping industry, because shrimp is the largest contributor to seafood revenue in the Gulf (see Figure 5). Gill et al. (2011) compared the social and mental health impacts of the 1989 *Exxon Valdez* and the 2010 *Deepwater Horizon* oil spills, and described the implications for Gulf coast residents.

The U.S. Small Business Administration contracted a report (U.S. Small Business Administration 2013) that examined the effects of the spill on communities and small business sectors, including the commercial fishing industry, likely to have been impacted by the oil spill. Louisiana and, to a lesser extent, Mississippi, were the most affected. The effects were compounded because the Gulf was facing other challenges, including recovering from the damage of several severe hurricanes throughout the 2000s, environmental challenges, frequently-changing fishing regulations, increasing fuel costs, and declining seafood prices. The report hypothesized that geographically isolated portions of the region would be disproportionately affected, but instead found that impacts were related to proximity to oiled areas and fishing closures and that economic benefits were most significant in the response staging areas.

Other efforts to track and record the social impact of the oil spill include an oral history project during which fishermen in the Gulf region were interviewed to document their experience in the fishing industry and with the oil spill (Kyriakoudes 2010–2012).

There is strong reason to believe that these impacts were attributed to the spill event. However, for this study it was difficult to focus spatially beyond the state level, given the limited availability of regional harvest data. It is clear though through the harvest data presented above that spill impacts were focused in particular in the states of Louisiana, Mississippi, and Alabama, and had much less influence, if any, in Texas and West Florida from a statewide perspective.

2.3 Ecosystem Effects

The DWH oil spill was the largest marine oil spill in U.S. history (Camilli et al. 2010). More than four million barrels (636 million liters) of oil were released into the Gulf (Deepwater Horizon Unified Command 2010, Levy and Gopalakrishnan 2010, Urriza and Duran 2010). The light crude oil was released at a depth of 1500 m, where it emulsified because of turbulent mixing, reduced buoyancy, and the addition of Corexit 9500 dispersant (Fodrie and Heck 2011). Although a significant portion of the released oil did not rise to the surface, oil emulsified throughout the water column can have detrimental impacts on marine life (Fodrie and Heck 2011). An oil spill can affect marine ecosystems for extended periods of time through direct destruction of habitats, mortality, and pollution of flora and fauna, and shifts in food web structure and function (Sumaila et al., 2012).

For example, long-term environmental and economic impacts from the 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska were still being felt in 2000 (Graham 2003). Similarly, the substantial release of oil into the Gulf and subsequent cleaning activities may have caused severe impacts on the ecosystem that may persist in the future (Love et al., 2013). In terms of landings, many fisheries have been impacted by post-spill closures. Spatial databases of annual reported commercial catch in the Gulf were analyzed, and data indicate that more than 20% of annual U.S. commercial fisheries catch in the Gulf was negatively affected by the oil spill (McCrea-Strub et al. 2011). The fisheries at the greatest risk of economic losses include shrimp, blue crab, menhaden, and oyster fisheries (McCrea-Strub et al. 2011). It is essential to gather as much information as possible regarding the biological consequences of the oil spill on commercial species, because the Gulf is one of the most productive fishery regions in the U.S.

Many habitats and associated biota within the Gulf are vulnerable to natural and anthropogenic stressors, such as destruction and alteration by oiling events (Zacharias and Gregr 2005, National Research Council of the National Academies 2005). Habitats that may be affected by the oil spill include oyster reefs, salt marshes, seagrasses, mangroves, pelagic sargassum, coral reefs, and estuaries (Getter et al. 1981, Jackson et al. 1989, Freeman et al. 2010, White et al. 2011). Commercial fish and shellfish depend on many of these habitats for some part of their life cycle and damage to these habitats, notably biologically rich marshes and estuaries, will affect many species (Corn and Copeland 2010).

Commercial Gulf species that are vulnerable to oil exposure and may be at risk for economic loss include Eastern oyster, blue crab, brown shrimp, Gulf menhaden, and other finfishes, such as snappers (*Lutjanus* spp.) and groupers (*Epinephelus* spp. and *Mycteroperca* spp) (McCrea-Strub et al. 2011). NOAA has documented direct impacts of past Gulf oil spills on blue crabs, shrimp, and finfishes, and these species are known to be susceptible to an oiling event (NOAA 2010).

Of all the world's native oyster reefs, those in the Gulf were the most productive (Beck et al. 2011). The offshore oil industry is responsible for considerable damage to the Gulf's oyster reefs (DNR 2012). The effects of an oil spill on marine fishes may not be evident until several years have passed. Crustaceans (shrimp and crab) have also likely been harmed through higher mortality and the harmful compounds released during and after the oil spill, which can be transferred to predators that consume the toxic crustaceans.

These past and future socioeconomic effects on commercially-important species (and the seafood industry) are somewhat unquantifiable until biological studies on the effects of the oil spill are complete. Even then, the lengths of time over which the biological (and therefore socioeconomic) impacts may be felt are uncertain.

In general, marine organisms can be affected by oil through surface exposure, ingestion, absorption, and fouling of important habitats that can create long-term alterations to an ecosystem (Jackson et al. 1989, Peterson et al. 2003). Eggs, larvae, and juveniles of many species are killed or suffer from genetic damage, physical deformities, and altered developmental timing after being exposed to oil (Kocan et al. 1996, Tuvikene 1995). Individuals that survive exposure can have potentially depressed immune functions that leave them susceptible to viral disease or mortality (Carls et al.1998). Large mortality events of eggs and larvae due to oil exposure can impact the population of inflicted organisms (Hjermann et al. 2007). In addition to physical effects of oil exposure, the life cycles of many marine organisms, particularly those of economic importance, can be disrupted through decreases in habitat use, altered migration patterns, and food availability (NOAA 2010). The subsections below describe potential effects that can be observed in oysters, fishes, crabs, and shrimp with observed examples of each type of organism.

2.3.1 Oysters

Oysters have an integral ecological role in marine environments with the numerous beneficial goods and services they provide (Cruz-Rodrígues and Chu 2002, Grabowski and Peterson 2007). Oysters are sessile invertebrates that feed by filtering large volumes of seawater to extract suspended particulate matter (e.g., algae and sediment particles) from the water (Cruz-Rodrígues and Chu 2002, Newell 2004). They form reefs by clumping together; these reefs form habitat and shelter for transient and resident fish and invertebrates (Kilgen and Dugas 1989, Grabowski and Peterson 2007). By attenuating wave energy, oyster reefs also help stabilize sediment and mitigate shoreline erosion of other valuable habitats, such as salt marshes and seagrasses (Henderson and O'Neil 2003, Meyer et al. 1997). Oysters aid in water quality by reducing phytoplankton biomass, microbial biomass, and contaminants associated with suspended matter during the filtration process (Björk and Gilek 1996, Dame and Dankers 1988, Grabowski and Peterson 2007). Due to the high volume of water that they can filter, oysters are considered an important biofilter that helps maintain ecosystem functioning (Baird and Ulanowicz 1989, Grizzle et al. 2006, Newell 1988). An event such as the oil spill, which exposed oysters to oil and also dispersants, could pose long-lasting impacts on the ecosystem and the various species it supports.

Due to their sessile nature, oysters are vulnerable to environmental conditions and stressors, such as an oiling event (Culbertson et al. 2007, 2008). When oil and dispersants are present in water, oysters can filter and accumulate harmful pollutants, such as polycyclic aromatic hydrocarbons (PAHs) present in oil, into their tissues as they feed (Fisher et al. 2000). Oysters have been documented to bioaccumulate contaminants within their tissues (Obana et al. 1981, Landrum et al. 1991). Contaminants absorbed in the tissues of organisms can be transferred to organisms that feed on them, which can have adverse effects for the consumers, including humans (Suedel et al. 1994). Because of potential carcinogenic effects in humans, after an oyster is contaminated with PAHs, it should not be consumed (Lubchenco et al. 2012, Bolger 1999). Fry and Anderson (2014) investigated the transfer of oil from the spill into estuarine food webs and found that oil was minimally assimilated in the diets of mussels and barnacles. Although this study did not test oysters, mussels and barnacles are also filter feeders and function similarly to oysters. Larval oysters are free-living until they find suitable substrate to attach to (Kilgen and Dugas 1989); oily substrate can prevent attachment or cause mortality (Freeman et al. 2010). Adult oysters can be suffocated if they are submerged in oil or if they close their shells to protect themselves in response to oil and chemicals in the water (Freeman et al. 2010). In cold water, oysters can close their shells for up to two weeks without direct adverse effects, but in warm water they can die within two days of closing their shells. The oil spill occurred in April, when water temperatures are variable; oysters may have suffered mortality due to closure of their shells in warm water. To date, there is little evidence of adverse effects on oyster recruitment post-oil spill. More data is needed to conclusively say whether oyster recruitment has been negatively affected after the oil spill.

2.3.2 Fishes

The effects of oil on marine fishes can often be difficult to detect. Visual signs of an oiling event are not as apparent with fishes as they are with birds or marine mammals. Determining if fishes are impacted by an oiling event may be difficult, particularly in the short-term after an oil spill (Sumaila et al. 2012). However, effects of oil on fishes have been well studied. In Prince William Sound, Alaska, the *Exxon Valdez* spill in 1989 provided a base for such studies (Sumaila et al. 2012). Important fish species, such as Pacific herring (*Clupea pallasii*) and pink salmon (*Oncorhynchus gorbuscha*), were negatively affected by that spill. Effects on these fishes included premature hatching, reduced growth rates, morphological and genetic abnormalities, and increased mortality (Bue et al. 1998; Rice et al. 2001). Liver lesions and increased disease due to depressed immune systems were also seen in adult Pacific herring (Moles et al. 1993; Carls et al. 2001); over a five-year period, these effects contributed to increased natural mortality for adult herring (Thorne and Thomas 2008).

As oil spreads through the marine ecosystem, it can damage coastal areas that are important nursery areas for juvenile fish and shrimp (Sumaila et al. 2012). PAHs can cause direct mortality in fishes and can induce sublethal effects such as DNA damage, liver disease, fin erosion, increased heart rates, and reproductive, developmental, and immune system impairment (NOAA 2010, National Wildlife Federation 2014). A recent study investigating the effects of crude oil on the developing hearts of embryos of large predatory pelagic fish reported abnormalities in cardiac function of bluefin and yellowfin tunas and amberjack (Incardona et al. 2014). In the Gulf, developmental crude oil toxicity of these fishes likely caused population declines of early life stages of tunas, amberjack, billfish, and other large predators that spawn near oiled locations (Incardona et al. 2014). Gulf killifish collected from an oiled location after the spill were also observed to undergo developmental abnormalities due to crude oil exposure (Dubansky et al. 2013). Fishes can also be affected on a trophic level through consumption of contaminated prey. For example, oil and associated hydrocarbons are taken up by plankton and other surface-dwelling species that link to aquatic food webs (Sumaila et al. 2012). Fishes can consume contaminated prey, bioaccumulate pollutants into their own tissues, and potentially pass the harmful contaminants to larger predators, including humans (Suedel et al. 1994, Sumaila et al. 2012). The effect of the oil spill on fish recruitment is still largely unknown. One study reported lower biomass of larval fishes of several important commercial species, including tuna, marlin, and dolphinfish, after the oil spill (Rooker et al. 2013). Other studies have reported the potential loss of recruitment due to crude oil exposure to larval stages of commercially important fish species (Incardona et al. 2014, Dubansky et al. 2013). In contrast, one study reported no significant differences in recruitment of marsh-associated fishes in coastal Alabama after the spill (Moody et al. 2013). Because the effects of an oil spill on marine fishes may not be fully apparent until several years after an oiling event (Thorne and Thomas 2008), it is unclear whether the spill has affected the recruitment of commercially-important fishes.

2.3.3 Crustaceans: Crabs and Shrimp

The impact of oil exposure on the benthic community, which includes crustaceans, such as crab and shrimp, and other invertebrates, can be variable and often difficult to predict (Mendelssohn et al. 2012). For example, Sanders et al. (1980) reported that oil can cause acute reduction in benthic invertebrate abundance due to mortality or avoidance. Other studies have documented minor or subtle changes in invertebrate abundance (Lee et al. 1981, DeLaune et al. 1984). In general, it is recognized that benthic organisms are more vulnerable to oil exposure because of their close association with contaminated habitats, food sources, and nutrients (Rozas et al. 2000; Chapman and Wang 2001, Culbertson et al. 2007, 2008). Benthic invertebrates are susceptible to mortality when initially in contact with oil and extreme fluctuations in populations and community diversity are not uncommon (Suchanek 1993). Oxygen availability, which is crucial to benthic organisms, can be greatly reduced due to oil (Mendelssohn et al. 2012). Oil exposure to crabs and shrimps can result in declines in abundance, growth rate, and condition (Culbertson et al. 2007, 2008). For example, juvenile shrimp exposed to oil from the spill experienced reduced growth rates when held in field mesocosms exposed to high levels of oil (Rozas et al. 2014). The PAHs that are present in oil can result in direct mortality to benthic crustaceans by smothering the organisms or by physically and chemically inducing toxicity (NOAA 2010). In laboratory experiments, adult Alaskan shrimp and juvenile crabs experienced mortality when exposed to crude oil for 96 hours (Brodersen et al. 1977). Oil that enters an estuary can cover crab burrows, deplete available oxygen in the water, induce toxicity in crabs that swim through the oil, and induce early molting, which leaves crabs more sensitive to oil pollution (Malan 1990). Both crabs and shrimp can accumulate PAHs in their tissues and may be unable to metabolize the compounds (NOAA 2010). If the animals are unable to process or dispel toxic compounds from tissues, these harmful compounds can be transferred to higher trophic levels through predators that consume the toxic crustaceans (NOAA 2010). There is little evidence of the effect of the oil spill on crab and shrimp recruitment. One study conducted along coastal

Alabama concluded that there were no significant differences in recruitment of marsh-associated nekton, including crabs and shrimps (Moody et al. 2013). This one study addressing recruitment of marsh associated fish was restricted to one location affected by the oil spill. Beyond this one study, little is known about shrimp and crab recruitment successes after the oil spill. The impact of the oil spill on crustacean recruitment is still largely unknown.

2.4 Consumer Demand

The effects on the marketability of species suspected to have been harmed by the oil spill are generally negative, at least in the short-term. Early on, concerns were expressed regarding seafood safety, often oysters specifically (Robbins 2010; Kirkham 2010). To address these concerns, NOAA and the U.S. Food and Drug Administration (FDA) immediately enacted a seafood testing program. After thousands of samples were tested, none tested above the FDA safety standards (Alexander-Bloch and Anderson 2011, Louisiana Seafood News 2011). However, the unknown nature of the extent of harm to various species was particularly concerning (Wittenberg 2010; Fowler 2012; Goldenberg 2010). Interviews with fishermen found that some continued to eat the seafood they caught throughout the period after the spill, and others stopped eating any of their catch (Austin et al. 2014). Some fishermen in Louisiana reported difficulty selling seafood to their usual customers due to food safety concerns (Austin et al. 2014). Even three years after the oil spill, though seafood safety may no longer be a primary concern, consternation persists about genetic mutations and cell damage in prey fish for food fish resulting from oil in bottom sediments with potential impacts to reproductive capability (Mohan 2013; Kaufman 2011; Pittman 2013; Fowler 2012).

One year after the oil spill, the Times-Picayune reported that some dealers were unable to sell the same volume they had sold in the previous years (in this case, oysters) due to decreases in consumer confidence, chef confidence, and brand damage (Alexander-Bloch and Anderson 2011). This and similar reports express concerns that though landings may return to pre-spill levels, the markets may not. It was reported in the media that BP gave the Louisiana Seafood Promotion and Marketing Board $30 million to help repair the Gulf's poor seafood brand image (Alexander-Bloch and Anderson 2011). Friedrick (2011) noted that BP issued an upfront payment of $2 million to fund a crisis communications and public relations campaign to combat misinformation and negative press about seafood consumption and tourism in the region. Although the program was considered to have fast-acting and deep-reaching positive benefits, consumer concerns still remained (Friedrick 2011). The Gulf Seafood Marketing Coalition reported that at the time of the spill, 70% of consumers were not comfortable with eating Gulf seafood; results were from a survey commissioned through Big Communications and New South Research and were reported at the 2012 International Boston Seafood Show (Telesca 2012). Joanne McNeely, a representative from the Gulf Seafood Marketing Coalition, stated "And now it's basically flipped. We have 70% that are comfortable with it, and we have about … 20% to 30% who are not comfortable or they're eating less" (Telesca 2012). From this study and others, it is believed that initial impacts due to food safety concerns and negative consumer perception were prevalent in most U.S. consumer markets but quickly subsided.

Similar studies show that due to health concerns, consumers were less willing to purchase Gulf shrimp, crabs, and oysters immediately after the oil spill, but consumer concerns declined notably during the post-spill period. A survey conducted in 2010 by the University of Minnesota concluded that greater than half of U.S. consumers say they would change their seafood consumption due to the safety concerns caused by the oil spill (Wittenburg 2011). The research also noted that, although consumers indicated they would change consumption, there was no proof that people actually changed consumption habits. The level of concern was at its highest in July of 2010 and appears to have reduced dramatically toward the end of 2010. From this research, it is apparent there were large short-term concerns with perception during the damage period in 2010, but longer-term concerns were much less apparent just months after the damage period.

A study by Michigan State University (McKendree et al. 2013) reported that 29% of U.S. consumers sought to reduce their seafood consumption due to the oil spill. Others, albeit seemingly fewer, surmise that the Gulf seafood brand may have been bolstered through publicity surrounding the oil spill (Alexander-Bloch and Anderson 2011).

Another factor affecting consumer demand for seafood and dockside values of landings is the change in the overall condition of the general economy that occurred from 2007 to 2010. From 2007 to 2009, the U.S. economy experienced the worst recession since the 1930s (Chandra 2010). During this period, the fourth quarter of 2007 to the second quarter of 2009 specifically, GDP shrank a reported 5.1% and then expanded at a 3.9% annual rate for the first three months of 2010 (Kowalski 2011, Chandra 2010). During the period of 2007 and 2009, seafood markets adjusted to compensate for the weak consumer markets. In times of recession, it is common for consumers to eat less often at restaurants and to buy more at retail markets. Wright noted that during 2009 restaurant sales of seafood declined notably, but retail sales did not compensate as expected due to price competition from other proteins (Wright 2010). The fact that a much higher percentage of seafood was consumed in the mid- to higher-end restaurants (Decker 2012), which were believed to be highly affected by this recession, complicates these economic adjustments. In 2010, it was reported that restaurant visits and sales dramatically increased (Decker 2012), and it was anticipated this increase was largest in the higher-end restaurants that tend to sell more local products. Many of the species harvested from the Gulf are sold as fresh or local products, which tend to be segmented for these higher-end markets and would have been highly impacted by these shifts in demand. The landings data and industry interviews indicated that prices and harvester revenues in various Gulf fisheries increased because of this general economic turnaround, and that the short supply in these markets added to price increases. Another confounding market factor during this period was the fluctuation in supply of imported products, which is discussed in the following section. Impact estimates based on fishery revenue changes from 2009 to 2010 will not be solely representative of impacts due to the spill.

2.5 Imports and Lost Market Share

The shortages of domestic Gulf seafood and perceived food safety risks forced distributors, retailers/restaurants, and some processors to find alternative sources of supply (both domestic and imported). For larger-volume frozen and shelf-stable products, as supply from the Gulf decreased, the number imported products increased to help meet demand. For smaller-volume fresh and live items, as supply from the Gulf decreased, there was an increase in non-Gulf domestic sources to help meet demand. The import data and industry reports suggest that import penetration has been significant in the U.S. seafood market before, during, and after the oil spill. The competition of imports, combined with the rising expenses of commercial fishing, such as increased fuel prices, has decreased profit margins for domestic seafood (Austin et al. 2014). Looking at import and landings data, it is difficult to attribute increases in imports in 2010 directly to shortages caused by the oil spill. However, numerous personal communications conducted in conjunction with this study revealed that after the spill in 2010, many key markets switched to imported product to cover supply shortages and appease consumer concerns. In many cases, this increase in imported products continued into the proceeding period of 2011 and potentially 2012. In addition to imports taking over many of these markets, certain species (blue crab and oysters) that are sourced in other regions of the U.S. were also substituted in place of local Gulf products. Changing sourcing is not trivial; adjustments back to Gulf resources can take considerable time and consultation on price on behalf of the seller. In some cases, buyers may have permanently switched because of consistency of supply and more competitive prices. In most cases, though, it was noted that buyers did resume purchases from Gulf sources sometime in 2011 or 2012.

Another important trend related to market fluctuations is shortages of global supply during the post-spill period. Both shrimp and crab supply from various Asian countries were experiencing rapid slowing in supply beginning in late 2010. The decline in shrimp and crab imports into the U.S. after the spill are illustrated in Figures 13 and 20. The supply of imports compared to domestic landings for shrimp and swimming crab or blue crab amounted to an estimated 80% and 18% respectively in 2010 (NMFS 2014); these decreases in imported supply are believed to have had compounded positive effects on prices both during and beyond the 2010 period.

It will be very difficult to discern, in this study, the effects of these import shortages in relation to the effects of the domestic shortages that resulted from the oil spill. Comparing the relative volume of imports to domestic production for key markets, such as shrimp, we can conclude that the domestic producer would, in many cases, be a price taker, and the importing producer would represent the price maker in most major seafood markets. In effect, this reduction of overall domestic and imported supply of particular species, such as shrimp and swimming crab or blue crab, would have driven market prices up for these products and increased dockside revenues paid in the Gulf region for these species. These market effects influencing price cannot be solely attributed to the oil spill; it is challenging to use only dockside revenue as a proxy for impacts created by the spill.

2.6 Temporary Fishery Closures

This section discusses state-level closures and outlines the size and scope of federal closures which occurred during the damage period. After the oil spill, several states and the federal government closed their respective areas to fishing. The harvest of commercial seafood products from those areas was prohibited and domestically-sourced product was prevented from entering the supply chain. Fishery closures in the Gulf during the damage period represent cause and effect impacts that occurred in the various fisheries during the official damage period defined for the settlement (May to December 2010). Randy Pausina, who oversees fisheries programs at the Louisiana Department of Wildlife and Fisheries, was quoted as saying, “I can say with complete certainty that any lowered numbers we had with shrimp, crab and finfish last year was absolutely

100 percent unrelated to anything other than the fisheries closures” (Alexander-Bloch 2011). At the time of the spill this claim seemed reasonable, but after further examination it is understood that various other biological and economic factors could have influenced, and to a certain extent have influenced, harvests of the noted Gulf species groupings. Examining the timing and extent of closures compared to historical landings can help us describe specific states and species that incurred impacts.

The first commercial fisheries closures began at the state level on April 30, 2010, when the Louisiana Department of Wildlife and Fisheries began to close oyster grounds. Also, the Mississippi River fresh water diversions were opened in an attempt to prevent oil from entering coastal marshes. At the height of fisheries closures, 55% of Louisiana state waters were closed to fishing (Upton 2011). On July 29, Louisiana state waters from the Mississippi River Delta to the Mississippi state line were reopened, and by November 10, 98% of state waters were reopened to commercial fishing. Public oyster beds in Western Louisiana opened in October 2010, and by mid-November all oyster beds west of the Mississippi River had reopened.

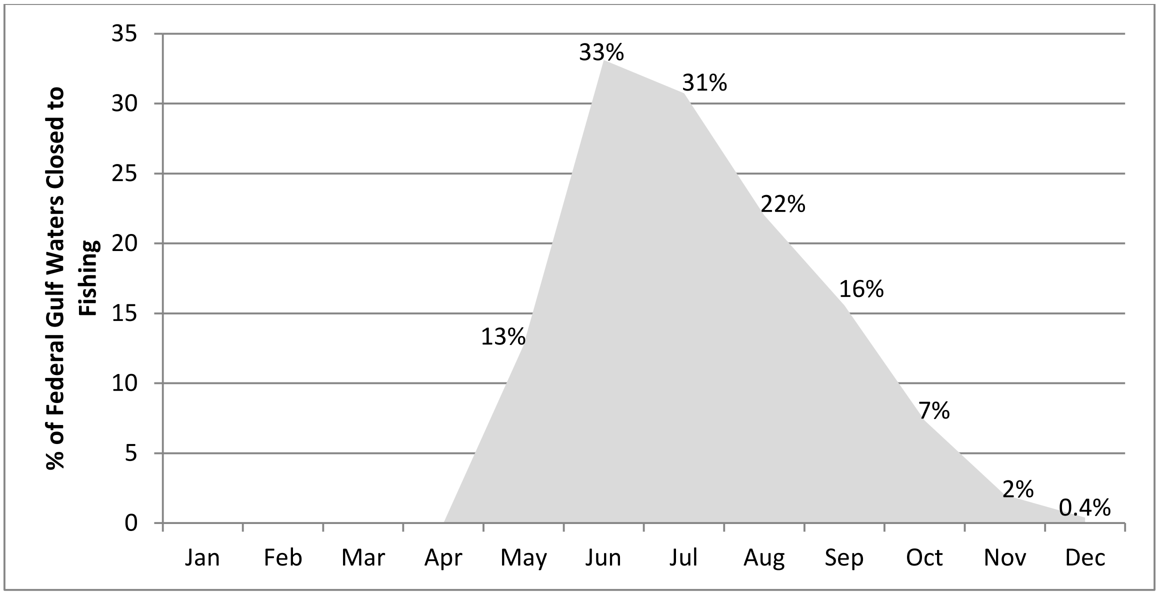
Portions of Mississippi state waters were first closed to fishing on June 1, 2010. Eventually 95% of Mississippi state waters were closed to fishing (Upton 2011). On August 6, state waters were reopened to finfish and shrimp fisheries, but not until November 8, 2010 were some public oyster beds were reopened.

Florida closed 2% of its state waters to commercial fishing on June 13, 2010 and reopened them August 16, 2010.

Beginning in June 2010, Alabama slowly closed its state waters to fishing; at its peak amounted to 40% of the state waters were closed (Upton 2011). During August, Alabama began to reopen sections to different types of fishing. By September 6, 2010, all state waters were reopened for commercial fishing with the exception of public oyster reefs, which remained closed for rehabilitation purposes.

Texas did not report any specific closures in state waters.

NOAA began to close federal waters to fishing on May 2, 2010. Figure 3 shows the monthly average of the percentage of Gulf waters in the U.S. exclusive economic zone (EEZ) that were closed during the damage period, May to December 2010. The largest closure at any given time was from June 2 to June 4, 2010, when 36.6% of Gulf waters were closed. On April 19, 2011, the last of the federal waters, those closest to the site of the spill, were reopened. NMFS records of daily Gulf closure percentages were aggregated into monthly averages so the date and magnitude of fisheries closures could be compared to monthly landings and dockside value.



Source: NMFS Deepwater Horizon/BP Oil Spill: Size and Percent Coverage of Fishing Area Closures Due to BP Oil Spill

Figure 3. Monthly Average of Gulf of Mexico Federal Fishing Closures (%EEZ) in 2010

2.7 Implications for Assessing Impacts

The oil spill can be expected to decrease commercial seafood landings, revenues, and exports, while increasing imports. For some species, this may have occurred immediately after the oil spill, be occurring now, and continue into the future. However, the complete effects of the oil spill on dockside landings and value (i.e., harvester and fishery revenues) and, ultimately, the profitability of the seafood industry are difficult to determine with the available data. Decreases in landings are visible in 2010 and subsequent annual landings data, due to temporary fisheries closures. There is also potential harm to habitat, fish health, and reproduction. Decreases in ex-vessel prices may also occur due to consumer safety and quality concerns, and a loss of available markets for Gulf seafood due to initial closures.

However, some of the decreases in landings and ex-vessel prices may have been offset by factors unrelated to the oil spill, such as shifts in fishing effort to other areas or other species, favorable market conditions (including a decrease in supply), population increases, and/or increases in beneficial fishing conditions (weather, water temperature). Isolating the distinct contribution of each confounding factor affecting the seafood industry supply chain (across space, time, and species) in the Gulf, though a laudable goal, is not achievable because data constraints and subjectivity about the extent to which secondary spill effects continue to be attributable to the oil spill. However, by examining the historical harvest data against 2010 harvest data from the period of fishery closures, we have noted fluctuations due, at least in part, and in some cases mostly, to the oil spill.

This study focuses on using landings and dockside value (harvester/fishery revenue) fluctuations that occurred during the damage period (i.e., May to December 2010) to estimate regional economic impacts which are surmised to be caused by the spill closure. The changes in landings and dockside value for the designated fishery categories are used as input data to calculate impacts. As a result, two scenarios will anchor this analysis:

- Scenario 1, Market Dynamic or change in reported dockside value, and
- Scenario 2, Market Constant or change in reported landings valued at pre-spill prices.

The derivation of these two input data scenarios are further defined in Chapter Four of this report. Because of the issues regarding the cause and effect relationship of these data and the oil spill, these two scenarios are assumed to bookend actual effects.

Chapter Three: Fishing and Seafood Industry Background

3.1 Overview of All Species

This chapter provides an overview of the species, fisheries, and supply chains that will be captured in the economic impact analysis of the *Deepwater Horizon* oil spill in the Gulf of Mexico. We review the regulatory structure of the Gulf fisheries, show historical landings data and landings data for the relevant 2009 and 2010 period, and offer insight on the supply chain and market factors that may have affected each species category. Each species category is discussed. The final section describes the Seafood Compensation Program and details how it was applied to estimate settlements for seafood industry participants who filed claims.

3.1.1 Commercial Fishing Regulations

Federal and state commercial fishing regulations affect the volume of seafood harvested from the Gulf. These regulations apply to stocks affected by the oil spill. Each species (or group of species) managed by federal and or state governments is regulated differently. Typical tools used for regulation include permitting, size limits, closed areas and seasons, trip limits, aggregate and individual quotas, gear restrictions, and vessel monitoring system requirements. Federal regulations apply to waters 3 to 200 nautical miles offshore; regulations by states apply to waters within three nautical miles of shore, with a few exceptions (e.g., Florida’s west coast and Texas, where state governance extends to three marine leagues or approximately nine nautical miles offshore).

Federal fisheries management is governed by NOAA. In the Gulf region, NOAA is advised by the Gulf of Mexico Fishery Management Council (GMFMC), one of eight regional Fishery Management councils established by the Fishery Conservation and Management Act of 1976. Each state that borders the Gulf manages their fisheries within their 3–9 nautical miles from shore through a state department. Each state has its own administrative process for developing and implementing regulations.

The numbers of federal dealer and vessel permits by species and state indicate the maximum number of operations operating in each species and state in the Gulf. In most cases, the number of active permits is likely to be less than the total number of permits. In some cases, a fishery permit may be retained for insurance purposes, in case other work is not available or hurricane damage or regulations limit the ability to participate in an alternative fishery. In general, fishermen own portfolios of permits and participate in those fisheries that are most profitable in any given season, which may change from year to year. In most cases, however, the number of permits gives the best indication of fishery participation, short of matching permits to logbook information, which is a lengthy process that is possible only under a specified grant from NOAA and the applicable science center.

Alabama: Alabama requires gear and species/species group specific commercial fishing licenses for oysters, mussels, mullet/mackerel, live bait, use of a gill net, shrimp boat (by vessel size category), purse seine, oyster dredge, oyster catcher, hook and line, and crab. A Seafood Dealer Permit is required for the sale of seafood.

Florida: Florida requires commercial fishermen to have a Saltwater Products License to fish in state waters and sell saltwater products. Endorsements must be obtained to harvest/sell blue crab, stone crab, lobster, and "restricted species." If a trap is used to commercially harvest stone crab or lobster, the fisherman must own trap certificates and obtain annual tags for each trap. The total number of traps is limited to the number of certificates a fishermen owns. Divers must obtain a commercial dive permit. Dealers must obtain either a Wholesale Saltwater Products Dealer License (for sales to any customer except the consumer) or a Retail Saltwater Products Dealer License (for sales to end consumer).

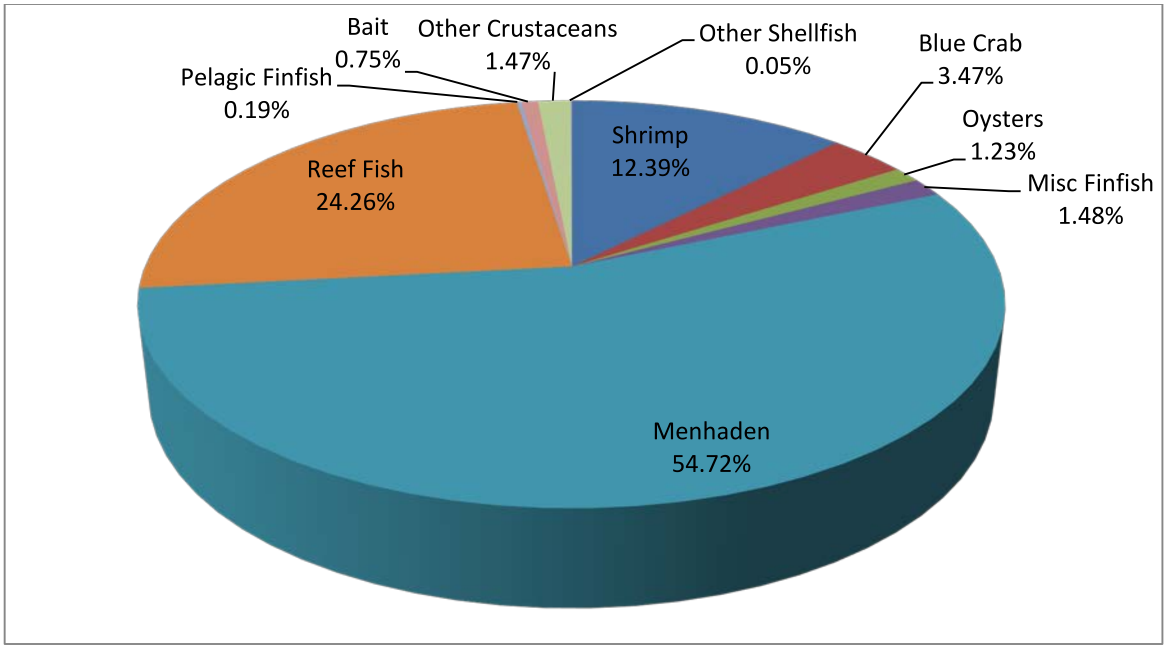
Louisiana: Louisiana requires gear and species/species group specific commercial fishing licenses for individuals participating in fishing (captains, apprentices), vessels, and numerous gear and species-specific gear. Dealer licenses are also required for wholesale, retail, and transport. Some are species-specific. In many cases, licenses must be obtained for boats, vehicles and individuals.

Mississippi: Mississippi requires gear and species/species-group specific commercial fishing licenses for captains, shrimp (by vessel size category), crab (by gear type), finfish hook and line (by gig per vessel and person), menhaden boat/net, oyster (by gear), and live bait (shrimp dealer, shrimp boat, minnow). Business licenses include an Interstate Commerce License, Seafood Dealer/Processor License, Menhaden Processor License, and Seafood Transport License. In many cases, licenses must be obtained for boats, vehicles, and individuals.

Texas: In Texas, commercial fishing licenses are required for fishermen and boats targeting finfish, oyster, mussel and clam, shrimp, crab, and menhaden. Business licenses include licenses for dealers, wholesalers, retailers, and those importing seafood. In most cases, licenses must be obtained for boats, vehicles, and individuals. Other licenses are gear-specific for a particular species.

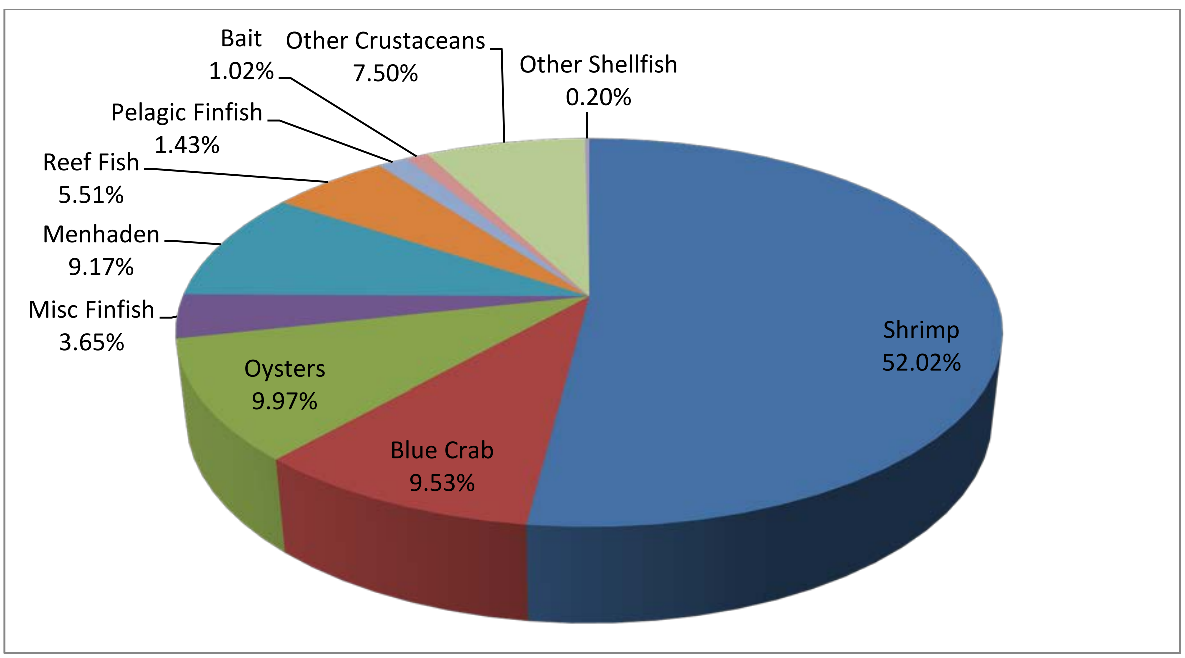
3.1.2 Fisheries Characteristics and Trends

Figure 4 and Figure 5 list the composition of total landings by weight and dockside value, respectively. The relative contributions from each species group are helpful in understanding the relative size of potential impacts that may have occurred in each fishery. Menhaden accounts for the highest volume of landings, but only 9% of dockside value, whereas shrimp accounts for 12% of landings by weight, but generates an estimated 52% of the total dockside value. During the period from 2007 to 2009, the relative percentages by species group remained fairly constant from year to year.



Source: NMFS Commercial Landings Statistics

Figure 4. Composition of Commercial Gulf Landings (lbs) by Core Species Group from 2007 to 2009



Source: NMFS Commercial Landings Statistics

Figure 5. Composition of Dockside Revenue (Nominal $US) of Commercial Gulf Landings by Core Species Group from 2007 to 2009

After reviewing the relative size and breakdown of these species categories, we determined that certain categories (other shellfish, miscellaneous finfish, and bait) were so small and fragmented that detailed examination of the historical harvest numbers would not yield much value to this study. See Chapter Five for a summary of the impact results for these smaller categories, but with fewer contexts to species-specific changes and market influences.

3.1.3 Supply Chain and Market Factors

Typically, seafood harvesters in the Gulf sell their catch to a dealer/aggregator or processor who has a dealer's license. In some cases, the harvester has a dealer's license and can sell directly to restaurants, the public, and/or at farmer's markets. Wholesalers/distributors purchase seafood from dealers and/or processors and sell the seafood to restaurants and retailers. Some dealers and processors have their own retail stores. That is, many entities' supply chains are vertically integrated; other supply chains rely on largely informal contracts between harvesters, dealers, and others to bring seafood to market. It appears that the seafood supply chain in the Gulf can vary greatly in level of integration, but most species sold for human consumption have supply chains with three to five basic components (harvester, dealer/aggregator, processor, wholesaler/distributor, and retail/restaurant outlet). Each species and/or product supply chain can follow a slightly different path.

Though some harvesters may have been able to switch to other fisheries or areas for fishing during the oil spill, others could not, due to longer and more costly travel distances, or lack of permits. In some fishing sectors, temporary and seasonal employment are common arrangements. Many employees, such as deckhands, are typically paid based on the volume of seafood (U.S. Small Business Association 2012) and were greatly affected by this disruption in fishing operations. Some docks were forced to shut down because they were diverted to spill cleanup efforts. At the processor level, there were not as many boats selling product because they were unable to fish or were participating in the VOO program (Austin et al. 2014). After supplies increased in 2011, labor recruitment problems arose because the previous lack of work had caused workers to move out of the region. To make up for decreased supply during 2010, wholesalers, distributors, retail stores/restaurants, and some processors relied on imports, freshwater fish, and seafood from other domestic regions. This substitution helped these entities retain their markets through diversification. When Gulf seafood became available, however, some buyers were no longer interested in purchasing domestic seafood, due to either the cost (as reduced domestic supplies could have increased prices) or commitments to remain with current suppliers. Many processors were forced to sell at lower profit margins in order to remain competitive, with the goal of maintaining their current customer base (Austin et al. 2014).

To provide a better understanding of the dynamics associated with the supply chain and how the interrelationship of these market segments may or may not have been impacted due to the spill, a typical supply chain is depicted in Figure 6. Based on literature gathered and input from supply chain participants, the diagram shows general relationships and market dynamics. Typically, a vessel sells to a dealer or aggregator at the dock, who then sells the product to a processor. After the product has been processed into its final form, it is sold to distributors. Specialty distributors are often vertically integrated with processors and tend to deal in specialty seafood products, such as fresh or live seafood, which requires time-sensitive distribution. Specialty distributors may sell direct to retail and restaurant outlets, or sell indirect to these outlets through a foodservice or retail distributor. Retail distributors are often subcontracted to transport the product to a location, such as a grocery store, where it can be purchased by a consumer. Foodservice distributors focus more on shelf-stable or frozen products that sell to restaurants and are then sold to a consumer.

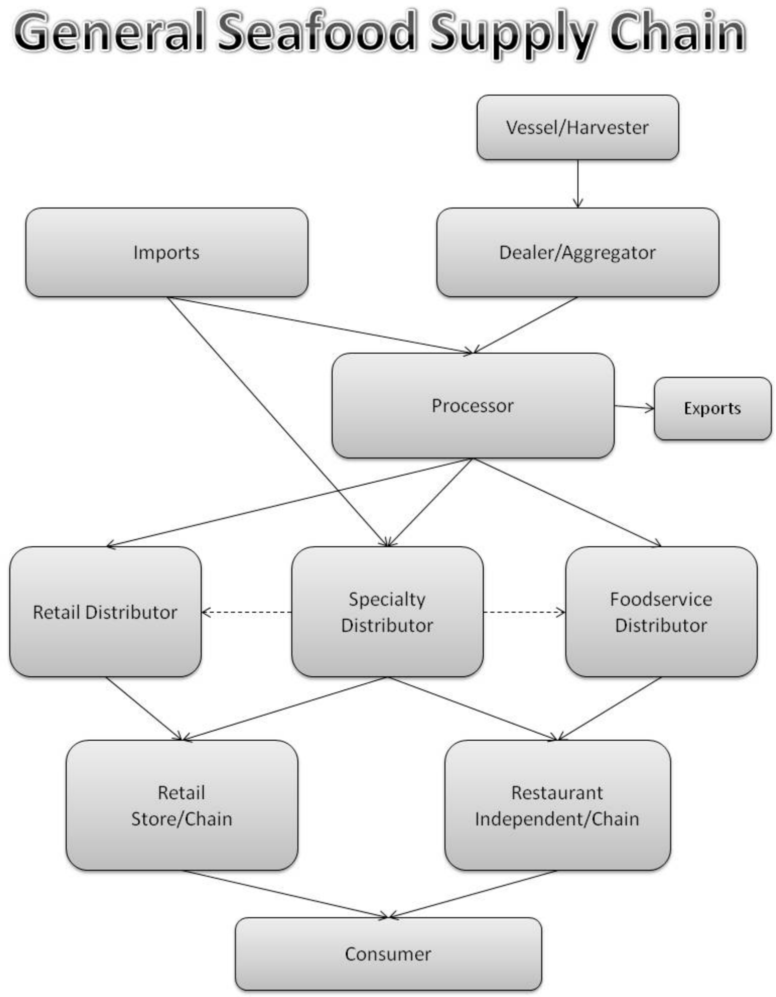


Figure 6. General Seafood Supply Chain Diagram

3.2 Shrimp

3.2.1 Shrimp Commercial Fishing Regulations

The Gulf commercial shrimp industry primarily harvests two different species: white (*Litopenaeus setiferus*), and brown (*Farfantepenaeus aztecus*). From 2007–2009, approximately 48% of shrimp landings and 50% of shrimp revenue in the Gulf were attributed to white shrimp, 47% of shrimp landings and 43% of shrimp revenue were attributed to brown shrimp, and the remaining 5% of landings and 7% of revenue were attributed to a combination of all other shrimp species (NOAA 2013). Shrimp (except royal red shrimp) are co-managed by federal and state entities. Some states make their regulations consistent with federal regulations to simplify management and rules for commercial fishermen. Offshore shrimping is not subject to seasonal closures, and fishing continues throughout most of the year. These vessels are typically around 100 feet in length, and are able to travel from Texas to Florida, often on trips lasting for weeks (U.S. Small Business Administration 2013). Inshore shrimping is state-regulated and has seasonal closures to protect juvenile shrimp. These vessels are typically less than 25 feet in length, and fish day trips or for a few days at most (U.S. Small Business Administration 2013). Brown shrimp are fished inshore from May to July; white shrimp are fished from August to December (BOEM 2014).

Shrimp harvest is usually managed by gear restrictions, minimum size requirements, seasonal closures, and area closures. Shrimping in federal waters does not have a trip limit or minimum size limit. However, when white shrimp taken in the EEZ are transported to Louisiana, they must be large enough to meet with the minimum size limit of that state in order to be landed there. Royal red shrimp is managed separately from the other shrimp species, with a quota of 392,000 lbs tail weight in 2013. Royal red season opens January 1 and closes when the quota is reached or projected to be reached.

Table 4 shows the number of federal dealer and vessel permits by state for shrimp at the end of 2013. Royal red shrimp is shown separately from other shrimp species because it is the only species that is fished exclusively in federal waters and therefore requires a separate permit. These numbers indicate the maximum number of shrimp operations operating in each state in the Gulf. The number of active permits is likely to be less than the official permits issued. In most cases, there is latent fishing effort represented in these permit figures because fishermen shift efforts between fisheries.

Table 4. Vessel Permits of Shrimp by State, Dec. 20, 2013

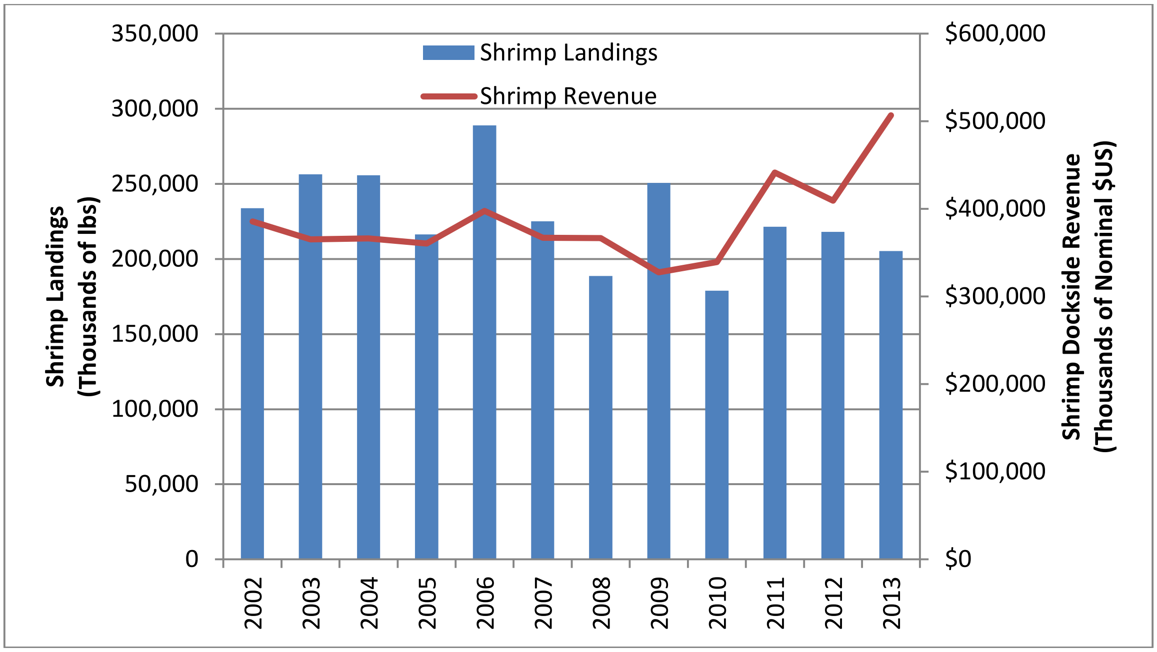
State	**Royal Red Shrimp**	**Other Shrimp Species**
AL	35	97
FL	52	204
LA	49	394
MS	17	104
TX	90	532
Total	**243**	**1,331**

Note: Florida permit numbers include permits for the entire state. That is, the numbers are for both the South Atlantic and Gulf of Mexico management regions of Florida. This is an over representation of fishing operations in the Gulf.

Source: Gulf of Mexico Fishery Management Council

3.2.2 Shrimp Fisheries Characteristics and Trends

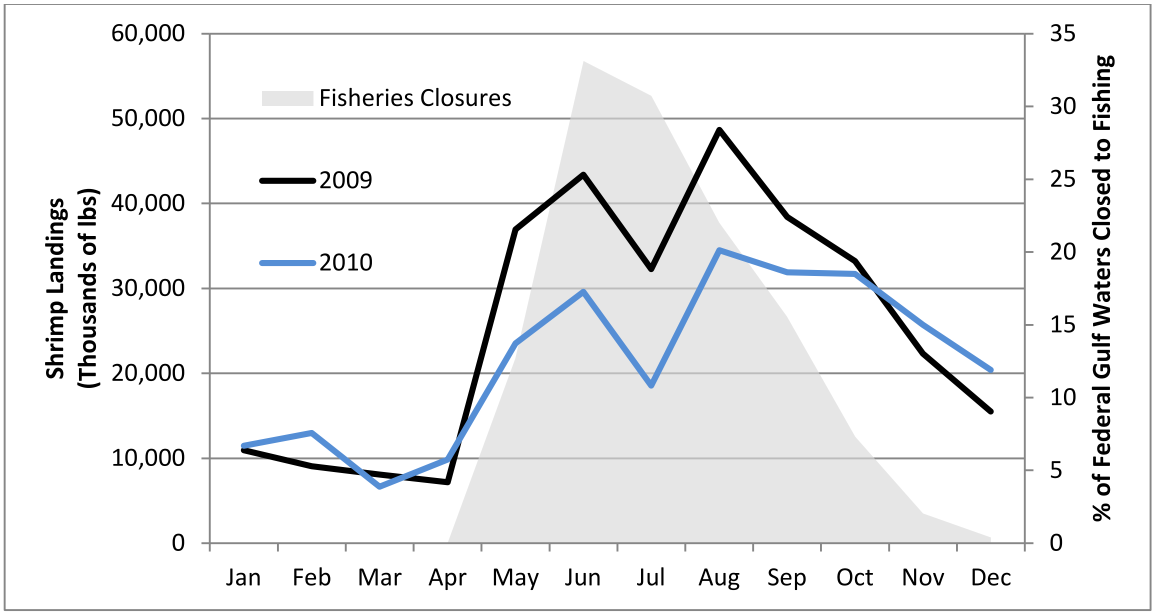
Gulf shrimp landings fluctuated from 2002 to 2009; there was a peak in 2006 of approximately 288 million pounds (Figure 7). In 2010, total shrimp landings declined to 179 million pounds, and then increased to 220 million pounds in 2011 and 2012. It declined to 205 million pounds in 2013. Shrimp landings in 2010 were down by 29% compared to the landings in 2009, whereas dockside revenues increased 3% in 2010 compared to 2009. This is because the average price of shrimp increased in 2010, perhaps in response to supply shortages caused by the fishery closures. With respect to volume of landings, it appears that shrimp harvests rebounded in the two years immediately following the oil spill. Such a recovery is not unexpected, because shrimp are highly resilient. Shrimp grow quickly, and have a typical lifespan of less than two years; near the ocean floor, each female releases up to a million eggs, which enter into estuaries as juveniles to grow to adulthood (NOAA Fish Watch 2014). However, oil contamination has been documented in the coastal marshes that are critical habitat for juvenile shrimp; this could have long-term negative effects on the stock and landings (Tunnell 2011).



Source: NMFS Commercial Landings Statistics

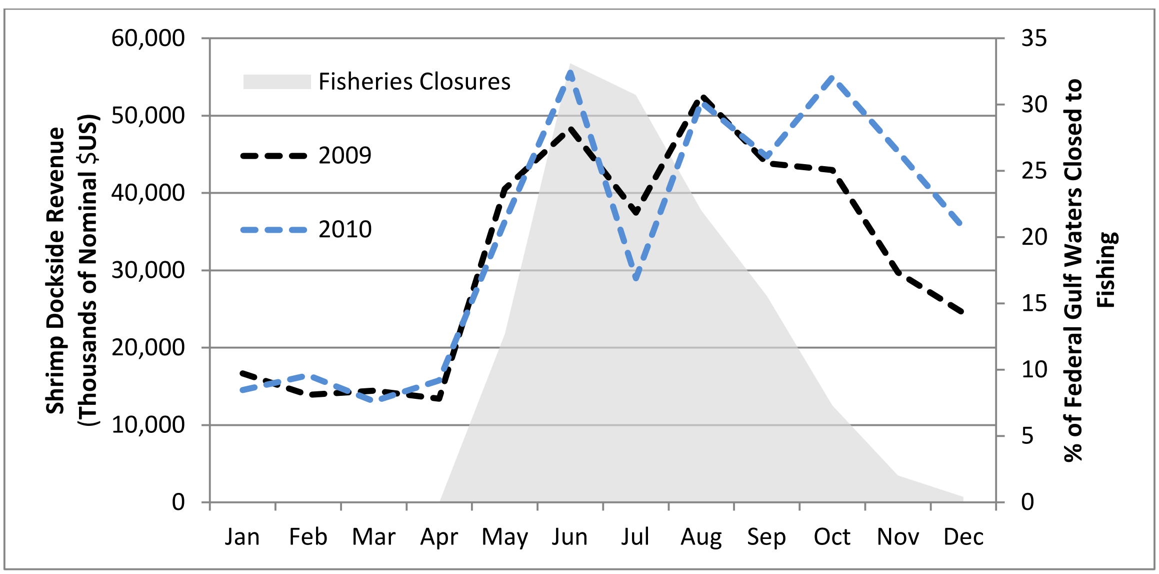
Figure 7. Gulf of Mexico Shrimp Landings and Dockside Revenue from 2002 to2013

Shrimping is driven by seasonal stock dynamics. Monthly commercial shrimp landings (Figure 8) and monthly dockside values (Figure 9) across all Gulf States in 2010 are shown in comparison to 2009. To facilitate evaluating landings with the oil spill event, the average share of Gulf U.S. EEZ waters that were closed to fishing each month is also shown as a relative proxy (see Figures 8 and 9). Though there was a notable decline in landings from 2009 to 2010 (Figure 8), the effect on revenue was not as significant (Figure 9).



Source: NMFS Commercial Landings Statistics

Figure 8. Commercial Shrimp Landings Before and During the DWH Oil Spill Relative to Fisheries Closures

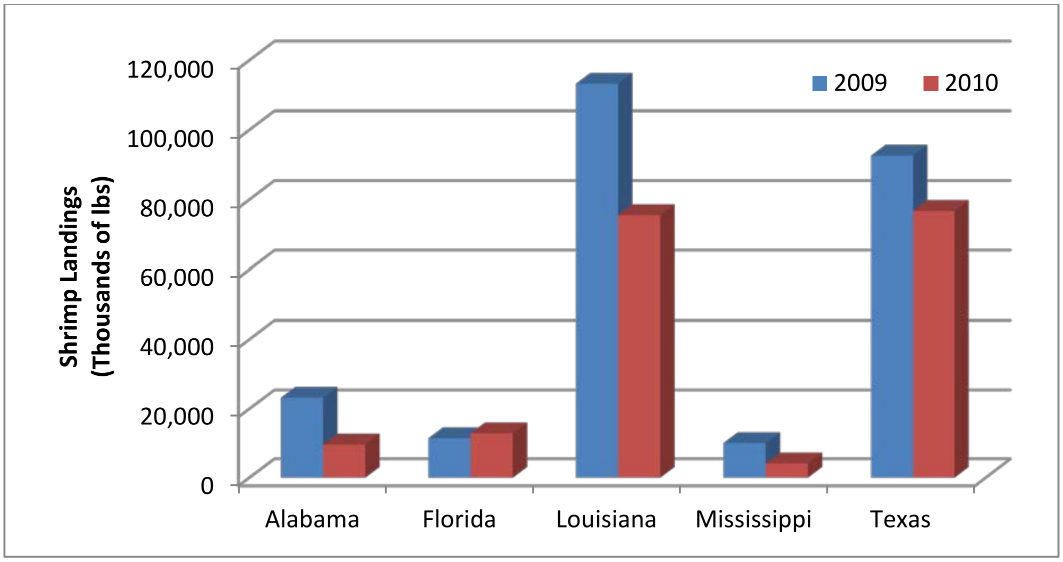


Source: NMFS Commercial Landings Statistics

Figure 9. Commercial Shrimp Dockside Revenue Before and During the DWH Oil Spill Relative to Fisheries Closures

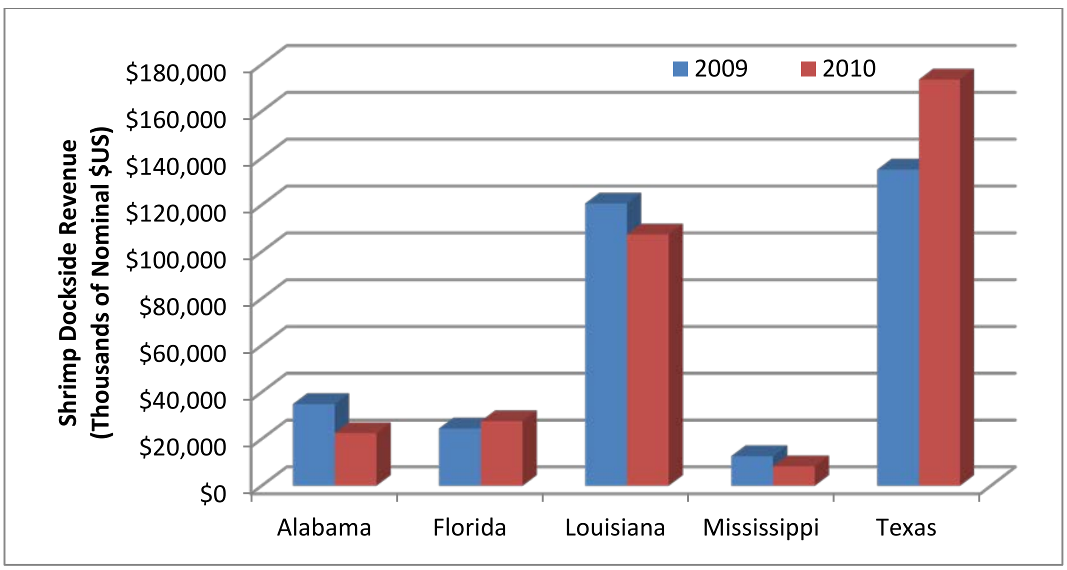
Shrimp is landed primarily in Louisiana and Texas (Austin et al. 2014). White and brown shrimp are caught throughout the entire Gulf region, and pink shrimp are caught off the coast of Florida. On average, Texas lands more brown shrimp and larger shrimp that fetch higher prices. Comparatively, on average, Louisiana lands more white shrimp and smaller shrimp which yield lower prices.

State level harvests from the 2010 period compared to the baseline period in 2009 show that landing volumes decreased in all states except West Florida; the largest decline occurred in Louisiana (Figure 10). In 2010, dockside revenue was less than it was in 2009 in each state except West Florida and Texas (Figure 11). Even though landings in Texas decreased, dockside revenues increased.



Source: NMFS Commercial Landings Statistics

Figure 10. Comparison of State Level Shrimp Landings from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 11. Comparison of State Level Shrimp Dockside Revenue from 2009 to 2010

In Louisiana, the peak month for shrimp is May. In May of 2010, 65% less shrimp were landed than in May of 2009 (NOAA 2013). May 2010 revenues in Louisiana were 44% less than they had been in May of 2009 (NOAA 2013). In Texas, the peak month for shrimp is August. In August of 2010, 26% less shrimp were landed than in May of 2009 (NOAA 2013). However, in

August of 2010, Texas shrimp revenues were 22% higher than they were in August of 2009 (NOAA 2013).

3.2.3 Shrimp Supply Chain and Market Factors

Typically, the first step in shrimp processing is done at the dock by the dealer/aggregator (Figure 12). It includes washing, sizing, and grading the shrimp. The shrimp can then be frozen whole or sent on to a processor. Processors produce primarily raw shrimp (peeled & deveined, peeled undeveined, green headless, easy peel, or shell on tail on). A small portion of production goes into cooked, cut, and breaded shrimp and other value-added items. Cooked, peeled shrimp can be canned, but, according to the International Trade Commission (ITC), most often shrimp is frozen (ITC 2011). The average size range of Texas product tends to be larger than product caught in Louisiana because of the species landed, differences in fishing area size, topography, and environmental conditions. This size difference has effects on price and can influence revenues realized in the fishery. Though most processors are separate from distributors and produce product to be sold on the spot market, a few processors distribute and sell. High volume processors sometimes purchase and freeze large quantities of shrimp and distribute it over several months (U.S. Small Business Administration 2013). The number of processors participating in the shrimp industry had been consolidating before the spill. Between 1991 and 2001, the Gulf region lost nearly a third of its processors (Keithly 2005).

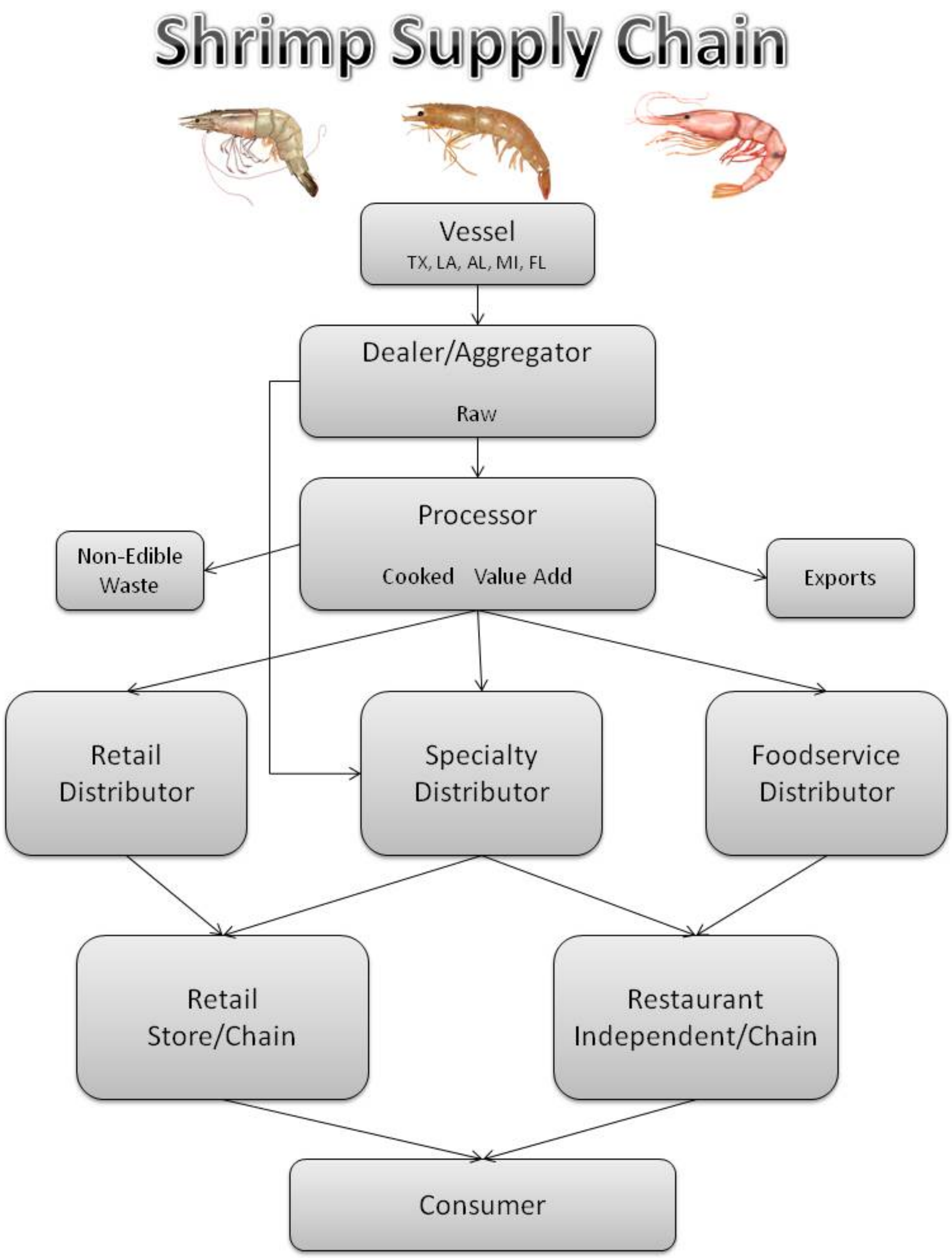


Photo of white, brown, and pink shrimp: (Fishwatch 2014)

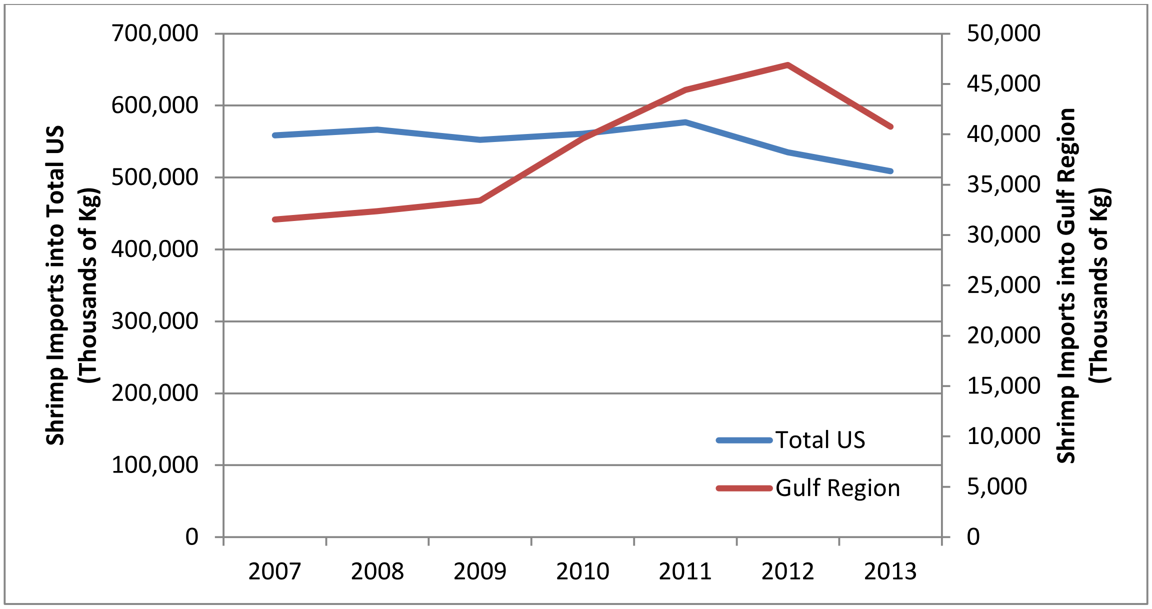
Figure 12. Overview of the Gulf of Mexico Shrimp Supply Chain

The majority of shrimp products in the Gulf go to the food service trade. Government institutional sales, such as the military, comprise about 15% of the food service trade. The remaining volume goes to the retail trade (Michael Stephens, General Manager and Chief Counsel of Bama Sea Products Inc., personal communication, 2014). An industry source believes that much of the market lost during the damage period has been gained back, but also that much of this returning volume was bought back by dropping price (David Veal, Executive Director of American Shrimp Processors Association, personal communication, 2014).

It is well established that shrimp imports are important in determining domestic shrimp prices in the Gulf region. As a result of an ITC investigation into foreign producer dumping, tariffs were levied for various producing countries (ITC 2011). This ITC report noted the relationship between domestic shrimp and imported shrimp as “sometimes interchangeable” and “comparable on many factors”; a “reasonable overlap of competition” exists (ITC 2011).

Additional research has estimated price elasticity relationships between imported shrimp and domestic dock price. Poudel (2008) found that when there is a 10% increase in Asian production of cultured shrimp, Gulf dockside price is expected to decline by approximately 3.5%. Similarly, when South American cultured shrimp production increases by 10%, dockside prices in the Gulf decline by approximately 2.2%. More recently, Tabarestani (2013) found that the quantity of shrimp imports into the U.S. and the dockside price of shrimp in the Gulf are related; however, they are two separate markets that do not follow the same price/quantity relationship. Although the quantity of shrimp landed in the Gulf has remained relatively stable, prices from the mid-1980s to the mid-2000s continued to decline (Poudel 2008). Also, as the quantity of imported shrimp available has risen, prices for imported shrimp have declined (Poudel 2008).

The trend of increasing shrimp imports into the Gulf region continued from the mid-1980s until 2012 (NMFS Trade Query 2014). After reviewing shrimp imports from 2007–2013 in Figure 13, we note that total U.S. imports and Gulf region imports both dropped during 2013, in effect, putting upward pressure on shrimp prices. Imports into the Gulf region actually continued to increase in 2012, but total U.S. imports were dropping precipitously during 2012 and 2013. This could indicate that the shrimp trade was actively substituting imported product up until 2012, at which point the shortage of imported product became too difficult to source from, but the concrete data to substantiate this may not be available.



Source: NMFS Annual Trade Data by Product through U.S. Customs Districts

Figure 13. Annual Shrimp Imports into the U.S. and Gulf of Mexico Region from 2007–2013

Early Mortality Syndrome is the primary factor that has negatively impacted U.S. shrimp imports over the past couple of years (2012 and 2013). This disease can kill 50% of shrimp on a farm. The full impact of Early Mortality Syndrome on global shrimp production was felt in the 2012 and 2013 markets, when global farm production decreased by 15%. Considering that global farmed production of shrimp from 2006 to 2011 had been increasing at a rate of 4.8% per year, the full effect of Early Mortality Syndrome in 2013 was based on a 23% reduction in expected global market volume (Chamberlain, 2013). In addition, in December 2012 a countervailing duty case filed against imports from China, Ecuador, India, Indonesia, Malaysia, Thailand, and Vietnam added pressure to reduce import volumes during the post-spill period (ITC 2011).

Gulf shrimp production recovered to historical levels and imports declined dramatically in 2013. The shrimp trade reported that domestic Gulf shrimp has been able to regain most of its lost market share (David Veal, Executive Director of American Shrimp Processors Association, personal communication 2014). These complex and dynamic relationships in the shrimp trade make it difficult to draw out all the factors that have influenced the trade of Gulf shrimp. We can deduce that these key issues post-spill have influenced the price of Gulf shrimp sold, and made it difficult to isolate the impacts of the oil spill.

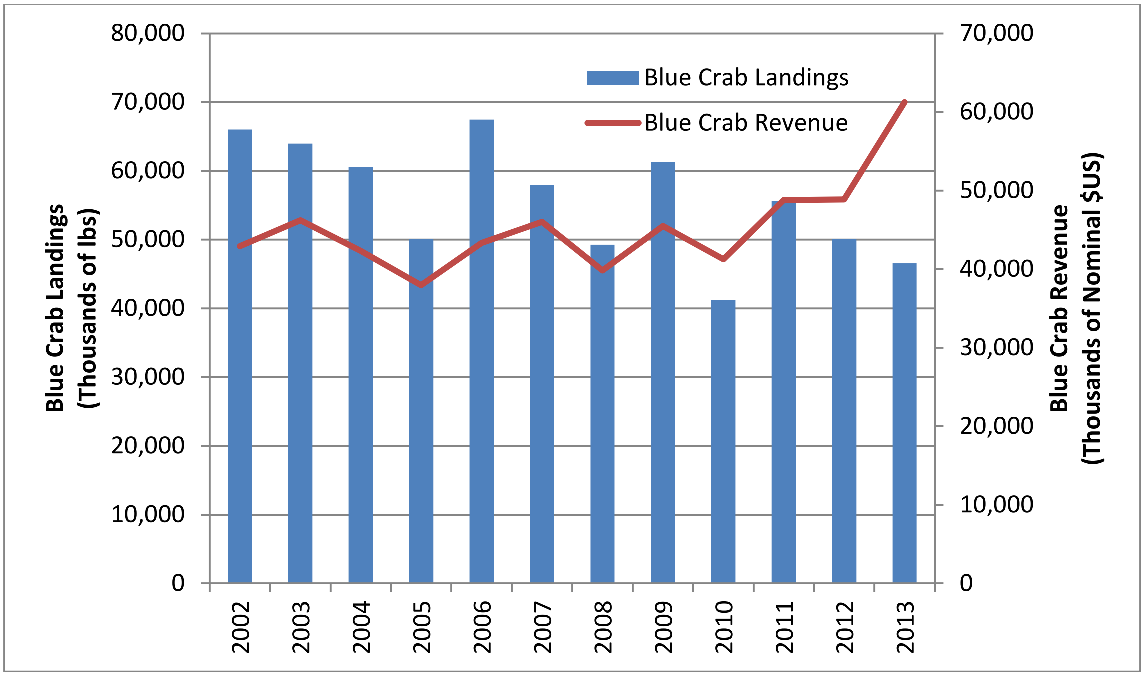
3.3 Blue Crab

3.3.1 Blue Crab Commercial Fishing Regulations

Management of the commercial blue crab (*Callinectes sapidus*) is conducted primarily by the states, because this species is found primarily in waters less than three nautical miles from shore. Sometimes blue crab is co-managed by federal and state entities. Some states make their regulations consistent with federal regulations to simplify management and rules for commercial fishermen. Crab management relies largely on gear requirements, rules regarding take of female crabs, and minimum size requirements. Crabbing vessels smaller than 35 feet often set 25–100 traps, and vessels larger than 35 feet set hundreds of traps (U.S. Small Business Administration 2013). The blue crab fishery is not subject to seasonal closures, so crab fishing continues year-round.

3.3.2 Blue Crab Fisheries Characteristics and Trends

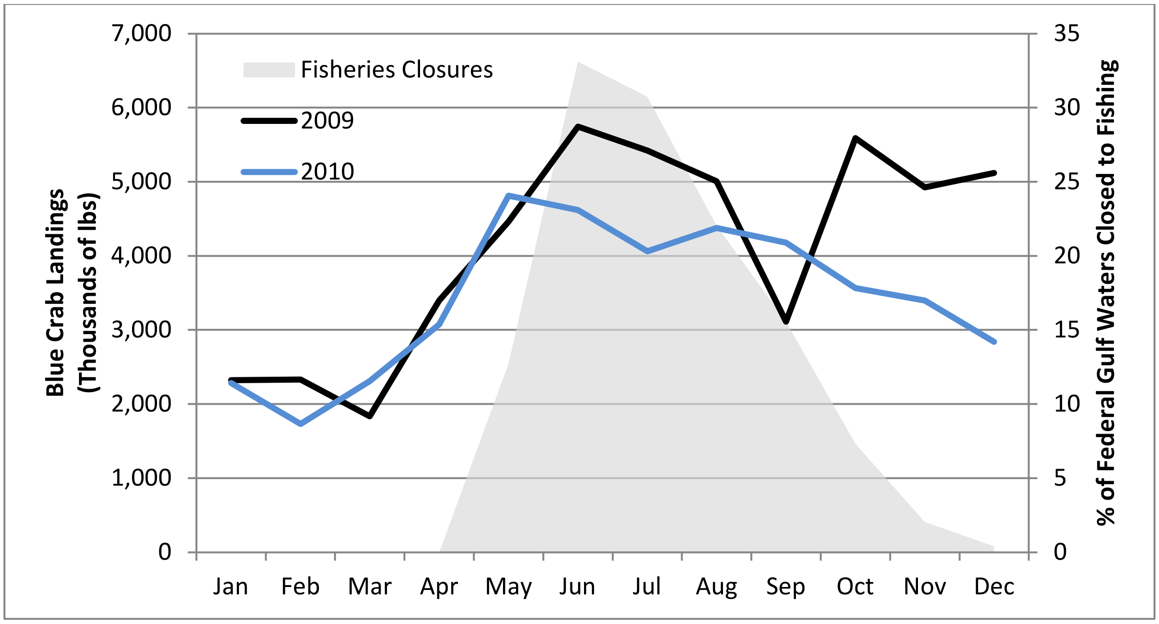
Figure 14 shows Gulf blue crab landings and dockside revenue from 2002–2013. Landings from 2002–2009 fluctuate, and reach an all-time low of 41 million pounds in 2010. Landings exhibited a downward trend from 2011–2013, dropping about five million pounds each year. However, dockside revenue increased from 2011–2013, from $49 million in 2011 to $61 million in 2013. In total, Gulf blue crab landings for 2010 were down by 33% compared to 2009, whereas dockside revenues in the blue crab fishery during 2010 were down by only 9% compared to 2009 (Figure 14). The market for blue crab, especially blue crab meat, is complex. This market is influenced by external factors, such as imports. Like shrimp, crabs are fast-growing and short-lived, which explains their quick recovery (Tunnell 2011). However, long-term effects could result from oil contamination in the nursery habitat of the coastal marshes. Though Moody (2013) observed a significant decline in 2010 blue crab populations, he also noted that in 2011, populations returned to pre-spill abundance. Overall, as blue crab landings in the Gulf have fluctuated but showed a general decline from 2002 to 2010, it is difficult to differentiate the long-term effects of the oil spill.



Source: NMFS Commercial Landings Statistics

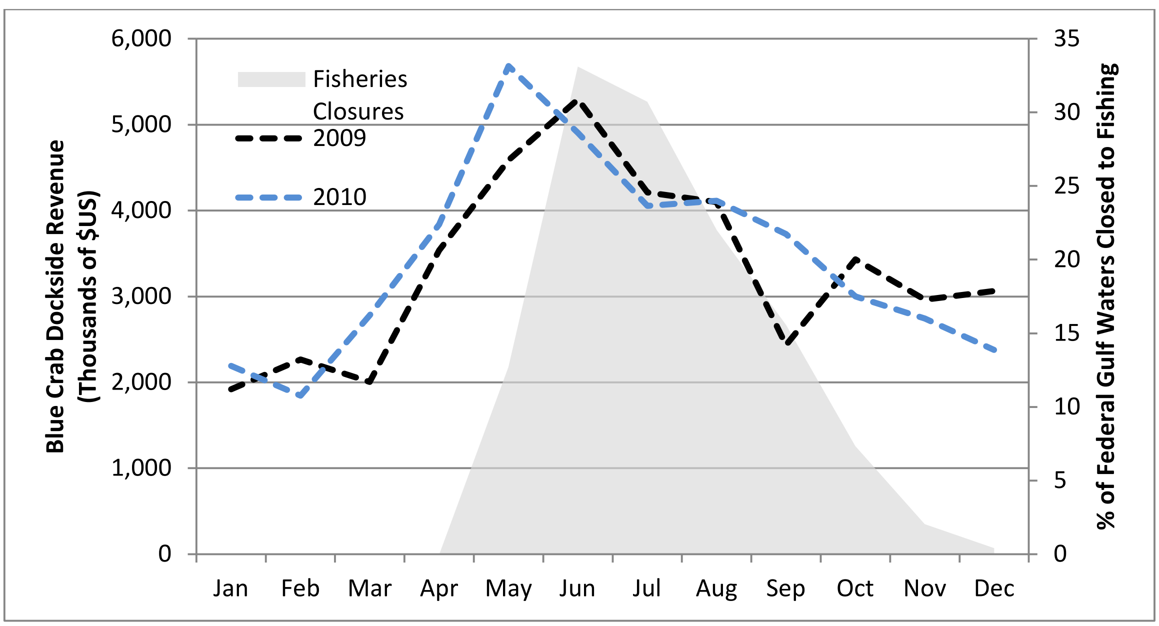
Figure 14. Gulf of Mexico Blue Crab Landings and Dockside Revenue from 2002–2013

Monthly landings (Figure 15) and dockside value (Figure 16) for commercial blue crab in 2010 are compared to the baseline year of 2009 and the federal fishery closures. Although blue crab fishing primarily occurs in state waters, this closure can be a relative proxy for when the inshore closures occurred. For details on temporary state level fishery closures, see Section 2.6. The period of May to October 2010 shows low landings in comparison to the previous year, but demonstrates a relatively small decrease in dockside value.



Source: NMFS Commercial Landings Statistics

Figure 15. Commercial Blue Crab Landings Before and During the DWH Oil Spill Relative to Fisheries Closures

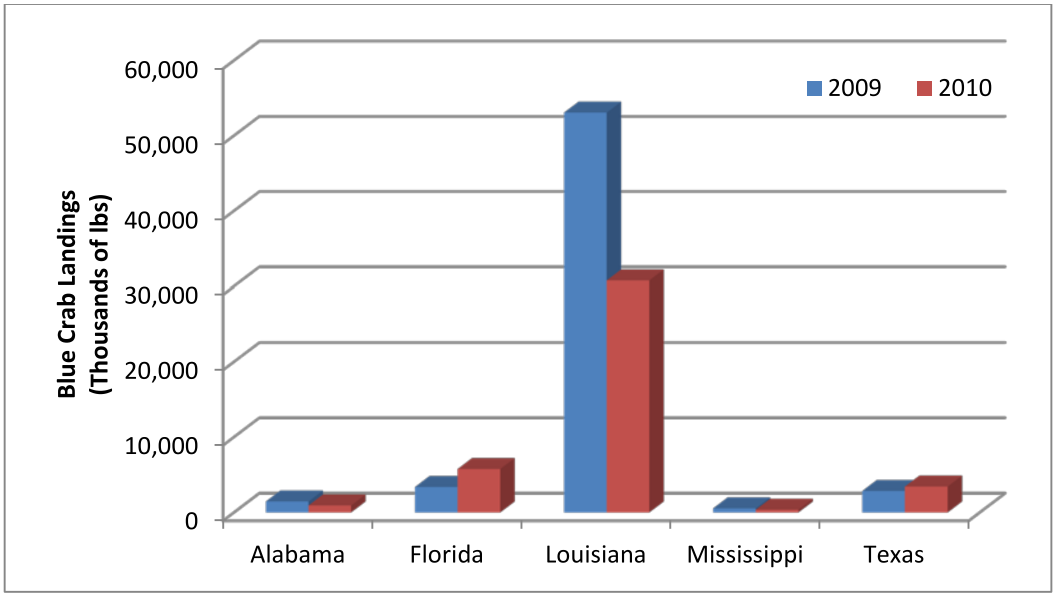


Source: NMFS Commercial Landings Statistics

Figure 16. Commercial Blue Crab Dockside Revenue Before and During the DWH Oil Spill Relative to Fisheries Closures

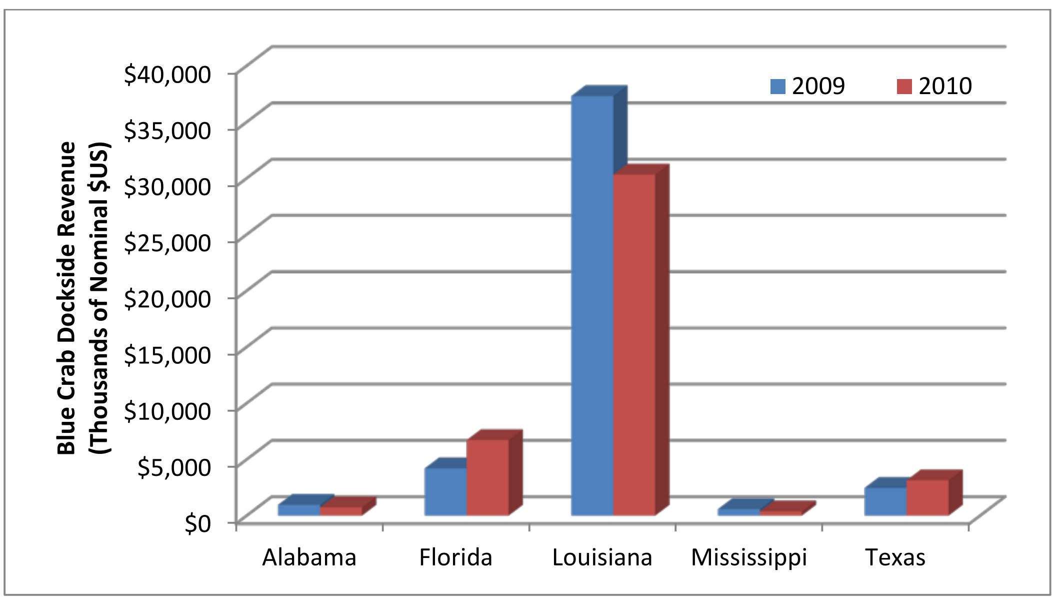
Figure 17 shows that Alabama, Louisiana, and Mississippi experienced declines in crab landings from 2009 to 2010, but West Florida and Texas saw increases. Louisiana landings declined by 42% to approximately 31 million pounds from 2009 to 2010 (NOAA 2013). Mississippi and Alabama crab landings also declined in 2010 by 38% and 36%, respectively, although comparatively in size they were significantly smaller than in Louisiana (NOAA 2013).

Corresponding dockside revenues were similar, with all states decreasing in revenue in 2010 except West Florida and Texas, although revenues did not decline as much as landing volume, potentially due to market adjustments that occurred in 2010 (Figure 18).



Source: NMFS Commercial Landings Statistics

Figure 17. Comparison of Blue Crab Landings by State from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 18. Comparison of Blue Crab Dockside Revenue by State from 2009 to 2010

3.3.3 Blue Crab Supply Chain and Market Factors

The blue crab supply chain begins with vessels selling to dealers/aggregators, who then sell to processors (Figure 19). On occasion, vessels sell directly to processors. Five basic product forms are produced from blue crab: whole live, soft shell, meat, whole cooked, and value added. Product aggregators cull out premium grade crabs, such as live males, for the whole live market and sell to shedding operations and specialty distributors, then sell remaining lower grade product to processors for meat, whole cooked and value added (Austin et al. 2014). Although all these product forms are imported, the meat product form has the most import competition. There are three basic product forms for meat: fresh, pasteurized, and frozen. The closest substitute for domestic blue crab is fresh blue crab meat from Venezuela and Mexico. The next-closest substitute is pasteurized blue crab meat from Thailand, Indonesia, and various other Asian countries. The third, but weaker, substitute is frozen meat from China and other countries.

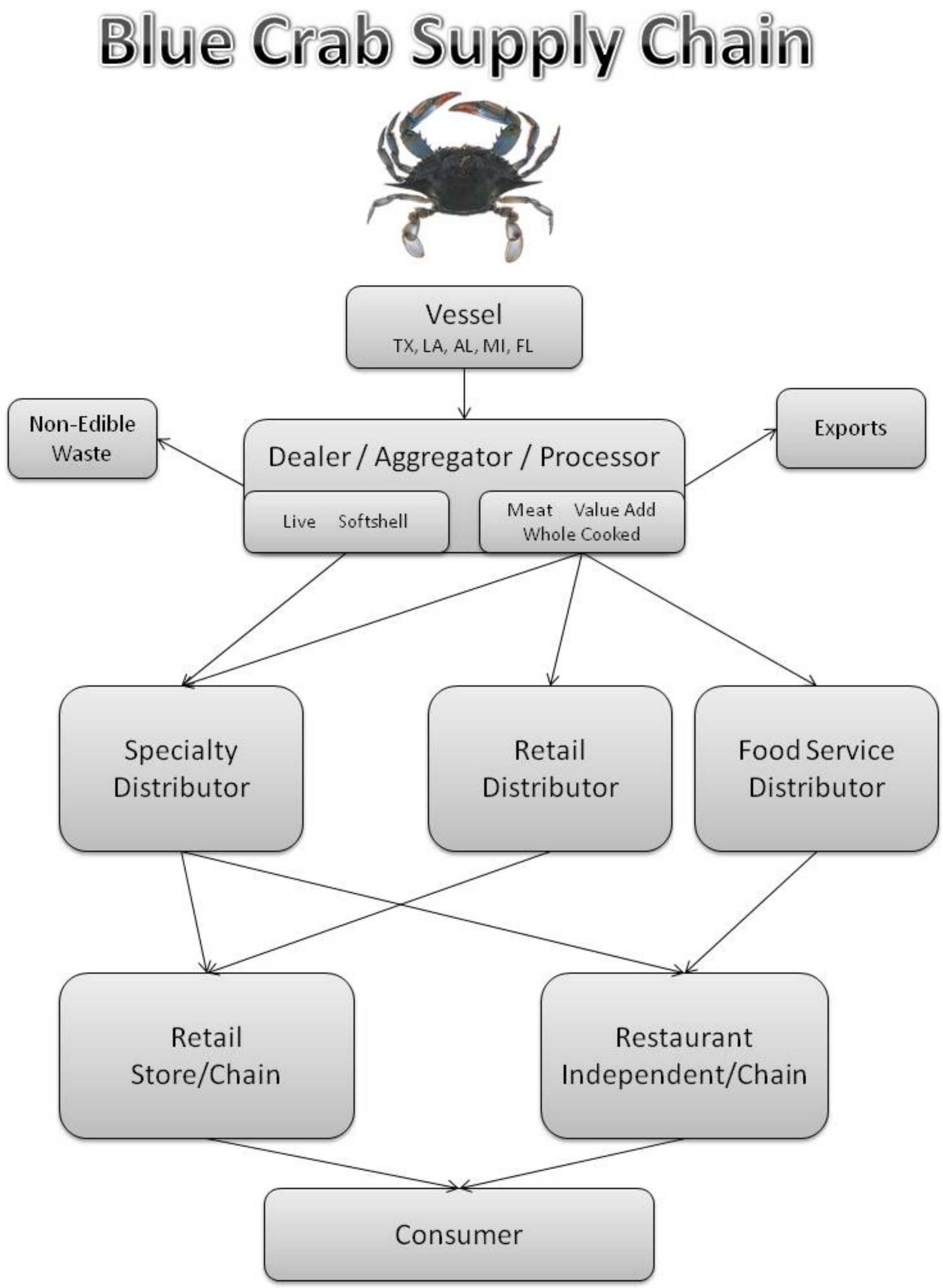


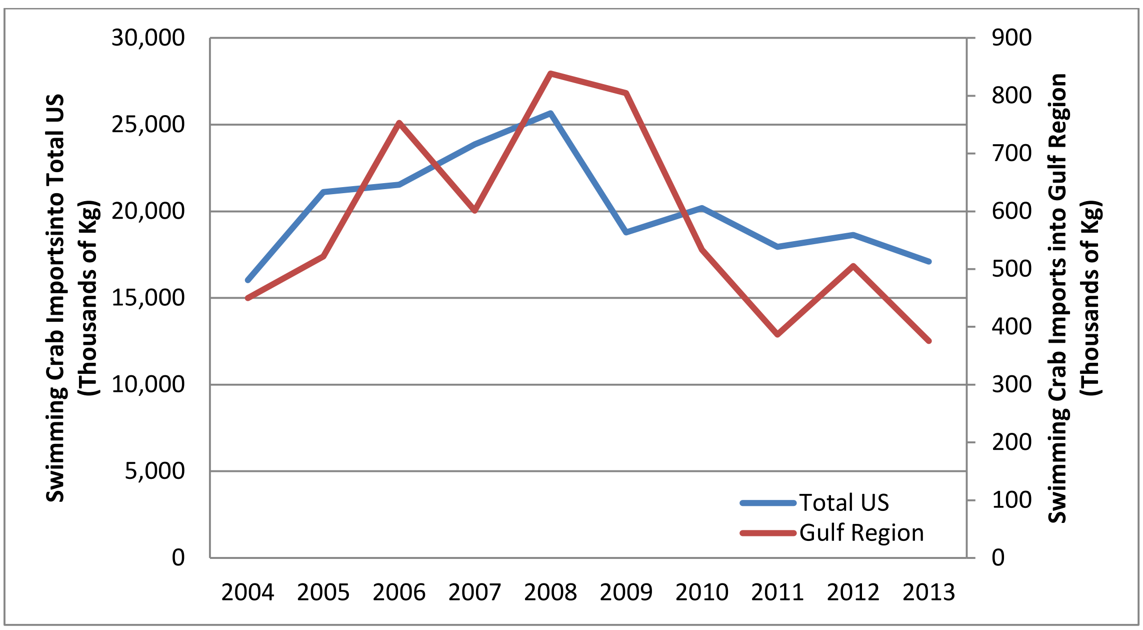
Photo of blue crab: (Monterey Bay Aquarium Seafood Watch 2015)

Figure 19. Overview of the Gulf of Mexico Blue Crab Supply Chain

Over the past 20 years, there has been a rapid reduction in blue crab processors in the Gulf region. A 2000 ITC report noted an increase in the number of crabs sold to the live market and a decrease in sales to the processor market. This report also noted a decrease in the average size of harvested crabs, which resulted in less meat (ITC 2000). In recent years, competition for supply at this level of the chain has increased progressively each year since the spill. An industry source indicated that lack of supply from 2011 through 2013 has created a difficult market for processors, and required daily break-even volumes are not always being met (Bauer 2014). In addition, larger, higher quality crab can yield around 18% meat, whereas the smaller, lower quality crab only yield around 13% meat, compounding the effects of this shift in use in recent years. The combination of these effects, and a reduction in both domestic landings and imported meat, created a volatile and difficult market for crab processors from 2011 to 2014.

Supply from import markets also competes with domestic blue crab. As was noted with frozen shrimp, blue crab meat has a distinct imported substitute product. The 2000 ITC report determined that domestic blue crab meat (*Callinectes sapidus*) is a "like" item to imported crab meat products of both blue crab (*Callinectes sapidus*) and flower crab (*Portunus pelagicus*). However, the report noted that because there were no significant idling of productive facilities and that firms were operating at a reasonable level of profit, no countervailing duties were instituted.

Figure 20 shows that imports of swimming crab meat (both blue crab and flower crab) peaked in 2008 and have trended downward since, except for a slight increase in crab meat imported into the Gulf region in 2012. It has been indicated by crab meat importers that lower harvest levels from importing countries has created a shortage in global supply of crab products, driving prices up over the past few years (Bauer 2014).



Source: NMFS Annual Trade Data by Product through U.S. Customs Districts

Figure 20. Annual Crab Imports into the U.S. and Gulf of Mexico Region from 2004–2013

The complexity of product use and global imports, combined with downward trend in supply and rapidly rising prices, has created a difficult business climate for processors (Bauer 2014). The crab market tends to be more volatile than the shrimp market, and it is a challenge to predict future crab volumes and prices. With the shrimp market, industry experts and retailers were well aware of the global supply shortage at least a year before it happened. The crab industry was aware of the general trends, but did not have the foresight or sophistication to predict future volumes or prices, which left the processors in a difficult price position on all forward contracts.

The results are seen in the supply chain. The increased competition for whole crab off the boat has created increasing prices paid to fisherman and has forced the prices of finished product to increase. Processors are a pass-through service provider and are paid on the pounds they produce, not the value of landed crab. In a rising market like this, it is critical that volumes are high and consistent, but it is also critical that processors are able to increase prices with their clients (distributors and retail/restaurant outlets) as soon as vessel price increases. In today's commodity seafood trade, almost all large distributors and retail/restaurant outlets have forward contracted prices that are difficult to adjust due to predetermined consumer promotions and preprinted advertising and pricing material. Due to the current climate of lower and less consistent volumes and rapidly increasing prices, the processors have struggled to remain profitable.

Another factor that was noted by the crab processors, but that may not have been as influential as it was with the shrimp processors or oyster processors, was the loss in market share and the transitional period to regain this market share (Bauer 2014). With frozen shrimp and Individually Quick Frozen (IQF) oysters, imported supply was abundant during the damage period, enabling substitution and a large shift in market share. Because of the rapidly declining supply of imported crab meat during the past five years, specifically the shortage during the damage period in 2010, it would be more challenging for the market to simply shift to imports.

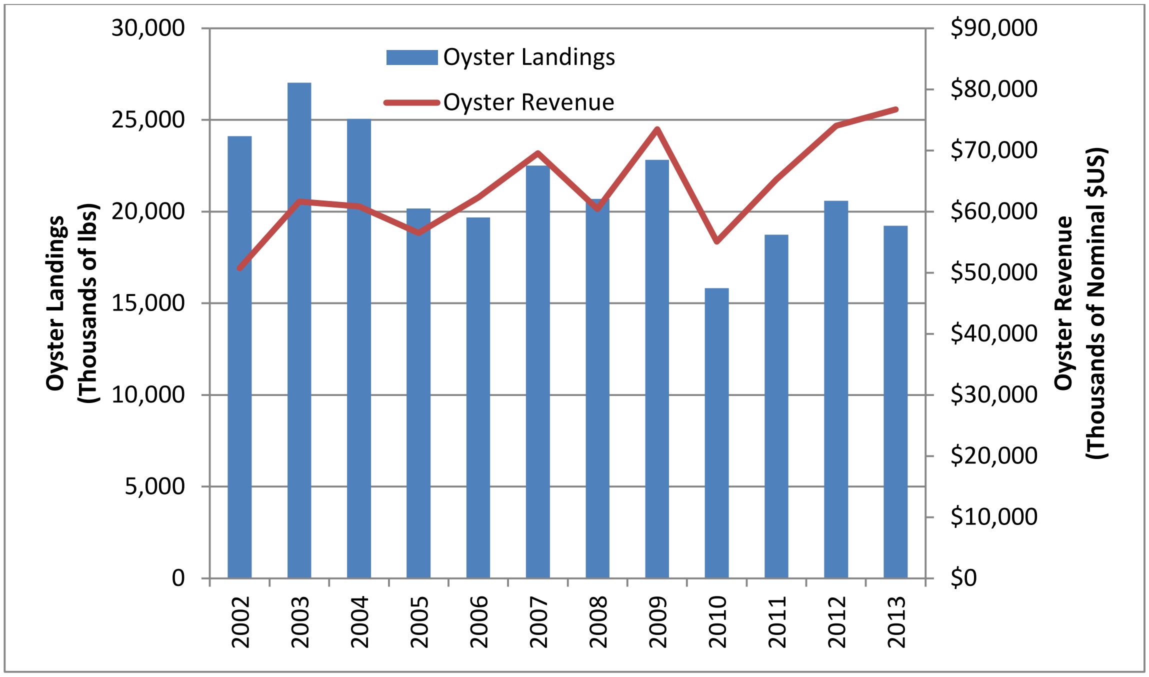
3.4 Oysters

3.4.1 Oysters Commercial Fishing Regulations

The eastern oyster (*Crassostrea virginica*) lives attached to structures in the shallow saltwater bays along the Gulf coast. Management of oysters is conducted by the states because these species are found in waters less than three nautical miles from shore. Oyster management is usually subject to a minimum size requirement, gear restrictions, handling requirements, daylight harvesting only, and day and area closures determined by the state. Many oyster beds are privately owned and the owners may harvest any time of the year, though peak harvest season is considered to be in the late fall. In Louisiana, there are many large privately owned oyster beds (U.S. Small Business Administration 2013). Public oyster beds are state-regulated: there is a limit on the amount that can be taken and time closures can also be implemented. Public beds account for the majority of Alabama and Mississippi's oyster harvests (U.S. Small Business Administration 2013).

3.4.2 Oysters Fisheries Characteristics and Trends

Gulf oyster landings have fluctuated from a high of 27 million pounds in 2003 to a low of 15 million pounds in 2010 (Figure 21). Post-spill landings from 2011–2013 have fluctuated between 19 million and 21 million pounds; they have not recovered to pre-spill levels of 23 million pounds landed during the baseline period of 2009. Though landings from 2012 to 2013 dropped from 21 million pounds to 19 million pounds, revenues increased from $74 million to $77 million, showing an increase in price in 2013. Total Gulf oyster landings for 2010 were down by 31% compared to landings in 2009 and revenues (nominal) in the oyster fishery during 2010 were down by 25% compared to 2009.

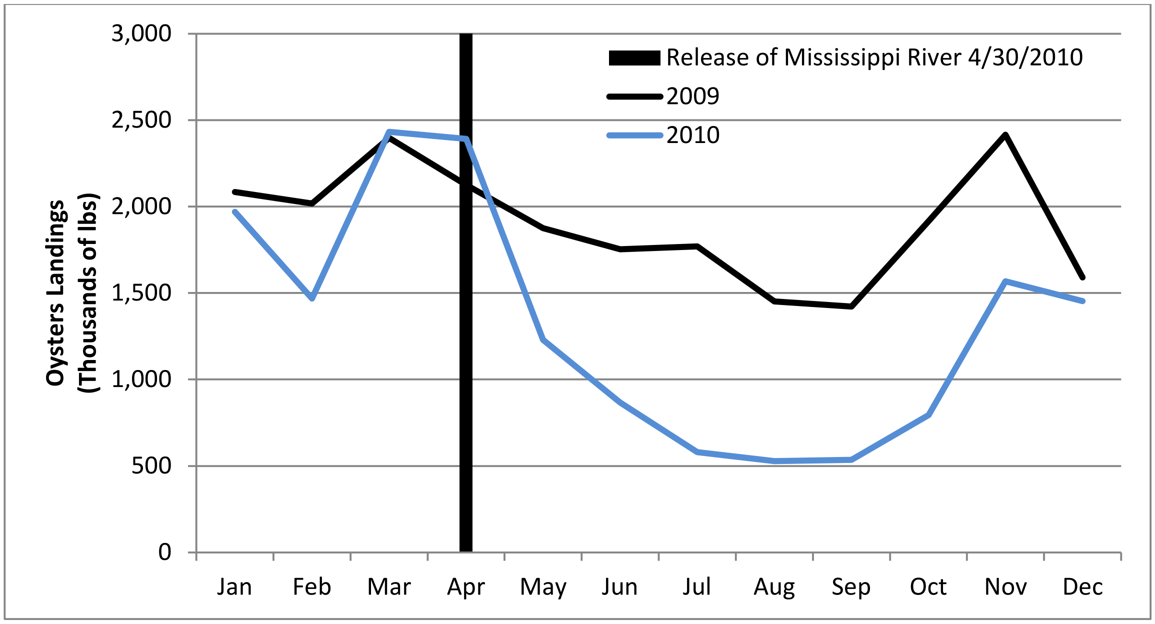


Source: NMFS Commercial Landings Statistics

Figure 21. Gulf of Mexico Eastern Oyster Landings and Dockside Revenue from 2002–2013

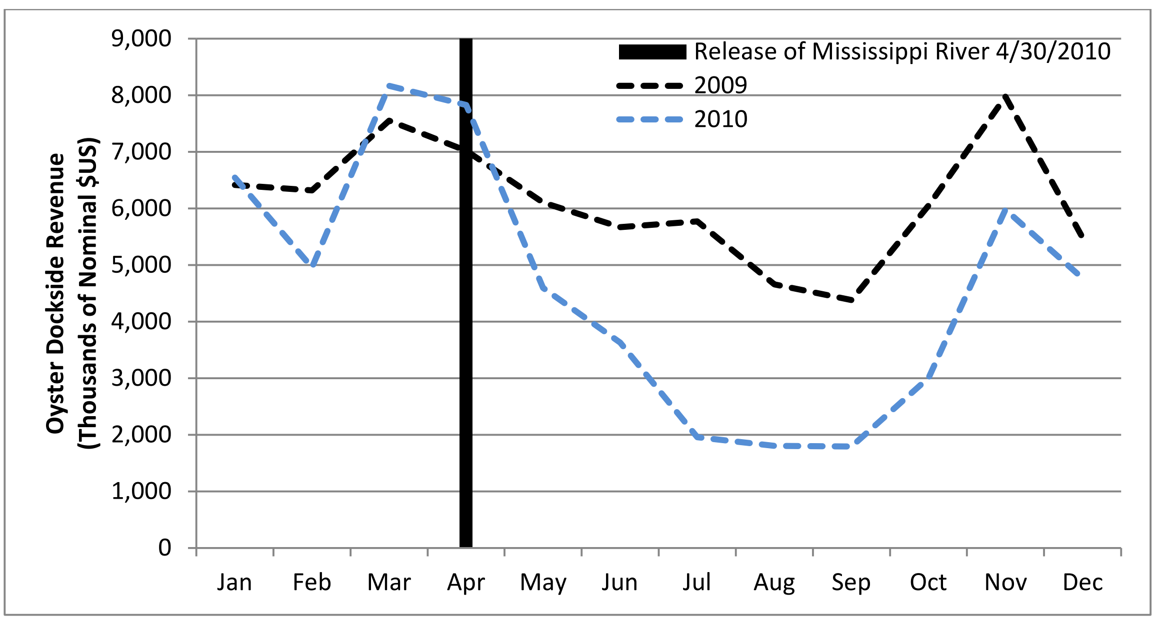
Monthly landings (Figure 22) and dockside values (Figure 23) for oysters in 2010 are compared to 2009. However, federal fisheries closures are not shown, because oysters are subject to fishing regulations by state, rather than federal fishing regulations. Instead, oyster landings and revenue in Figures 22 and 23 are shown relative to when the freshwater diversions from the Mississippi River were opened at the end of April 2010 (see Section 1.1). Though this was intended to keep oil from flowing into bays and estuaries, the large influx of freshwater had the unintended side effect of decreasing the salinity in the oysters' habitat and causing greater than 80% mortality in some areas (Buskey 2010). For oysters this is a more relevant spill-related event than federal fisheries closures.

Figures 22 and 23 show a steep declines in oyster landings and revenues in the Gulf after the opening of the Mississippi River diversions. Though landings were still higher October to December of 2010 than they were from May to September of 2010, total oyster landings during the peak harvesting month of November were 35% less in 2010 than they were in 2009.



Source: NMFS Commercial Landings Statistics

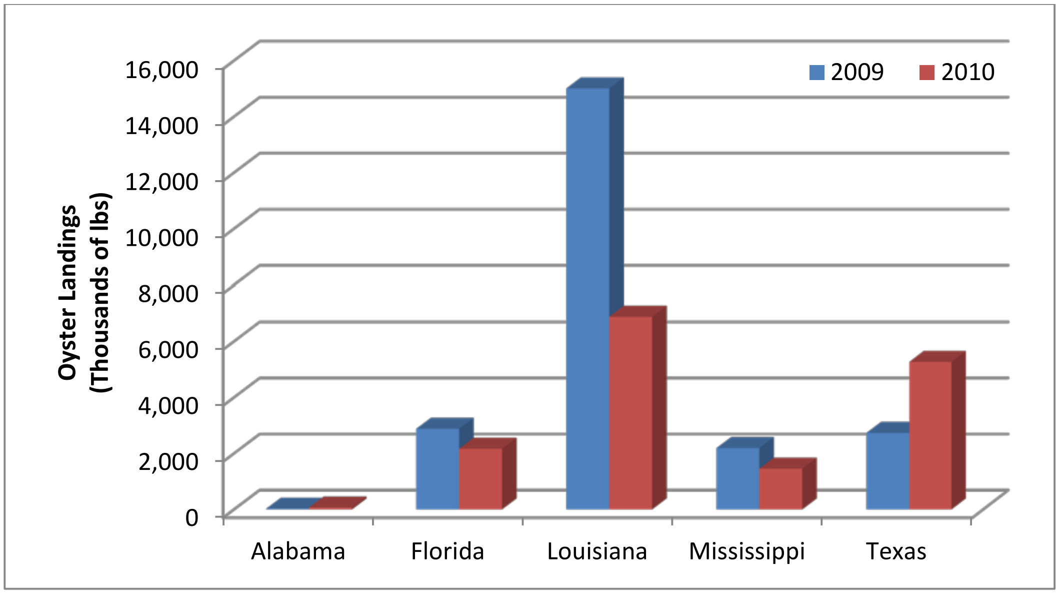
Figure 22. Commercial Oyster Landings Before and During the DWH Oil Spill Relative to Fisheries Closures



Source: NMFS Commercial Landings Statistics

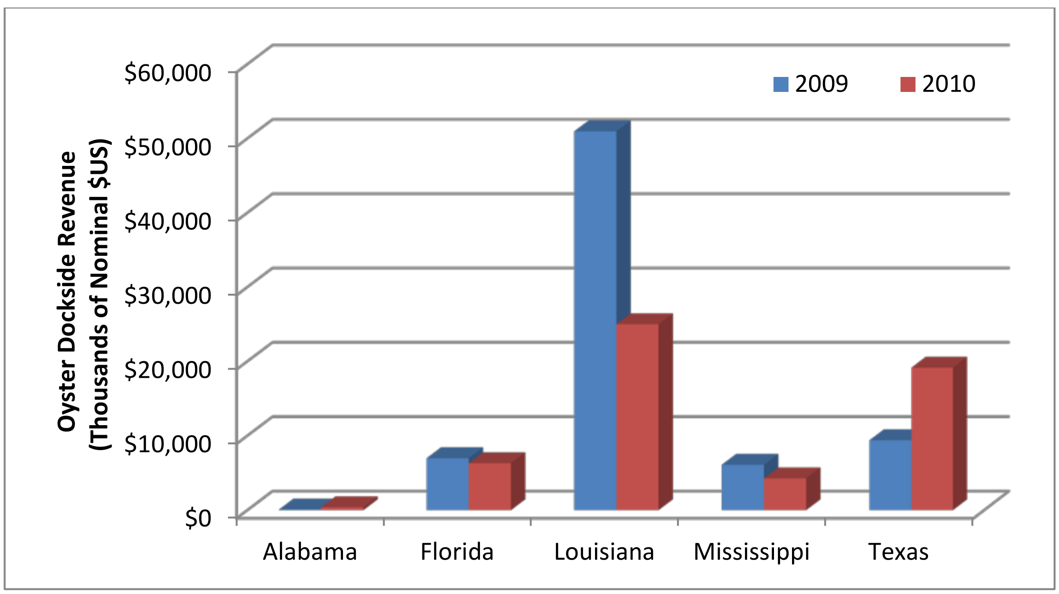
Figure 23. Commercial Oyster Dockside Revenue Before and During the DWH Oil Spill Relative to Fisheries Closures

Louisiana and Texas generate the highest landings and dockside revenue from the oyster fisheries (see Figures 24 and 25). Louisiana and Mississippi had the greatest declines in oyster landings from 2009 to 2010 (54% and 34%, respectively) and revenue (51% and 30%, respectively) and do not appear to have fully recovered (NOAA 2013). In contrast, Texas oyster landings actually increased by 93% and revenues increased by 104% from 2009 to 2010. This would suggest that when Louisiana and Mississippi landings were low due to the oil spill and release of the Mississippi River freshwater diversions, Texas may have decided to harvest more oysters, to fill in for this shortage of supply. Though oyster landings in Texas then decreased in 2011, they increased again in 2012 and 2013, when the average price was higher.



Source: NMFS Commercial Landings Statistics

Figure 24. Comparison of State Level Oyster Landings from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 25. Comparison of State Level Oyster Dockside Revenue from 2009 to 2010

3.4.3 Oysters Supply Chain and Market Factors

Gulf oyster production produces four primary products (whole live, shucked, IQF and post-harvest process), which are sold predominantly in the U.S. market (Figure 26). During the period after the spill, product substitution occurred in various markets in which Gulf oysters were dominant (Nelson 2014). Whole, live production out of the Gulf is the highest-value product and competes predominantly with live oyster from both the Chesapeake region and the West Coast. Whole, live oyster in most cases goes straight from an aggregator to a specialty distributor who sells into high-end restaurant and retail markets.

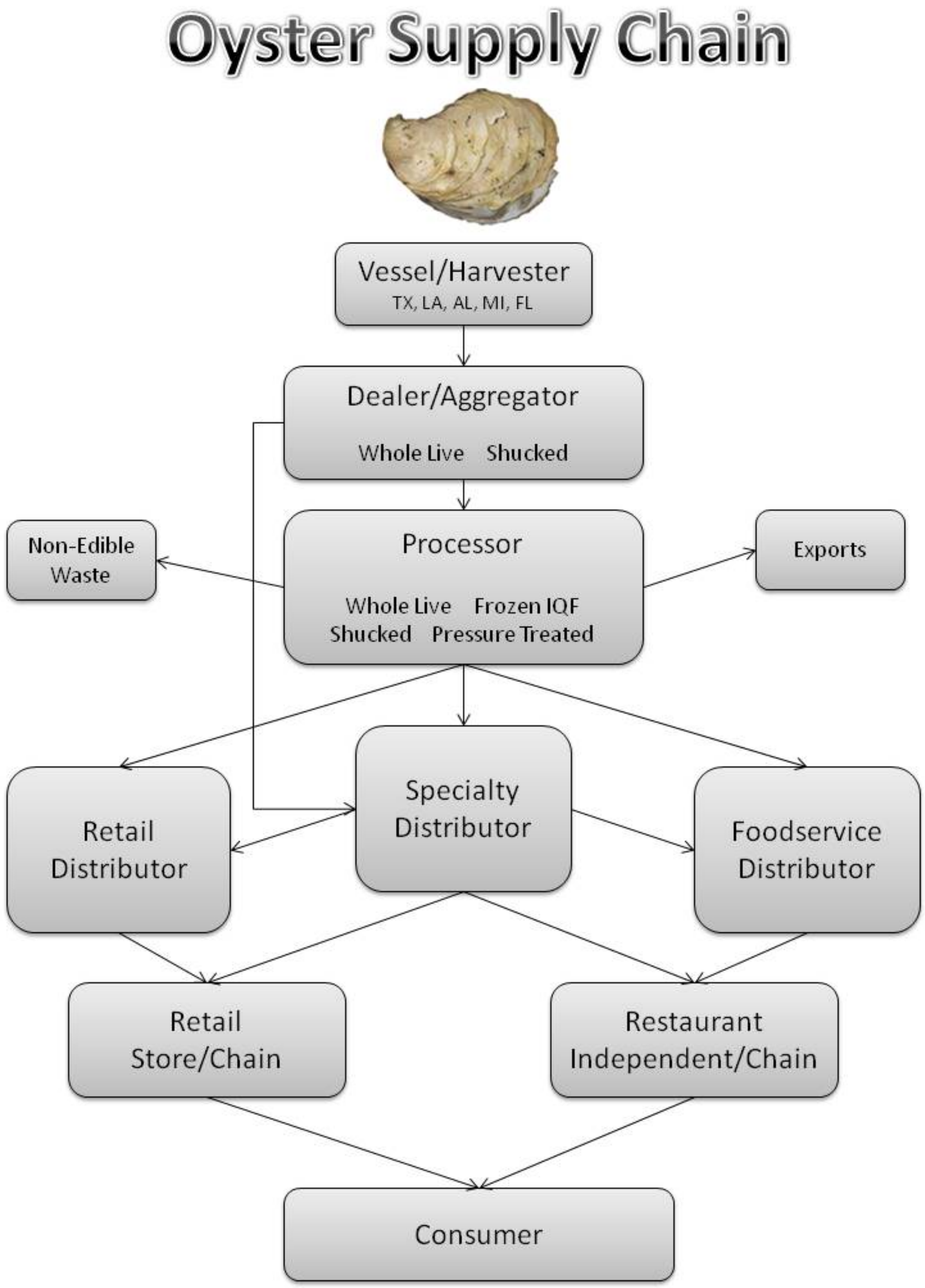


Photo of eastern oyster: (Fishwatch 2014)

Figure 26. Overview of the Gulf of Mexico Oyster Supply Chain

During the period following the spill, product substitution for live Gulf oysters occurred for many major markets. An industry source indicated that, in some cases, end retail and restaurant customers did not return to purchase of live Gulf oyster products. It was reported that many large retailers shifted to companies like Coast Seafood Company, a large vertically-integrated oyster grower and specialty distributor on the West Coast of the U.S. Due to the consistency of product that Coast Seafood offered, these retail clients may have permanently shifted sourcing away from the Gulf oyster industry (Nelson 2014).

IQF product from the Gulf is the lowest-value product and competes predominantly with imported frozen product from Korea. IQF product is sold for secondary processing/breading operations, such as King and Prince Seafood and Tampa Maid Foods. These secondary processors have traditionally used excess domestic Gulf oyster production that is over-abundant in the spring months of the year to supply IQF raw material for their breading operations. As early as the late 1980s, these secondary processors started buying supplemental IQF oysters to be used as raw material in their breading operations here in the U.S. When the supply of low-value Gulf oysters is affected by external impacts, such as hurricanes, these secondary processors rely heavily on IQF oyster imports from Korea. During and after the oil spill, it was reported that the secondary processors switched, for the long-term, almost all raw material purchases over to imports, and dramatically limited Gulf oyster purchases. This fact was validated when an outbreak of Norovirus in 2012 required the FDA to recall various oyster products produced from frozen oysters imported from Korea (FDA 2012). Because imports of IQF products are blended with various other product forms in the import figures, it is difficult to show these effects or determine whether these breaded processors have shifted back to Gulf oyster product. An industry source indicated that if the recall had not occurred, the supply chain relationship most likely would have been permanently altered (Nelson 2014).

Another notable change in the supply chain was that dealers or product aggregators to become more vertically integrated into processing and distribution. Due to the current supply constraints, many dealers have shifted their operations vertically up the supply chain to capture more market share (Nelson 2014).

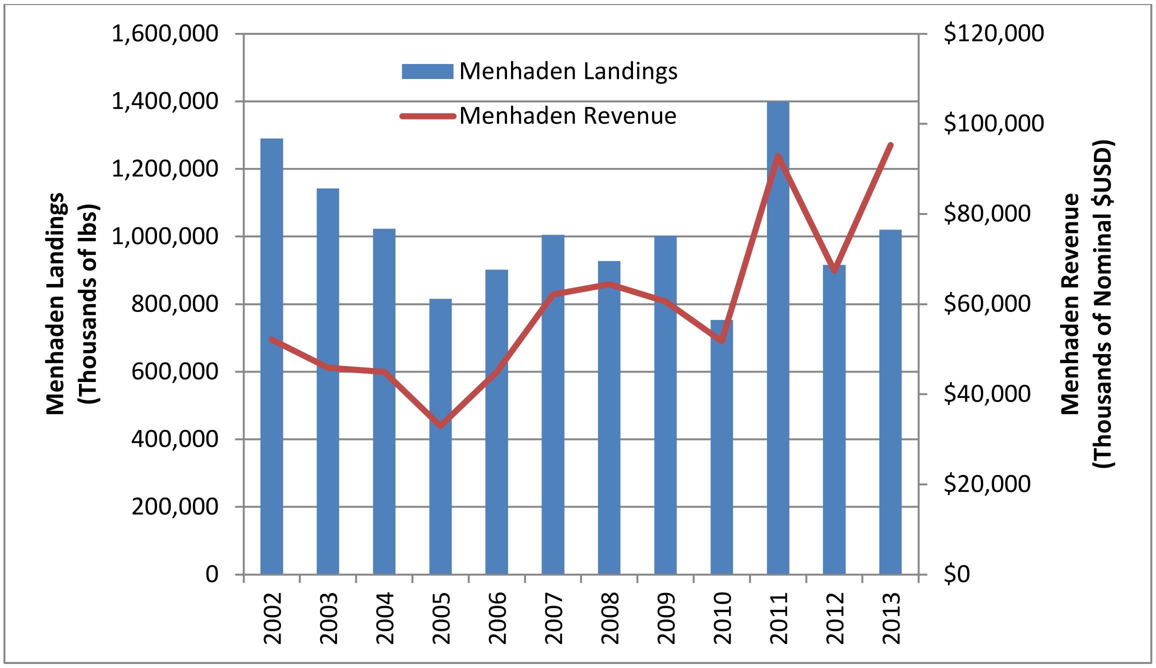
3.5 Menhaden

3.5.1 Menhaden Commercial Fishing Regulations

The fishing season for Gulf menhaden (*Brevoortia patronus*) opens in late April and runs until November. In 2010, the oil spill occurred one day after the menhaden season had opened. Menhaden are captured offshore by large purse seine vessels and smaller net running boats that are guided by spotter planes (Austin et al. 2014). Menhaden is landed primarily in Louisiana.

3.5.2 Menhaden Fisheries Characteristics and Trends

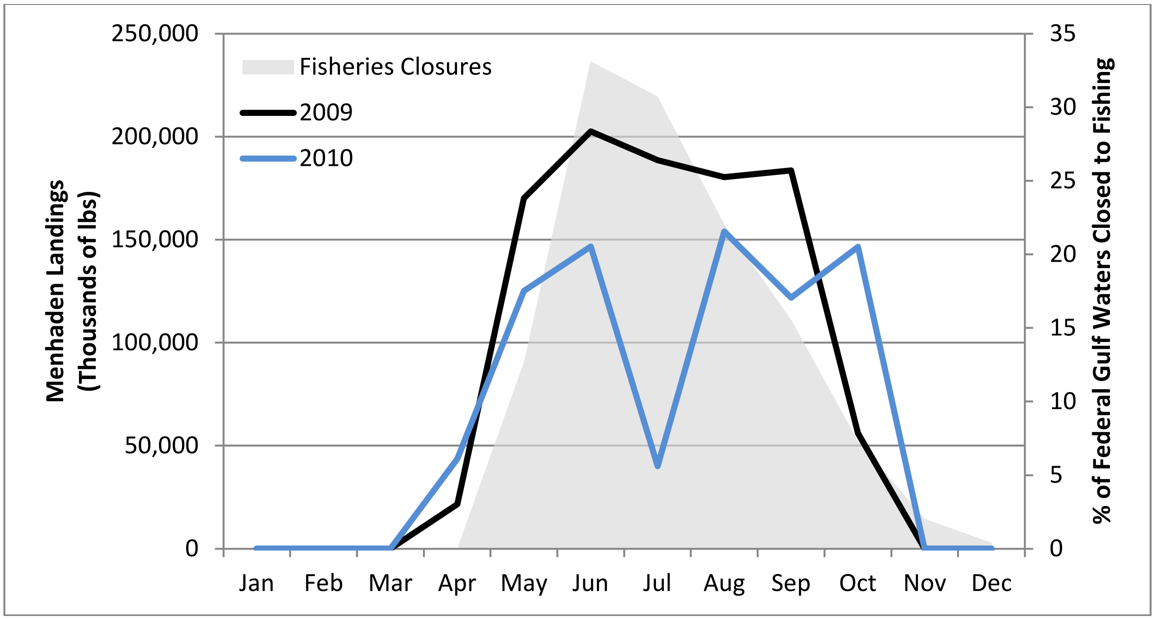
In 2010, aggregate menhaden landings hit an all-time low for the Gulf of 750 million pounds (Figure 27). Compared to 2009, total Gulf menhaden landings for 2010 were down by 25%; compared to 2009, revenues (nominal) in the menhaden fishery during 2010 were down by 15%. From 2010 to 2011, total Gulf landings nearly doubled, from 753 million to 1.4 billion pounds, and revenue increased 80%, to $93 million. In 2012, landings and revenue declined to pre-spill numbers.



Source: NMFS Commercial Landings Statistics

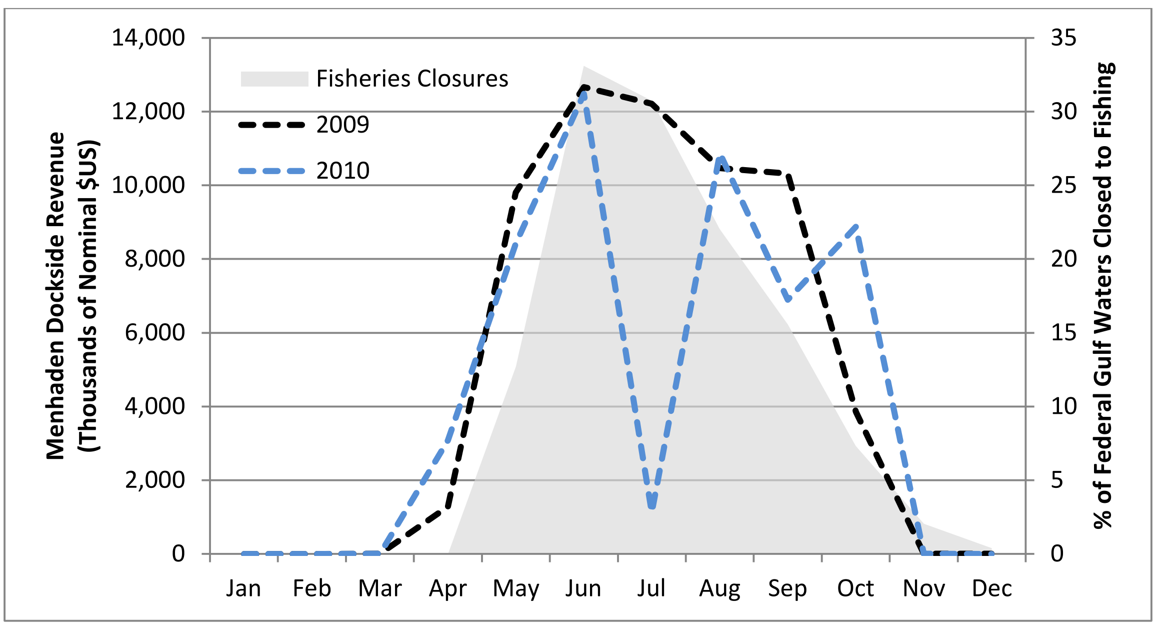
Figure 27. Gulf of Mexico Menhaden Landings and Dockside Revenue from 2002–2013

Monthly menhaden landings and dockside values in the Gulf States in 2010 are compared to 2009 in Figures 28 and 29, respectively. The figures also include the percentage of the Gulf EEZ that was closed to fishing in the months following the spill. Total landings and revenue of Gulf menhaden were negatively impacted during the fishery closures, although toward the end of the closures (October 2010) the fishery appeared to rebound above both revenue and landings from the previous year.



Source: NMFS Commercial Landings Statistics

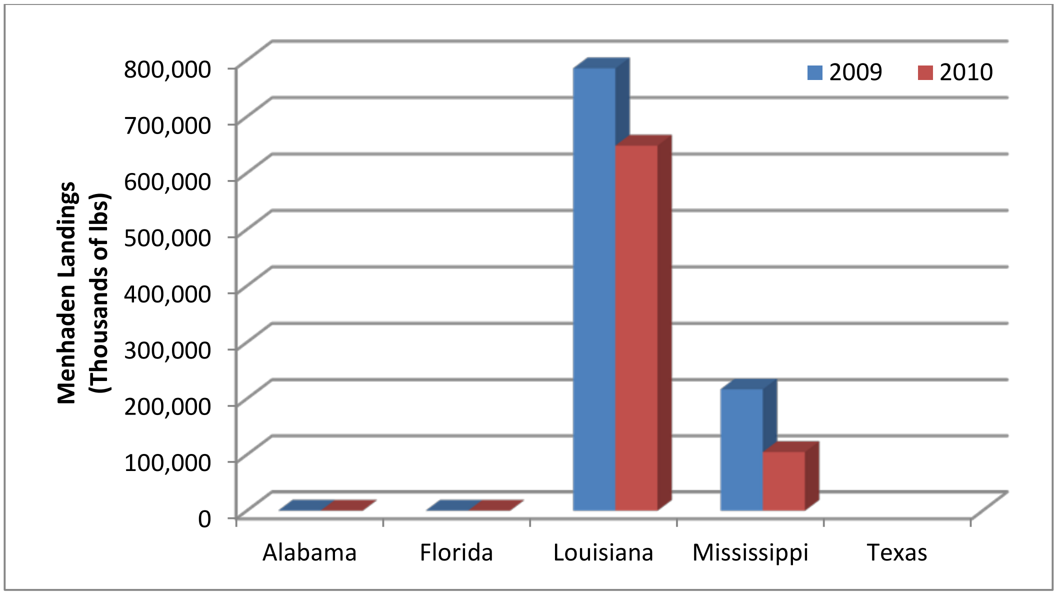
Figure 28. Commercial Menhaden Landings Before and During the DWH Oil Spill Relative to Fisheries Closures



Source: NMFS Commercial Landings Statistics

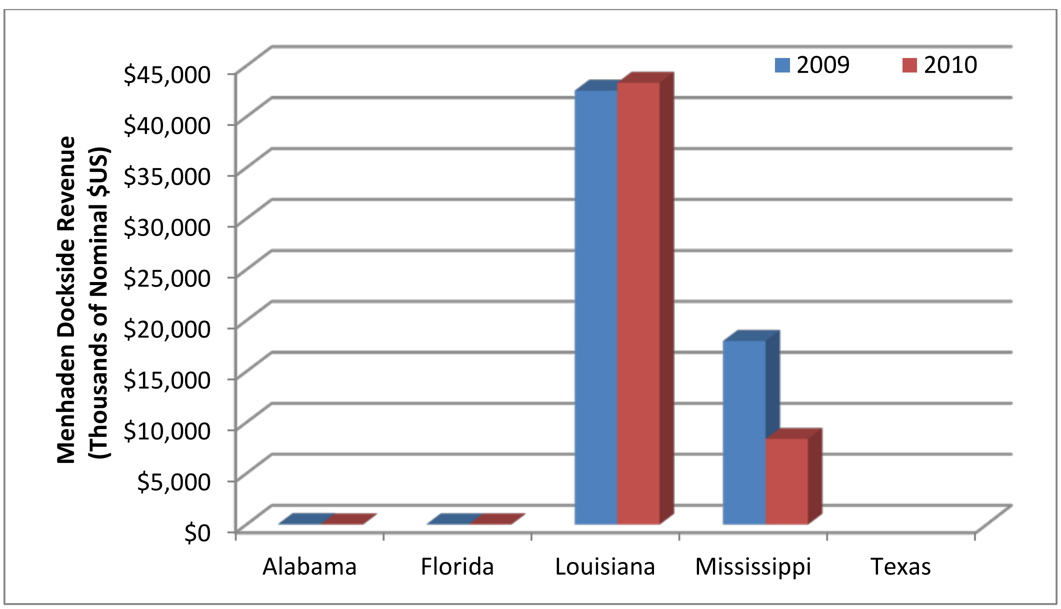
Figure 29. Commercial Menhaden Dockside Revenue Before and During the DWH Oil Spill Relative to Fisheries Closures

Louisiana menhaden landings are approximately six times larger than the next highest landings state (Mississippi) (see Figure 30). Alabama and West Florida total less than 1% of the Gulf's menhaden landings (NOAA 2013). Louisiana's menhaden landings in July of 2010 were 40 million pounds, 79% less than 2009 landings (NOAA 2013). In July 2010, revenues in Louisiana were 91% less than revenues in July of 2009 (Figure 29). Though landings and revenue were severely impacted in July of 2010 in Louisiana, in August they rebounded to 2009 levels and were higher than 2009 levels in October, likely in an effort to make up for the reduced harvest volumes which had occurred in July.



Source: NMFS Commercial Landings Statistics

Figure 30. Comparison of State Level Menhaden Landings from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 31. Comparison of State Level Menhaden Dockside Revenue from 2009 to 2010

3.5.3 Menhaden Supply Chain and Market Factors

Two companies account for nearly all menhaden processing in the Gulf: Daybrook Fisheries and Omega Protein. The supply chain for menhaden is vertically integrated within these two companies, meaning that they own the vessels, docks, processing plants, and distribution (Figure 32). The products they produce for human consumption include fish oil supplements and fish oil as a food ingredient. They also produce fish meal and fish oil as an ingredient for agriculture, aquaculture, and pet food products. According to Daybrook (2014), their processing includes the fish being steamed, and pressed. It is then run through decanters and oil separators. After the oil is removed and used, the rest of the product goes through an evaporator and multiple drying processes before it is cooled and stored as fishmeal. The main competitor of fishmeal is soybean meal (International Fish Meal and Fish Oil Organization 2009), but some other competitors include animal feed made from algae, poultry by-product, and yeast extract. Substitutes for fish oil made for human consumption include flaxseed oil and supplements made from algae.

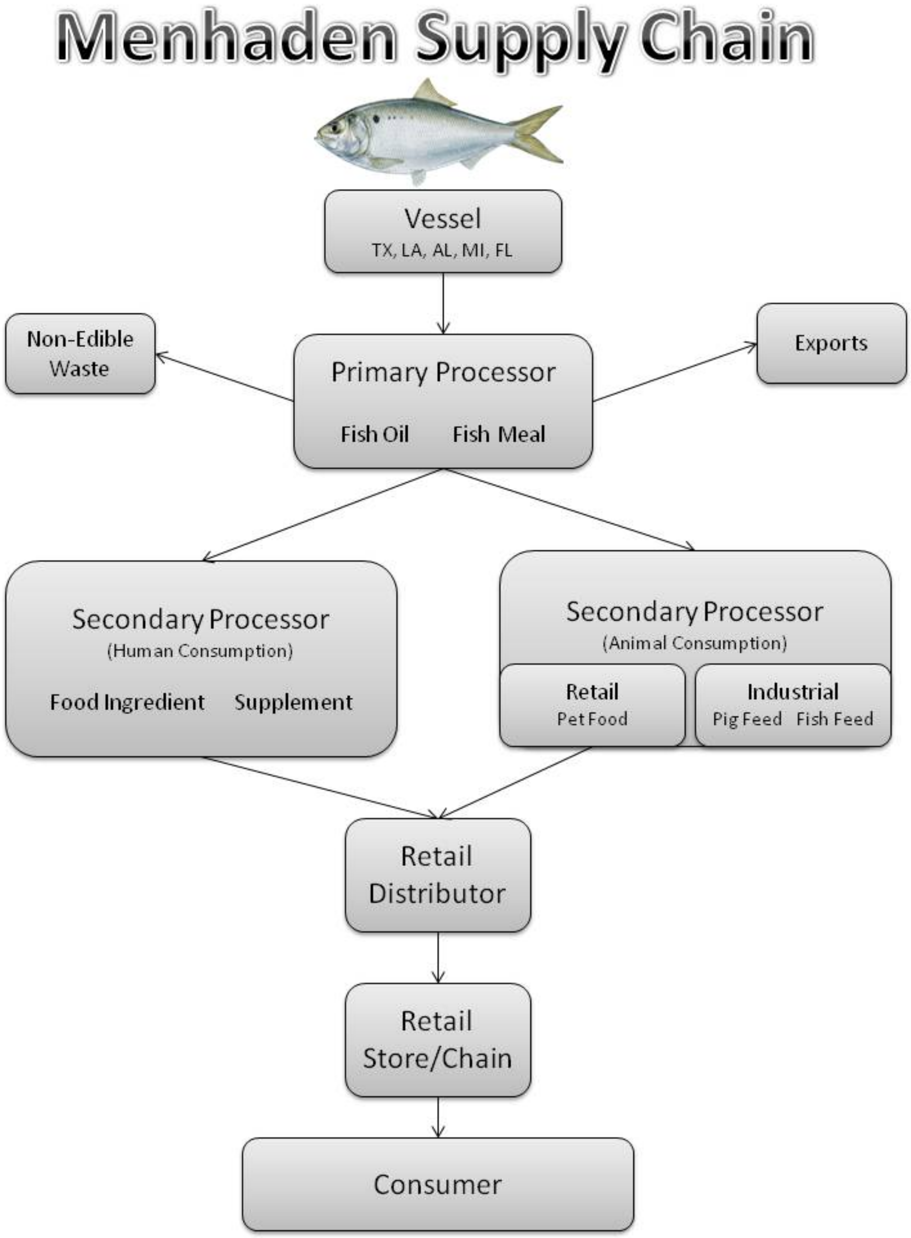


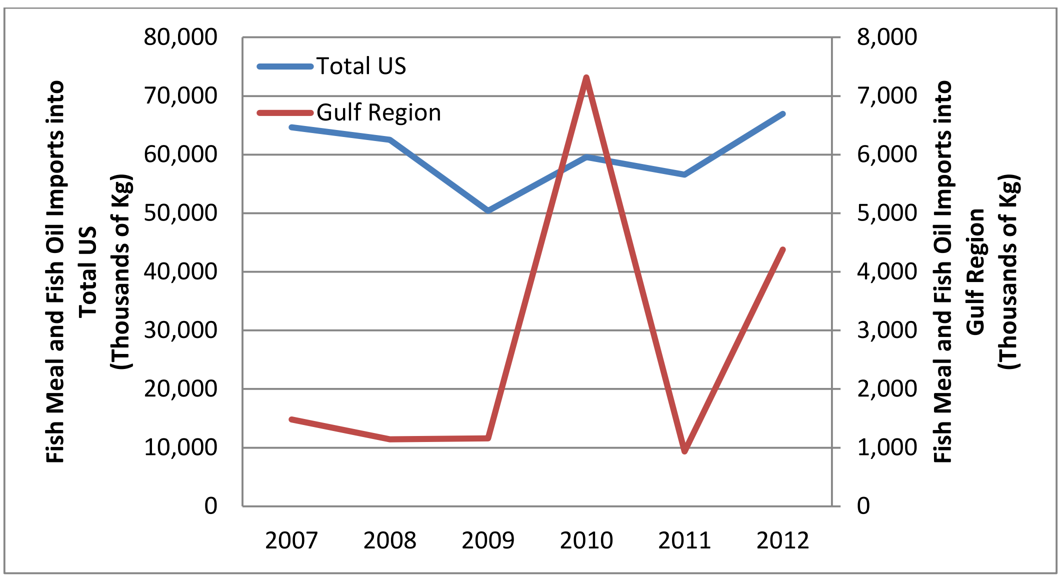
Photo of Gulf menhaden source: (Monterey Bay Aquarium Seafood Watch 2015)

Figure 32. Overview of the Gulf of Mexico Menhaden Supply Chain

In 2010 and 2011, demand for fish oil was high, which lead to a 40% increase in prices (La Monica 2011). Although fisheries closures delayed the menhaden fishing season, fishing was still able to occur successfully around the closures; Omega Protein stated that in 2010 it caught 90% of the fish it had planned to catch that year (La Monica 2011). Omega Protein Inc.'s 2011 annual report states that

> In September and October 2010, Omega Protein received its first and second emergency payments from the GCCF of $7.3 million and $11.4 million, respectively. These payments were utilized in the following manner: 1) $0.6 million of the payments to offset recognized losses as of June 30, 2010 related to costs that were not able to be allocated to production as a result of intermittent plant closures, 2) to offset costs Omega Protein incurred to purchase 6,315 tons of fish meal to partially offset lost production, and 3) to offset the high costs per unit of production Omega Protein incurred during the 2010 fishing season in the Gulf of Mexico as a result of the closure of its fishing grounds. (Omega Protein 2011)

It concludes by stating "In total, the Company received payments of $44.8 million, net of fees and expenses, from the GCCF in 2010 and 2011" (Omega Protein 2011). Comparative U.S. Import statistics (see Figure 3) confirm this large increase in both Total U.S. and Gulf region imports of menhaden fish oil and meal during 2010 and further confirm changes in business practice in the menhaden industry due to the oil spill and its associated closures.



Source: NMFS Annual Trade Data by Product through U.S. Customs Districts

Figure 33. Annual Fish Meal and Fish Oil Imports into the U.S. and Gulf of Mexico Region from 2007–2012

3.6 Reef Fish

3.6.1 Reef Fish Commercial Fishing Regulations

In general, reef fish species in inshore waters are managed with size limits, gear restrictions, and aggregate quotas or bag limits. Seasonal closures are also common. Table 5 below gives an overview of fishing regulations of reef fish species.

Table 5. Federal Regulations for Commercial Reef Fish Harvests (Snappers, Groupers, & other Reef Fish), 2013

Species	Minimum Size Limited	Trip Limited	Quota / Closed Seasons
Red Snapper	13" total length	Red snapper is managed under an Individual Fishing Quota (IFQ) program. Anyone commercially fishing for red snapper must possess IFQ allocation and follow established protocols.	5.61 mp gutted weight
Vermilion Lane Gray (Mangrove) Mutton Yellowtail Cubera Blackfin Queen Silk Wenchman	10" total length 8" total length 12" total length 16" total length 12" total length 12" total length None None None None	None None None None None None None None None None	NOTE: The Gulf Council has set a control date of December 31, 2008, for the commercial reef fish fishery.
Shallow-Water Groupers (SWG) Gag Red Black Yellowfin Scamp Yellowmouth	 22" total length 18" total length 24" total length 20" total length 16" total length None	Grouper are managed under an IFQ program. Anyone commercially fishing for grouper or tilefish must possess IFQ allocation and follow established protocols.	Gag: 0.567 mp gutted weight Red Grouper: 5.37 mp gutted weight Other shallow water grouper: 0.510 mp gutted weight
Deep-Water Groupers (DWG) Yellowedge Snowy	 None None		DWG quota 1.127 mp gutted Weight
Speckled Hind Warsaw			For purposes of the IFQ, these species are also included as SWG.
Goliath	Harvest and possession is prohibited.		
Red Drum	It is illegal to harvest or possess in federal waters.		

Species	Minimum Size Limited	Trip Limited	Quota / Closed Seasons
Tilefish (Golden) Blueline Tilefish Goldface Tilefish	None None None	Tilefish is managed under an IFQ program. Anyone commercially fishing for tilefish must possess IFQ allocation and follow established protocols.	Overall tilefish Quota: 582,000 lbs gutted weight
Hogfish	12" fork length	None	Closed Dec 2 – Dec 31, 2013
Gray Triggerfish	14" fork length	12 fish	60,900 lbs whole weight Closed June 1 through July 31
Greater Amberjack	36" fork length	2,000 lbs	409,000 lbs round weight Closed March 1 through May 31
Lesser Amberjack Banded Rudderfish	14" – 22" fork length 14" – 22" fork length	None None	None None

Source: Gulf of Mexico Fishery Management Council

Table 6 shows the number of federal dealer and vessel permits by state for reef fish at the end of 2013. These numbers give an indication of the maximum number of reef fish operations operating in each state in the Gulf. The number of active permits is likely to be less than the official permits issued. In most cases, latent fishing effort is represented in these permit figures because fisherman shift efforts between fisheries.

Table 6. Vessel and Dealer Permit Requirements by state for Commercial Reef Fish Harvests (Snappers, Groupers, & other Reef Fish), 2013

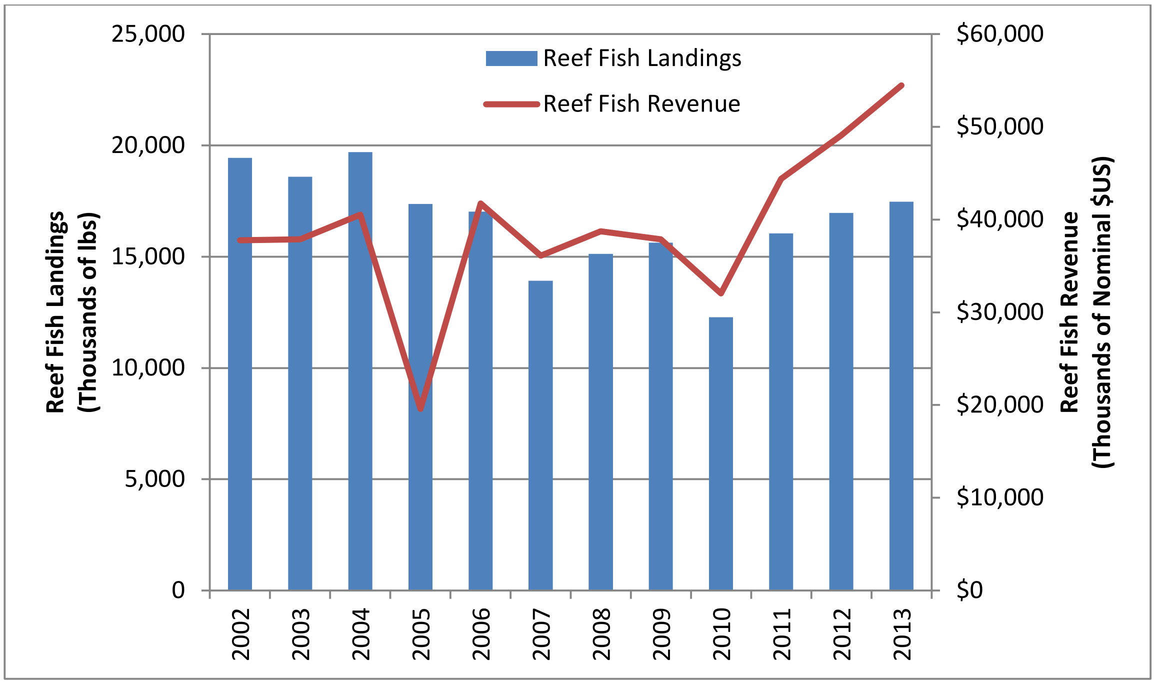
State	Vessel Permits Reef Fish Longline Endorsement	Vessel Permits Reef Fish	Vessel Permits Reef Fish IFQ Account	Dealer Permits Reef Fish
AL	0	39	35	7
FL	59	642	592	145
LA	0	38	42	16
MS	0	9	12	3
TX	2	67	58	22
Total	**61**	**795**	**739**	**193**

Note: Florida permit numbers include permits for the entire state. That is, the numbers are for both the South Atlantic and Gulf of Mexico management regions of Florida. This is an over representation of fishing operations in the Gulf.

Source: Gulf of Mexico Fishery Management Council

3.6.2 Reef Fish Fisheries Characteristics and Trends

Reef fish landings hit a low in 2010 at 12 million pounds; revenues were lowest in 2005, at $17 million. Total Gulf reef fish landings for 2010 were down by 21% compared to the 2009 landings, and dockside revenues in the reef fish fisheries during 2010 were down by 15% compared to 2009 (Figure 34). Although reef fish landings increased slightly from 16 million pounds in 2011 to 17 million pounds in 2013, revenues jumped from $44 million in 2011 to $55 million in 2013. This shows an increased price for reef fish from 2011–2013.

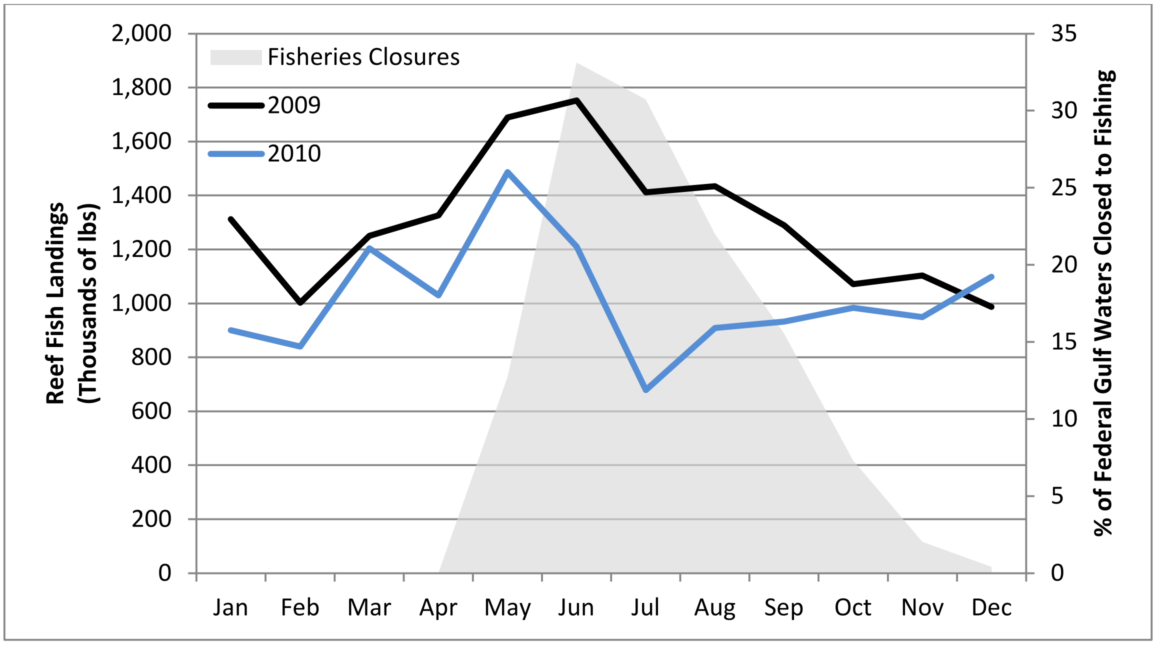


Source: NMFS Commercial Landings Statistics

Figure 34. Gulf of Mexico Reef Fish Landings and Dockside Revenue from 2002–2013

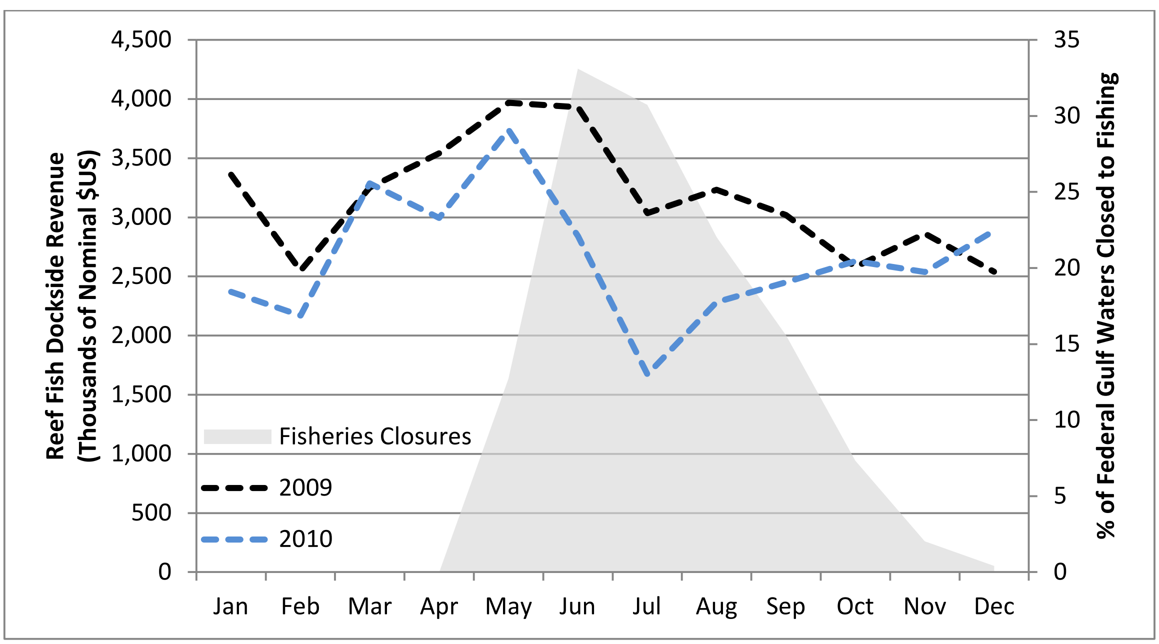
The full list of species categorized under reef fish for this study is displayed in Table 3. The reef fish category includes all species of grouper and snapper, which accounted for 90% of the total landings in 2009 (NOAA 2013). These species are most often harvested by larger ocean-going vessels (U.S. Small Business Administration 2013). Grouper landings were down 27% in 2010 compared to 2009, and revenue was down 22% in 2010 compared to revenue for 2009 (NOAA 2013). Snapper landings were down by 18% in 2010 compared to 2009, and revenue was down only 10% in 2010 compared to 2009 (NOAA 2013). The 2005–2006 red snapper trawl survey indicated strong recruitment, which is believed to have supported landings from 2007–2013, except the year of the spill, 2010 (SEDAR 2009).

Fishery closures after the oil spill appear to have impacted reef fish landings during the damage period. The monthly landings and dockside value of reef fish in 2010 are shown in Figures 35 and 36, relative to the baseline period of 2009 and the fishery closures. This shows a slight reduction in landings from March to October 2010 in comparison to 2009, and also demonstrates a relatively similar decrease in dockside value. Reef fish landings in the months of 2010 before the spill date were not as high as the previous year, but it should also be noted that landings in the months following the spill decreased notably. It appears that, as the closures were lifted, landings made an unseasonable increase from September to December.



Source: NMFS Monthly Commercial Landings Statistics

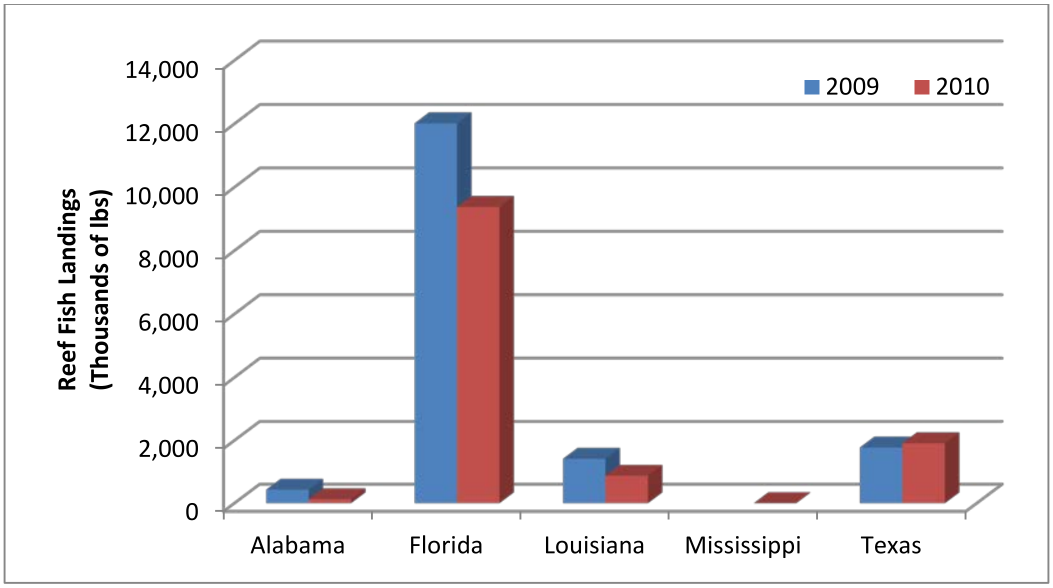
Figure 35. Commercial Reef Fish Landings Before and During the DWH Oil Spill Relative to Fisheries Closures



Source: NMFS Monthly Commercial Landings Statistics

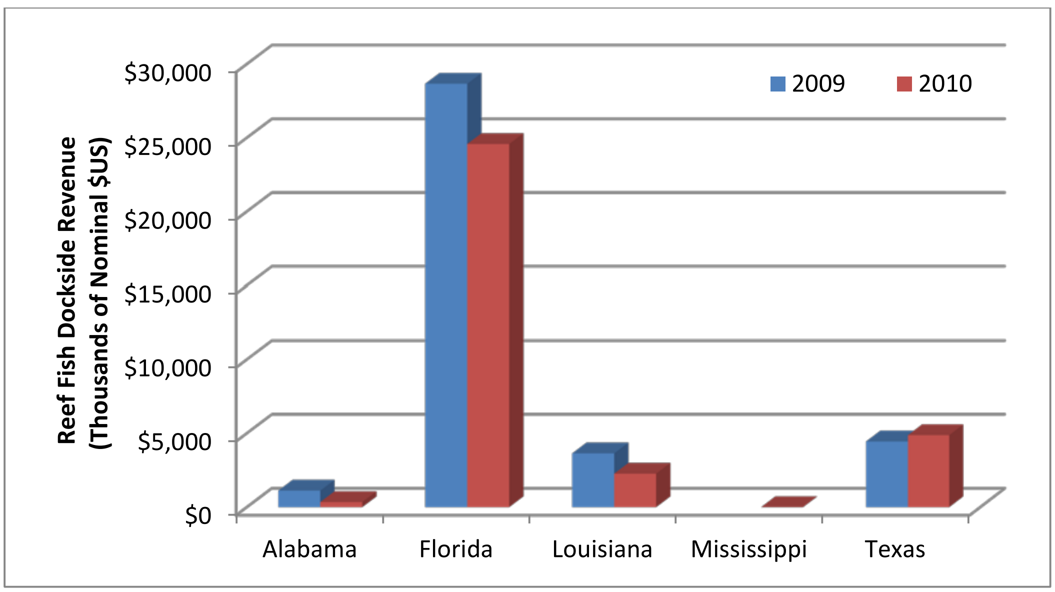
Figure 36. Commercial Reef Fish Dockside Revenue Before and During the DWH Oil Spill Relative to Fisheries Closures

Figures 37 and 38 show that reef fish harvests are by far largest in West Florida, followed by Texas and Louisiana, and minimal landings in Mississippi and Alabama. The geographic focus of the reef fish category is in West Florida and Texas, the two states that had minimal, if any, closures due the oil spill. Although this geographic focus may have insulated this species category, there were apparent reductions in both landings and dockside value in West Florida, Louisiana, and Alabama, but steady increases in Texas.



Source: NMFS Commercial Landings Statistics

Figure 37. Comparison of State Level Reef Fish Landings from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 38. Comparison of State Level Reef Fish Dockside Revenue from 2009 to 2010

An industry source indicated that the majority of fisherman in Alabama, Mississippi, and Louisiana stopped fishing during the damage period; some fisherman in northwest Florida shifted their fishing locations away from the spill, and Texas did not have to alter its fishing practices (Krebs 2014). It was indicated that depressed prices and fear of oil in the fish encouraged many fisherman not to fish during the damage period. After the DWH well was capped in July, a series of fishing areas were reopened over the next few months, and reef fish fishing effort resumed well above average levels. An industry source noted that this flooded the snapper market with product in November and December of 2010, driving prices down (David Krebs 2014).

3.6.3 Reef Fish Supply Chain and Market Factors

Although many of the primary reef fish species are caught by different vessels and in different geographic areas, the product market and supply chain for snapper and grouper species are very similar (see Figure 39). Both the snapper and grouper fisheries in the Gulf region are relatively fragmented because there are various participants. On the dockside, the supply chain becomes more consolidated with fewer companies processing and shipping fish into market. These reef fish species are sold primarily into fresh domestic markets in a fillet and whole product form and can compete in lower-end markets with imported reef fish shipped from around the world. Due to the premium paid for fresh product, a smaller portion of this product goes to frozen markets.

As with most of the finfish species, reef fish can directly compete with both fresh and frozen imported product in some lower-end markets because from a presentation standpoint, the product is completely indistinguishable to the consumer. The nature of the product and strong availability of imports would have made it easy for seafood wholesalers and distributors to substitute product during the oil spill. Evidence does support that substitution occurred; there was also strong evidence that unique local markets do occur for species like red snapper. As was noted in the harvest data in Section 3.6.2, reef fisherman, specifically red snapper fisherman, were able to resume harvests and effectively flooded the market, driving prices down.

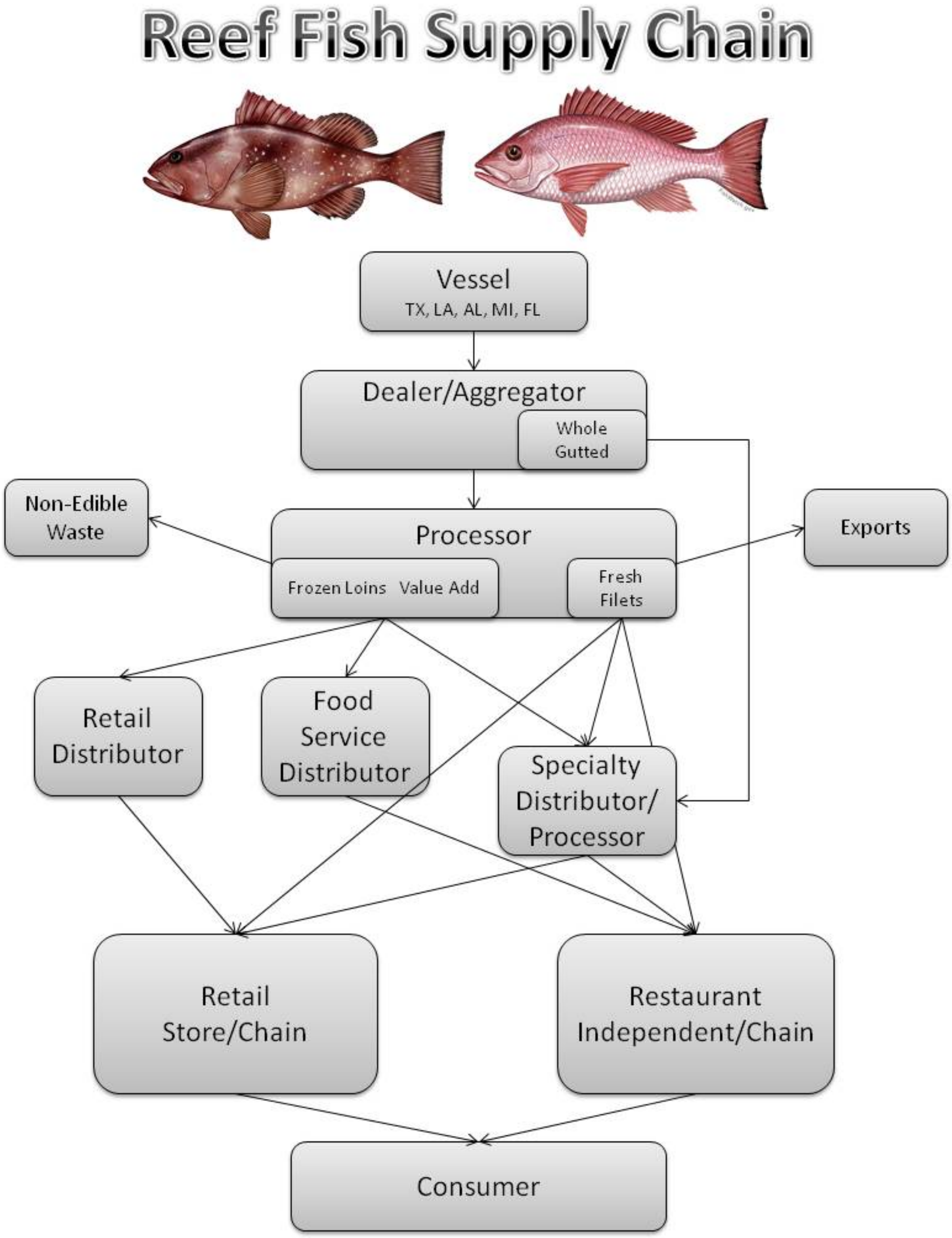


Photo of grouper and snapper source: (Fishwatch 2014)

Figure 39. Overview of the Gulf of Mexico Reef Fish Supply Chain

The red snapper fishery has been undergoing a rebuilding strategy since the 1990s. On January 1, 2007 NOAA instituted an IFQ system. The effects of this and some focused marketing projects in the Gulf region created many positive effects on the snapper fishery before and after the damage period. Marketing efforts, established in 2010, have helped the snapper industry establish new business relationships with companies like HEB Grocery Company in Texas. An industry source indicated that the transferable nature of the IFQ system, combined with these new business relationships, have enabled fishing effort to shift geographic focus away from the DWH fishing areas in Louisiana and Alabama and focus more in the Texas region, where there are strong historical harvests and newly established markets (Krebs 2014).

Although import competition for reef fish does exist, including imports of snapper, there is limited evidence of direct substitution in premium markets. In case of red snapper and many other higher value reef fish, there is a defined market and premium paid for fresh domestic product which limits the opportunity for substitution of imported products. Although we know substitution did occur in some markets, gaining back market share for the domestic producers seems to have happened relatively easily according to an industry source (Krebs 2014).

3.7 Pelagic Finfish

3.7.1 Pelagic Finfish Commercial Fishing Regulations

Table 7 shows the number of federal dealer and vessel permits by state for different pelagic finfish fisheries at the end of 2013. These numbers give an indication of the maximum number of operations operating in each fishery in the Gulf. However, ownership of a permit does not necessarily indicate that the permit is being used.

The number of active permits is likely to be less than the official permits issued. In most cases there is latent fishing effort represented in these permit figures due to fisherman shifting efforts between fisheries. Still, the values below provide the best indication of fishery participation available short of matching permits to logbook information to determine the number of active permits.

Table 7. Federal Vessel and Dealer Permits by State in the Gulf of Mexico, 12/20/2013

State	Vessel Permits Dolphin Wahoo	Vessel Permits Swordfish (Handgear)	Vessel Permits Swordfish (Directed)	Vessel Permits Swordfish (Incidental)
AL	19	0	0	**0**
FL	1403	50	74	**33**
LA	20	0	30	**5**
MS	1	0	0	**0**
TX	20	1	2	**6**
Total	**1,463**	**51**	**106**	**44**

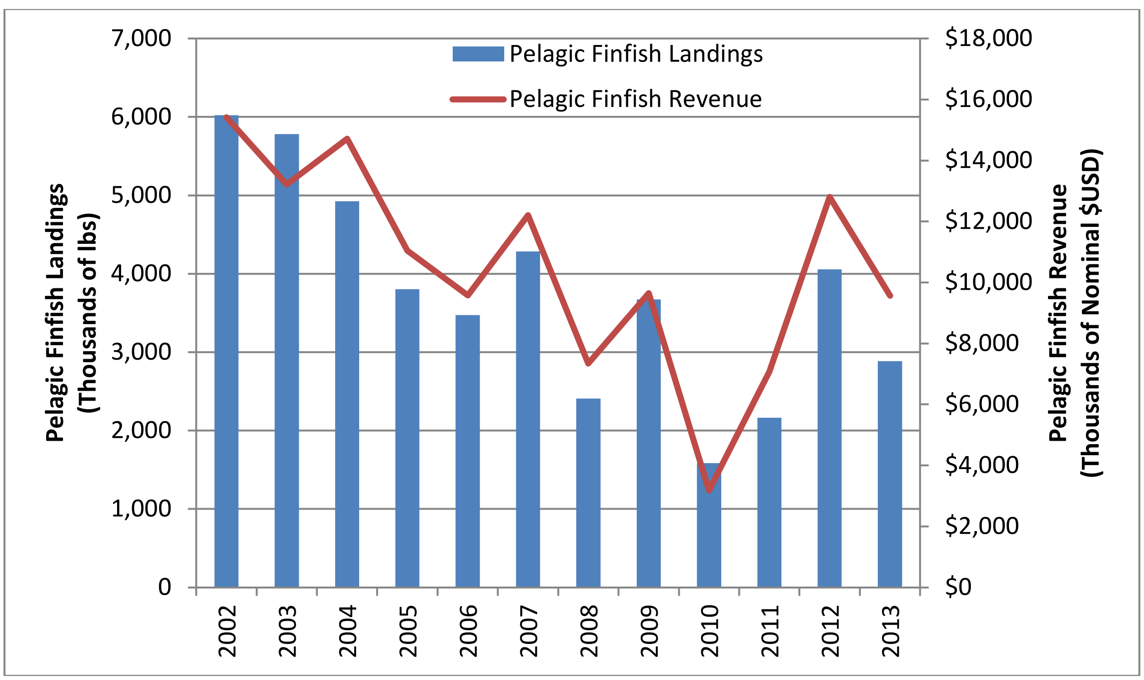
State	Dealer Permits Dolphin Wahoo	Int'l Trade Permits Pelagic Finfish Species	Dealer Permits Swordfish
AL	3	0	4
FL	108	54	81
LA	5	0	8
MS	0	0	0
SC	18	1	7
TX	2	4	3
Total	**136**	**59**	**103**

Note: Florida permit numbers include permits for the entire state. That is, the numbers are for both the South Atlantic and Gulf of Mexico management regions of Florida. This is an over representation of fishing operations in the Gulf.

Source: Gulf of Mexico Fishery Management Council

3.7.2 Pelagic Finfish Fisheries Characteristics and Trends

Figure 40 shows that pounds of pelagic finfish landed in Gulf States plummeted from 3.6 million in 2009 to 1.5 million in 2010, but by 2012 were back up to 2009 landings. Pelagic finfish revenue hit an all-time low in 2010 at $3 million, but increased back up to $13 million in 2012. Pelagic finfish in 2010 were down by 57% in landings and 67% in revenue compared to the baseline period of 2009. (See Table 3 for a list of the species categorized under pelagic fish.)



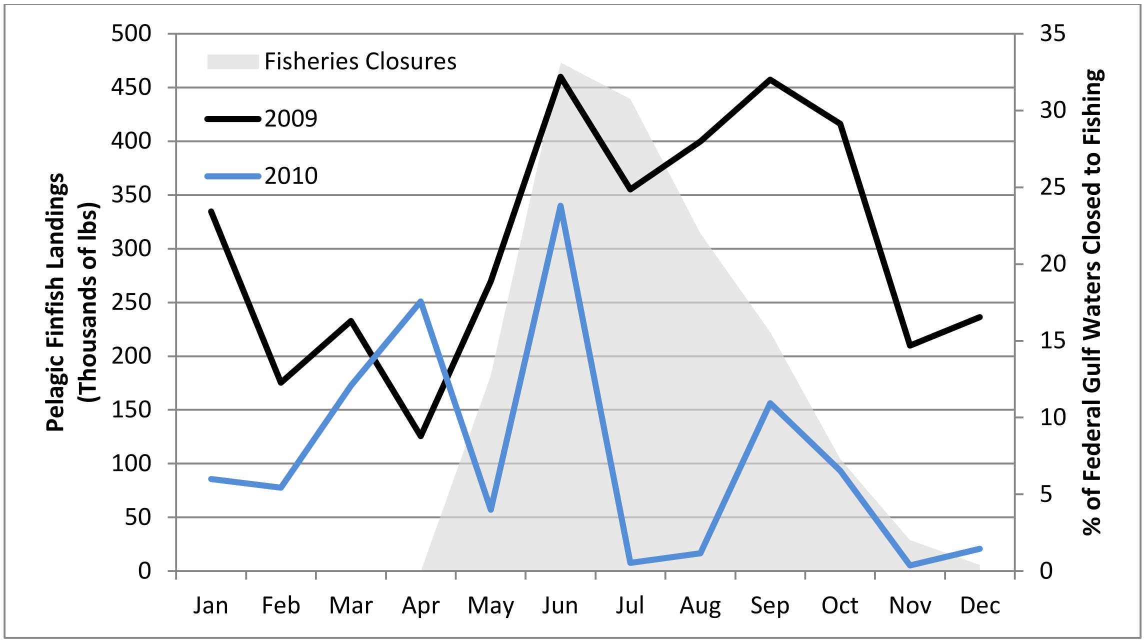
Source: NMFS Commercial Landings Statistics

Figure 40. Gulf of Mexico Pelagic Finfish Landings and Dockside Revenue from 2002–2013

Yellowfin tuna *(Thunnus albacores)*, bluefin tuna *(Thunnus thynnus)*, and bigeye tuna *(Thunnus obesus)* together account for approximately 75% of 2009 pelagic finfish landings, and therefore tuna harvests are the primary factor affecting pelagic finfish landings.

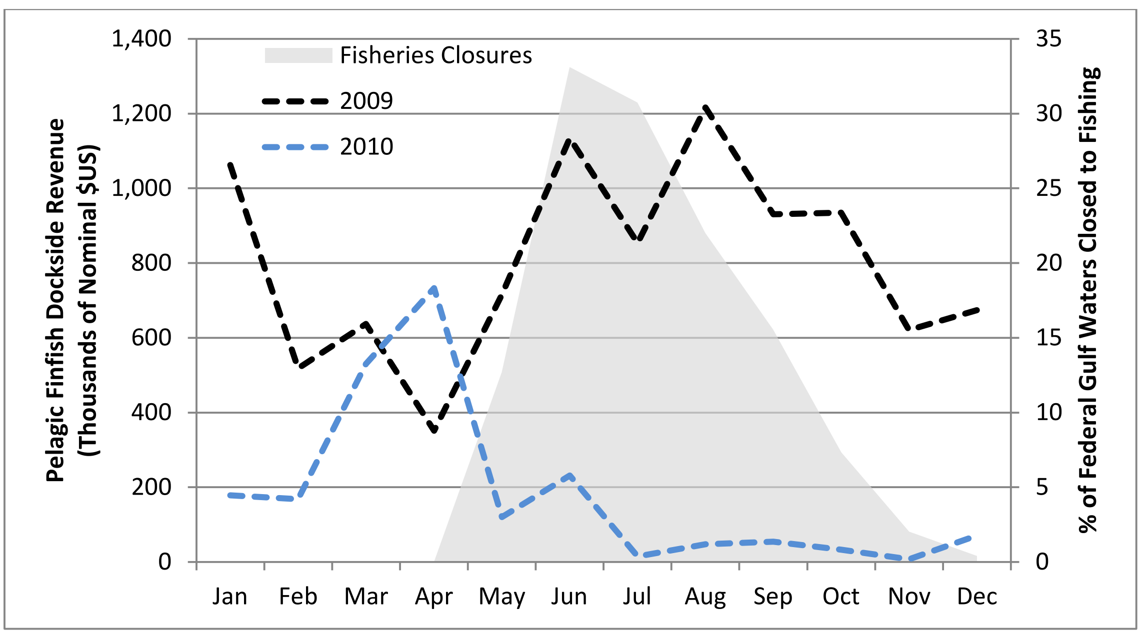
Although the 2011 rebound in landings could indicate a minimal long-term effect from the oil spill on these species, recent studies indicate larvae could have been harmed due to the spill, which would not yet be reflected in landing data. A study of the larvae of Southern bluefin tuna, yellowfin tuna, and yellowtail amberjack by Incardona (2014) showed that crude oil exposure compromised the function of the larvae's heart development; exposure to oil even at very low concentrations can have an effect, and the larvae that survive the initial exposure can have reduced swimming performance later in life due to heart development issues. Because the oil spill occurred during tuna spawning season in the Gulf, there is concern that the 2010 year class was affected in this way, but this could be very difficult to confirm because of the longer life cycle of these species and the highly migratory and trans-boundary nature of these stocks (Incardona 2014).

Monthly landings (Figure 41) and monthly dockside values (Figure 42) for pelagic finfish in 2010 are represented in comparison to the baseline period of 2009 and the fishery closures. This shows a clear reduction in landings and dockside value during the damage period in comparison to the 2009 baseline year. This landings data seems to suggest that the vessels stopped fishing almost entirely from shortly after the spill until the end of the year. Austin et al. (2014) interviewed a tuna processor in Louisiana who stated no tuna was sold to his company for a year after the date of the spill. He stated that most tuna boats in the area did not fish at all after the spill in 2010. Instead, they participated in the VOO program, and then went back to their homes in Vietnam.



Source: NMFS Commercial Landings Statistics

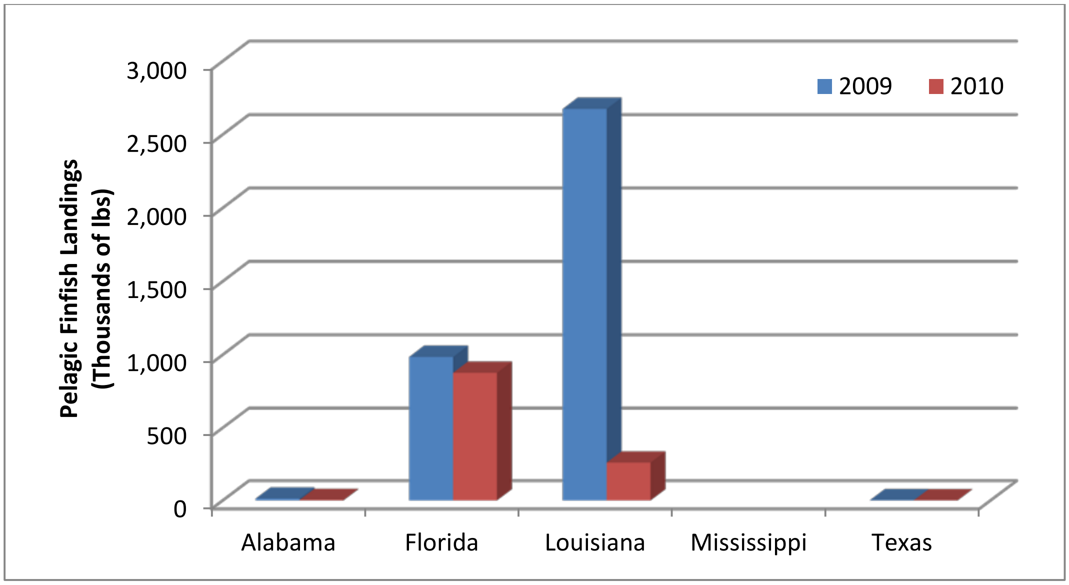
Figure 41. Commercial Pelagic Finfish Landings Before and During the DWH Oil Spill Relative to Fisheries Closures



Source: NMFS Commercial Landings Statistics

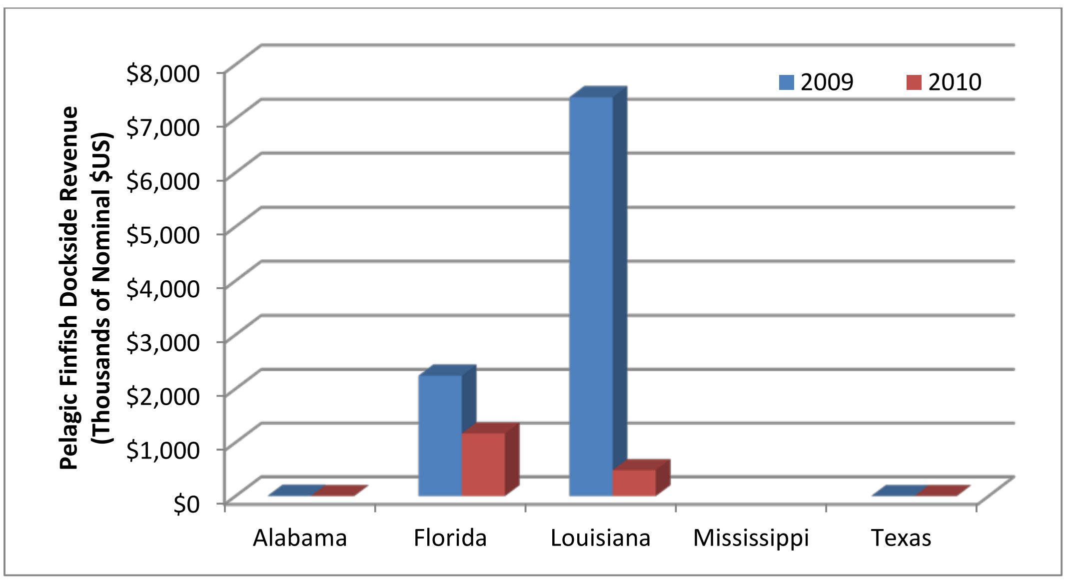
Figure 42. Commercial Pelagic Finfish Dockside Revenue Before and During the DWH Oil Spill Relative to Fisheries Closures

Based on Figures 43 and 44 below, it can be noted that nearly all Gulf landings of pelagic finfish occur in Louisiana and West Florida. Louisiana landings decreased 90% and revenues decreased 93% from 2009 to 2010 (NOAA 2013). The primary driver in the reduction of Gulf-wide landing was due to Louisiana having little to no landings from June to December of 2010 (NOAA 2013). West Florida tuna landings decreased 11% and revenues decreased 47% from 2009 to 2010 (NOAA 2013). Though West Florida saw some sporadic tuna landings during the damage period (May–December 2010), these levels were much less consistent than in 2009.



Source: NMFS Commercial Landings Statistics

Figure 43. Comparison of State Level Pelagic Finfish Landings from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 44. Comparison of State Level Pelagic Finfish Dockside Revenue from 2009 to 2010

3.7.3 Pelagic Finfish Supply Chain and Market Factors

Although many of the primary pelagic finfish species are caught by different vessels and in different geographic areas, the product market and supply chain for yellowfin, bigeye, and bluefin tuna are very similar. Though not completely integrated like the menhaden fishery, the commercial Gulf tuna fleet is relatively vertically integrated compared to that of other species categories like reef fish, oyster, blue crab, and even shrimp.

These tuna species are sold primarily into fresh domestic markets in a loin product form and compete directly with imported tuna shipped from around the world. A smaller portion of this product is sold into frozen product markets. Domestic tuna competes directly with both fresh and frozen imported tuna and is almost completely indistinguishable to the consumer. The nature of the product and strong availability of imports would have made it very easy for the seafood wholesalers and distributors to substitute product during the oil spill. It appears this was the case, because harvest data indicates that the Gulf tuna fisherman stopped fishing almost altogether during the damage period.

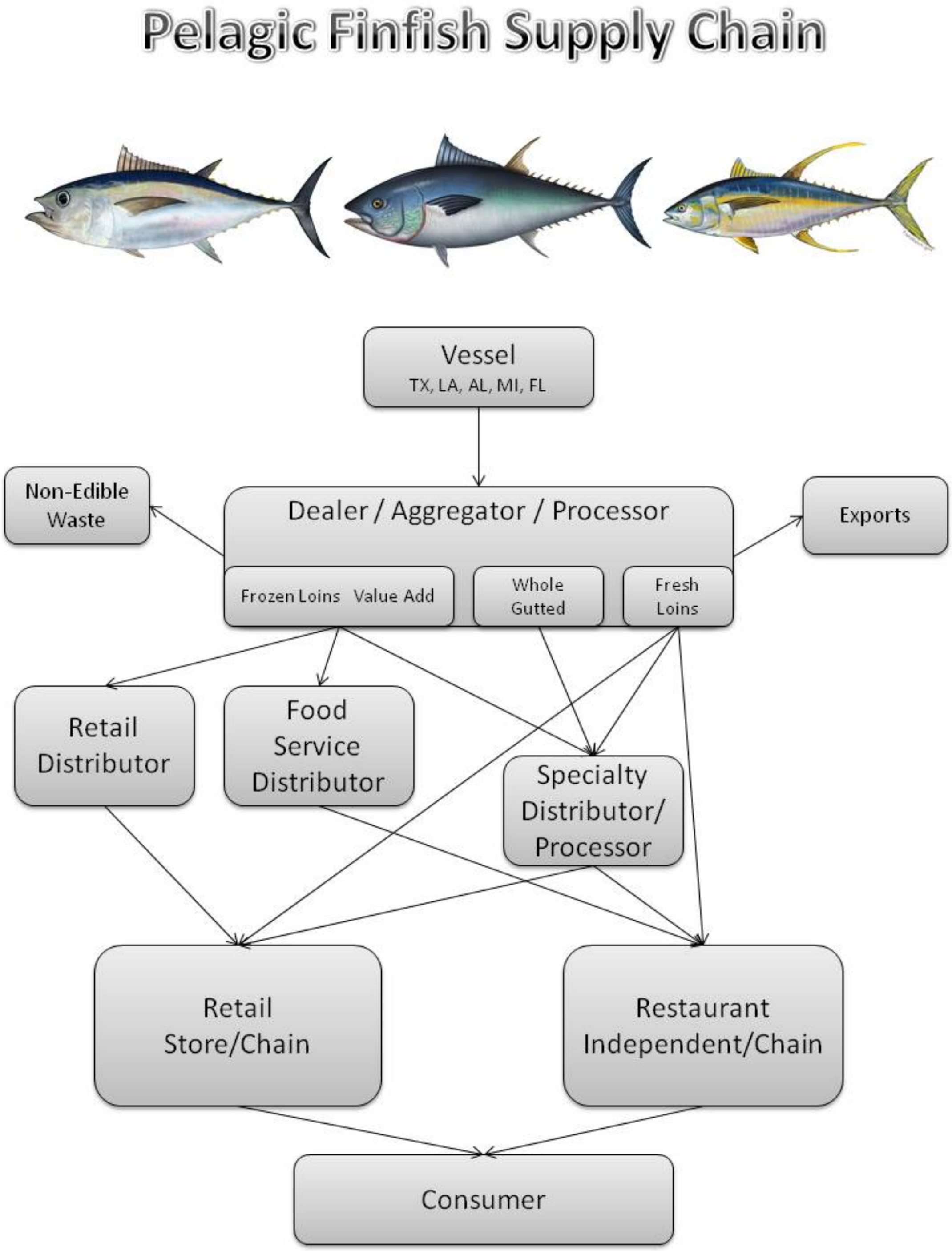


Photo of bigeye, bluefin, and yellowfin tuna source: (Fishwatch 2014)

Figure 45. Overview of the Gulf of Mexico Pelagic Finfish Supply Chain

Although other external factors may have affected the Gulf tuna market in 2010, it appears from the harvest data that fisherman did not fish during the latter part of the damage period. It can be surmised that this decision was made based on the fishery closures, but there were most likely other associated factors that weighed into this decision, such as the high cost of operating and strong competition from imports and other domestic markets in light of a tarnished product image.

3.8 Other Crustaceans

3.8.1 Other Crustaceans Commercial Fishing Regulations

The "other crustaceans" category is comprised of three primary species: crawfish, Florida crab (also known as stone crab), and spiny lobster. In 2010, both the commercial spiny lobster and stone crab fisheries were managed with tradable effort permits, and fishermen were allocated a number of traps they could use to fish each year. The programs were intended to reduce commercial fishing effort and have largely been successful in that regard. The spiny lobster fishery is managed by a federal regional council, the stone crab fishery is managed by the State of Florida, and the crawfish fishery is managed by the state of Louisiana. Under these management systems, permits are required, the number of legal commercial traps is fixed, and the traps are regulated to be of the same dimensions and construction.

Currently the spiny lobster fishery is regulated with an additional total allowable catch ("aggregate catch limit" or ACL) and associated measures, but this regulation was implemented after the spill. Spiny lobster harvests are also regulated by a minimum size limit (i.e., carapace must be more than 3"). The commercial fishing season is closed from April 1 to August 5. Other regulations for spiny lobster include prohibition on landing females that are carrying eggs ("berried" animals), and prohibition on the use of casitas (small structures that attract lobsters). Table 8 below shows the number of vessel permits held in 2013 for spiny lobster.

Table 8. Federal Vessel and Dealer Permits by State in the Gulf of Mexico, 12/20/2013

State	Vessel Permits Lobster Tailing	Vessel Permits Spiny Lobster
AL	4	9
FL	211	166
LA	1	2
MS	0	1
TX	4	5
Total	**220**	**183**

Note: Florida permit numbers include permits for the entire state. That is, the numbers are for both the South Atlantic and Gulf of Mexico management regions of Florida. This is, therefore, an over representation of fishing operations in the Gulf.

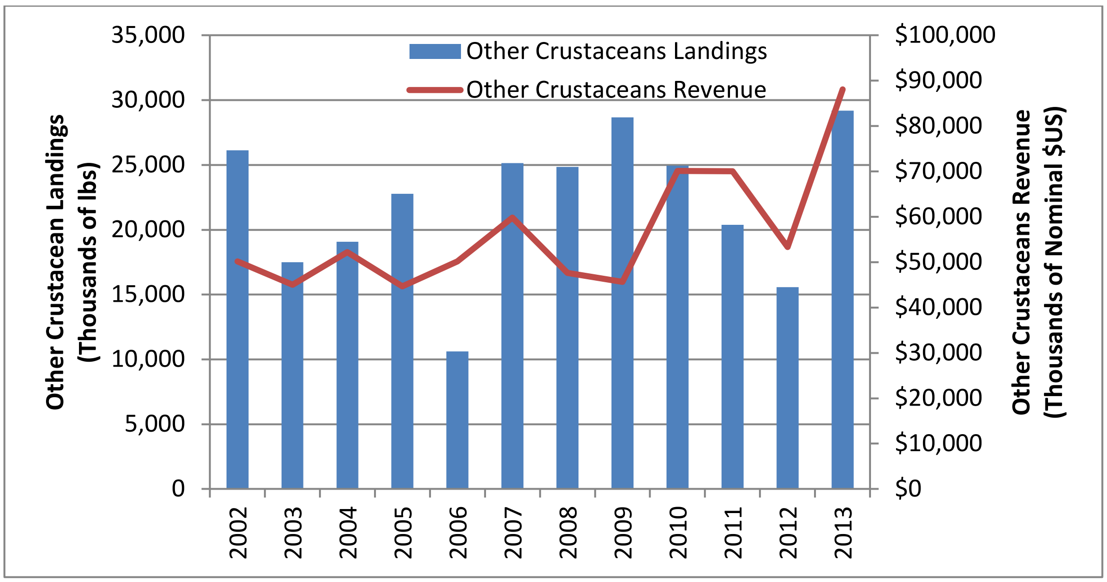
Source: Gulf of Mexico Fishery Management Council

The stone crab fishery is unique: typically only one claw from each animal is harvested, and larger claws receive significantly higher prices. The stone crab fishery also has a limited harvest season (15 October through 15 May) and a minimum harvest claw (propodus) size of 2–3/4 in (70 mm). Peak landings were 3.5 million pounds of claws statewide in the 2000–01 fishing year. Statewide landings in 2009–2010 were 2.4 million pounds of claws.

The crawfish fishery is highly seasonal, and most of the harvest occurs between March and June. Crawfish are primarily harvested and sold live to consumers local to the Louisiana area due to the short shelf life of the live product (UL 2010).

3.8.2 Other Crustaceans Fisheries Characteristics and Trends

In 2006 landings of other crustaceans hit an all-time low: 11 million pounds, though revenues fluctuate but show a general upward trend (Figure 46). Landings of other crustaceans in 2010 were down by 13% from 2009, and revenues increased by 54%. This trend shows that the price of other crustaceans was much higher in 2010 than it was in 2009.

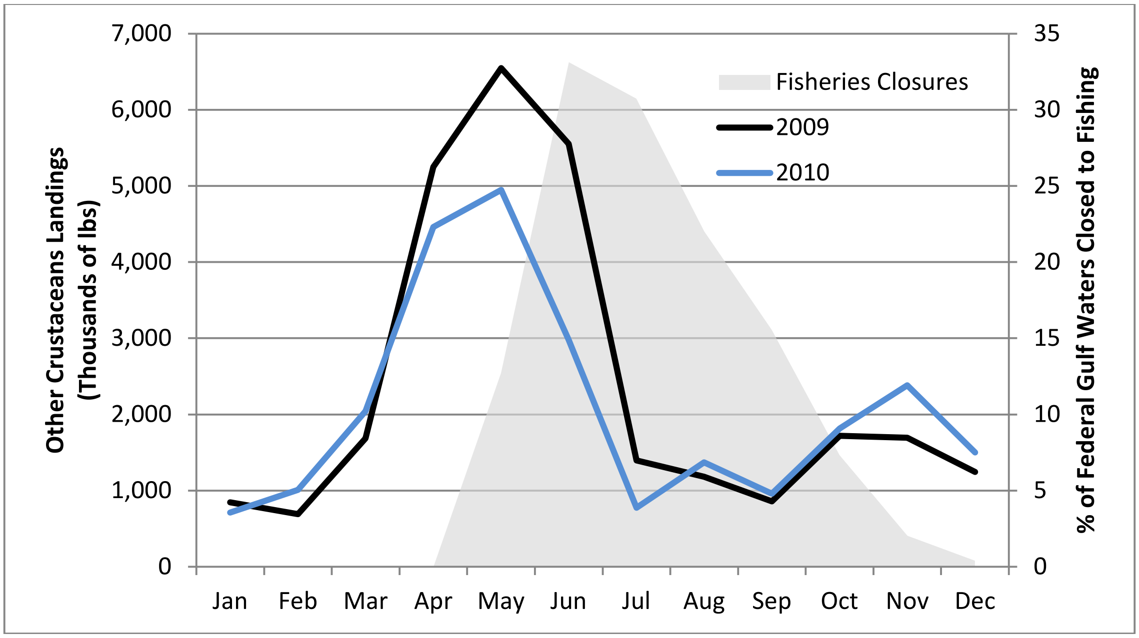


Source: NMFS Commercial Landings Statistics

Figure 46. Gulf of Mexico Other Crustaceans Landings and Dockside Revenue from 2002–2013

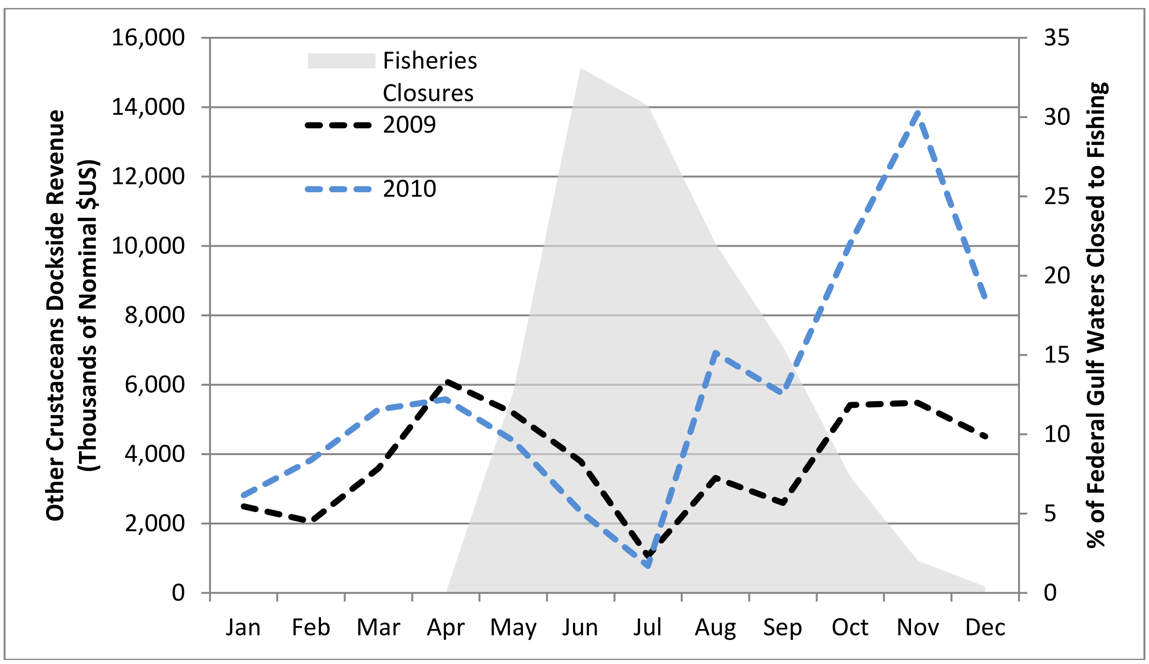
The species categorized under other crustaceans for this study are listed in Table 3. During 2009, landings in the "other crustaceans" fishery category included 67% crawfish, 19% Florida crab, 13% spiny lobster, and 1% slipper lobster. However, the species composition of this group fluctuates from year to year more than the other species categories. From 2009 to 2010, crawfish landings decreased 25%, but spiny lobster landings increased 33%. Additionally, there was a 31% increase in Florida crab revenue and a 168% increase in spiny lobster revenues, suggesting that the price of spiny lobster increased rapidly and drove the overall increase in revenues of the other crustacean category during 2010. Further decreases in other crustacean landings in 2011 and 2012 were primarily due to decreases in crawfish landings, but 2012 also saw a decrease in spiny lobster landings. In 2013, other crustacean landings were back up to pre-spill levels, primarily due to a 195% increase in crawfish landings between 2012 and 2013.

Figures 47 and 48 present other crustacean landings and dockside revenue in 2010 by month, relative to the baseline period of 2009, and the federal fishing closures. Landings and dockside revenue in 2010 were notably lower than 2009 from May to July. After July, both landings and revenues surpassed 2009 harvests, but with revenues increasing dramatically toward the end of 2010. This would suggest that some sort of market event drove prices in West Florida on spiny lobster during the latter part of 2010.



Source: NMFS Commercial Landings Statistics

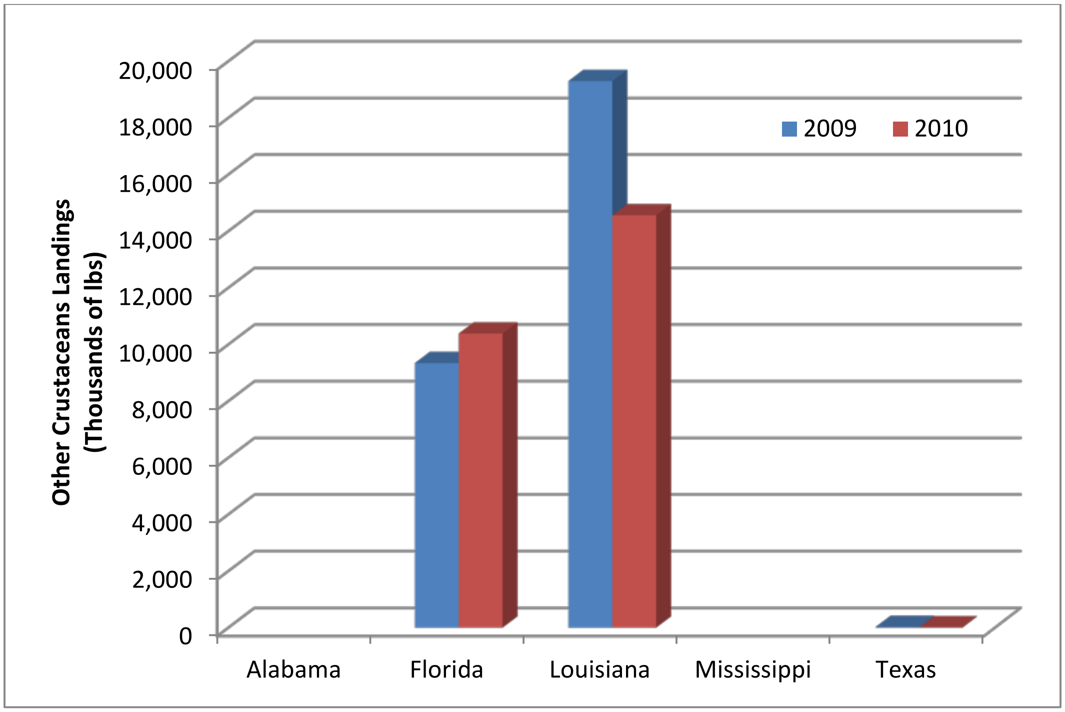
Figure 47. Commercial Other Crustacean Landings Before and During the DWH Oil Spill, Relative to Fisheries Closures



Source: NMFS Commercial Landings Statistics

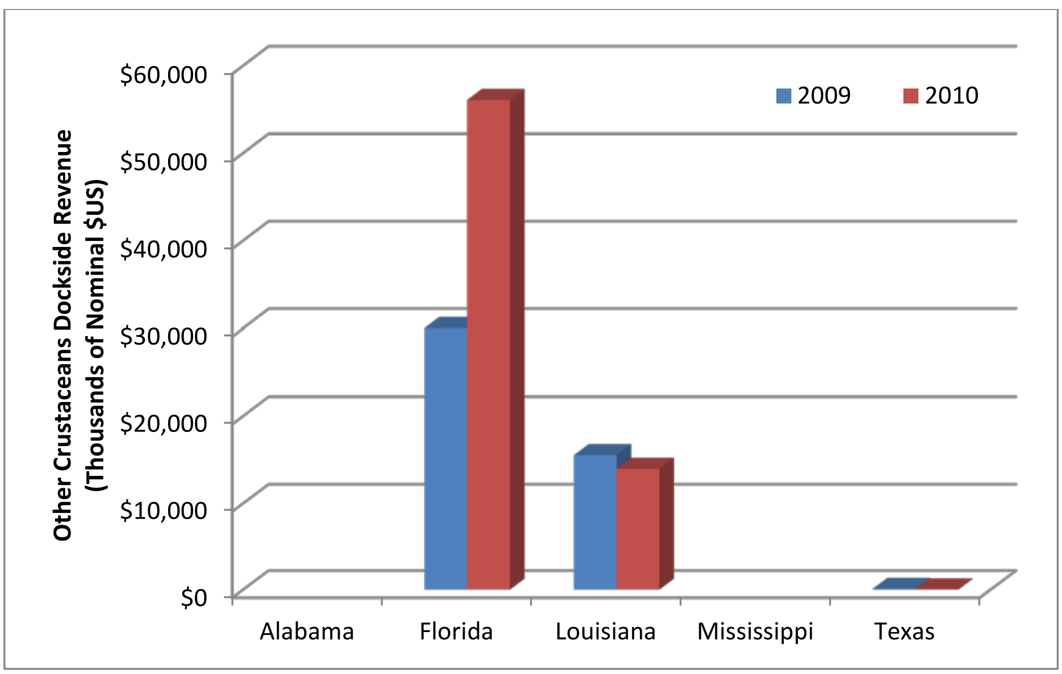
Figure 48. Commercial Other Crustacean Dockside Revenue Before and During the DWH Oil Spill, Relative to Fisheries Closures

In reviewing Figures 49 and 50 below, it is important to note that all crawfish was landed in Louisiana, all lobster (spiny and slipper) was landed in West Florida, and over 99% of Florida crab was landed in West Florida. The large drop in landings in Louisiana can be attributed to a large reduction in crawfish harvest with a much smaller decrease in Louisiana dockside value of crawfish, indicating some market adjustments in price due to the supply shortage. In West Florida, the increase in landings can be attributed to spiny lobster, and the large dockside revenue increase is believed to be driven by a dramatic increase in spiny lobster price in the latter part of 2010.



Source: NMFS Commercial Landings Statistics

Figure 49. Comparison of State Level Other Crustaceans Landings from 2009 to 2010



Source: NMFS Commercial Landings Statistics

Figure 50. Comparison of State Level Other Crustaceans Dockside Revenue from 2009 to 2010

The primary harvest region for spiny lobster and Florida crab is geographically located far enough from the spill and federal closures that they appear to have had minimal effects on harvests (GOM FMC 2011). In addition, it is important to note the seasonal harvest of these West Florida fisheries occurred at the latter part and somewhat outside the damage period. To date, there has been no indication the oil spill has had any effects on the spiny lobster stock or fishery. For example, there was no mention of the DWH oil spill during the Spiny Lobster Review Panel meeting (which was convened in February 2015) to discuss the validity of the most recent stock assessment and recommended ACLs; in fact, the Panel noted that landings increased in 2010 and 2011 compared the previous decade (Spiny Lobster Review Panel Summary 2015).

3.8.3 Other Crustaceans Supply chain and Market Factors

The other crustaceans category includes three primary species: crawfish, Florida crab (also known as stone crab), and spiny lobster. Although these are three distinctly different species, we will summarize their relative differences and similarities in the supply chain and markets.

Crawfish are harvested (farmed and wild) almost exclusively in Louisiana and are sold mostly live to local markets within a one-day driving distance. The supply of crawfish can be volatile, and when supplies are abundant, crawfish are frozen and sold whole. Abdominal or “tail meat” is processed and sold both fresh and frozen. Due to the extended shelf life of this product, it can be sold in markets outside of the direct Louisiana region (UL 2010).

Spiny lobster and Florida crab are both harvested almost exclusively in West Florida, and both are featured in high-end product markets. Spiny lobsters are sold both live and as frozen tails. Florida crabs are harvested only for their claws, and the live carapace is returned to the sea. Both these species are sold into local West Florida markets, but there are also lucrative export markets in Asia that have been growing in recent years and driving up product values.

Crawfish harvests tend to fluctuate largely from year to year and tend to be highly influenced by weather events such as Hurricane Katrina. Landings of crawfish decreased by 25% from 2009 to 2010. Overall landings in the other crustaceans category show a decline from 2010 to 2012, which can be attributed to crawfish harvest declines. Because of the historical volatility of landings and sensitivity to weather events, it is difficult to separate these effects and definitively say this reduction was solely due to the oil spill. Another factor that has not been thoroughly examined, but may have influence on crawfish revenue, is the large increase of imported crawfish products from China in the past decade.

In the 2010, there was a large increase in dockside revenue compared to 2009 in the other crustaceans category. The state and species level harvest data in Chapter 3.8.2 indicate that this large increase is based primarily on price increases in spiny lobster and somewhat based on price increases in Florida crab. In general, a suite of factors can contribute to fluctuations in revenue, but in this particular case it appeared to be mostly driven by favorable market factors. The primary factor that influenced revenue in the spiny lobster industry in recent years has been the transformation of its production capacity from processed lobster to live lobster, to meet the demand of the high-priced live Asian markets. This transformation in markets is believed to have had a large impact on price received by the fisherman and driven up the revenues in the other crustaceans category. Note, however, that large price and revenue increases were in return for healthy live lobsters that are more costly to harvest, such that revenue increases may have been offset by higher cost of handling, masking any potential increases in net returns or profits (Spiny Lobster Review Panel Summary 2015). The magnitude of the 2010 increase in revenue was complicated by the fact that spiny lobster prices were at their lowest since 1970 in the 2009 harvest year, due to unprecedented weak global market demand (Vondruska 2010). In addition to these market factors, a lack of recent hurricanes, and potentially a reduction in recreational fishing effort during the early part of the 2010 summer due to concerns of the spill, could have contributed to the increase in commercial landings during the latter part of the damage period (Spiny Lobster Review Panel Summary 2015).

3.9 Summary of Seafood Industry Trends

After reviewing the regulations, harvest trends, supply chain, and market factors by key species category and state, we can identify some relative trends. Although it appears that landings decreased in most major fisheries due to the spill closures, based on the spatial and temporal nature of these fisheries we see that certain species and states appear to have been unaffected by the spill. When reviewing changes in dockside revenue of the species categories, we see that the situation is more complex due to the dynamic nature of markets and moving prices, and the same conclusions cannot be clearly drawn from the data. In general, it can be noted that a series of events external to the oil spill increased prices and overall revenues in 2010 and minimized potential damages that could have occurred if favorable market conditions had not existed during the damage period.

Distinct trends show the effects of the spill were focused in the geographic region closest to the spill and the areas that incurred sizable closures, primarily Louisiana, Mississippi, and Alabama (see section 2.2 for more details). In states further away from the spill that incurred minimal if any closures, like West Florida and Texas, effects on landings and dockside revenue seem to be relatively muted.

3.10 Seafood Compensation Program

Another approach considered in estimating losses to the seafood industry of the oil spill is to look at the amount paid through legitimate claims made to BP funds. This approach requires examination of the Seafood Compensation Program. A substantial amount of effort and funding went into the methodology and development of this program. This program is a concrete representation of how these impacts were quantified and paid out.

A $20 billion initial estimate of the potential damage of the spill was made and allocated to the *Deepwater Horizon* Oil Spill Trust. The trust was established by BP to settle claims resulting from the oil spill. The fund was established to compensate for natural resource damages, and to compensate state and local response costs, and individuals. The funds were distributed by the GCCF, established in June 2010 after a meeting of BP executives with U.S. President Barack Obama. In June 2012, the settlement of claims through the GCCF was replaced by the court-supervised settlement program.

The Seafood Compensation Program is a separate $2.3 billion fund established under the Economic and Property Damages Settlement. Its sole function is to compensate for economic damages suffered by seafood vessel owners, commercial fishermen, or seafood crew that owned, operated, leased, or worked on a vessel that was home ported in a Gulf coast community, or landed seafood in the Gulf coast area. The Program also specifically covers economic damages suffered by oyster leaseholders and IFQ owners, which includes participants in the reef fish programs in the Gulf.

Eligible claims were awarded to entities in the following categories:

- Oyster Leaseholders: Person or business holding one or more private oyster leases.
- Seafood Vessel Owners: Person or business who owns a vessel and earns income from leasing or renting that vessel to a commercial fisherman and/or oyster leaseholder; also may be a commercial fisherman if also a boat captain.
- Commercial Fishermen: Boat captains, including businesses who hold a commercial fishing license and make income from catching/harvesting and selling shrimp, oysters, finfish or blue crab/other seafood caught in certain Gulf waters.
- Seafood Crew: First Mate, Second Mate, or Boatswain working for a commercial fisherman; Deckhand whose primary responsibilities occur off-shore in certain waters (Deepwater Horizon Settlements 2012).

According to the settlement, the damage period is defined as the time between May and December of 2010. The definition of the damage period is important, because it determined the period over which businesses, including fishermen and fisheries and other supply chain participants, could claim compensation. Businesses could use any of the following three baseline reference periods, across the same months, to estimate a loss in dockside value or revenues loss: 2009; the average of 2008 and 2009; or the average of 2007, 2008, and 2009 (Settlement Agreement 2012).

The verification of earnings was based on tax records or other documentation sufficient to identify gross revenues. Though some commercial fishing fleets had improved their documentation practices due to missed opportunities to receive aid after Hurricane Katrina, many had not (U.S. Small Business Administration 2013). As an alternative, individuals were able to complete a Sworn Written Statement for Sufficient Documentation of Benchmark Revenue that includes the information required to identify revenue by vessel, catch types, and landing locations. Documentation showing revenue by vessel and catch types is evident in trip tickets if these are submitted. However, fishermen and dealers have noted that some individuals' trip tickets do not always accurately reflect revenue earned due to illegal landings for species out of season or brought in by unpermitted individuals. The extent to which this occurs is unknown.

Crew needed to submit tax records or pay period documentation to receive compensation. This can also be problematic, because crew arrangements with vessel owners are sometimes informal and crew are often paid in cash or in catch that they can sell, so there would not be an automatic paper trail. However, this often cannot be documented. The extent to which this occurs is also unknown. For these reasons, the claims distributed are very possibly an underrepresentation of actual seafood revenue effects.

Seafood processors are compensated separately under the Economic and Property Damages Settlement. The Seafood Compensation Program does not apply to claims relating to fishing, processing, selling, catching or harvesting of menhaden.

The Seafood Compensation Program has five separate plans to provide compensation, each of which has its own eligibility requirements, documentation requirements, and compensation method. The five categories are Shrimp, Oysters, Finfish, Blue Crab/Other Seafood, and Seafood Crew (excluding Boat Captains) for all seafood industries. Each claim category is divided into different claim classes. The class an individual is in depends upon the claims made, with the types of compensable claims determined by the relationship the individual has with the vessels used in the claims. These distinctions are important because each class may give an individual the chance to file a new/additional claim. They may fall within more than one seafood-type category if they distribute different types of seafood (Settlement Agreement 2012).

The deadline to file a claim under the Seafood Compensation Program was January 22, 2013.

After the Seafood Compensation Program initial funds distribution, any additional money left in the Fund will be distributed to those claimants who already received compensation. In other words, those who make claims now may later receive an additional share of this final distribution amount, which will be systematically distributed as lump sums. However, this process is being challenged due to accusation of fraud by plaintiffs (BP 2013).

If an individual made a claim and/or received compensation under the Seafood Compensation Program, they may still be eligible to separately receive compensation under other sections of the *Deepwater Horizon* Economic and Property Damages Settlement, or the Medical Benefits Settlement, depending on the nature of their loss.

In this way, the full amount of the Seafood Compensation Fund is the lower limit of the amount of compensation going to the seafood industry. Specifically, it is distributed only to those directly impacted by the oil spill. Processors, dealers, wholesalers, and fishing supply industries would be compensated through other fund sources.

As of January 21, 2015, approximately $1.104 billion has been offered and accepted by claimants to the Seafood Compensation Program. This amount was distributed to 4,747 unique claimants. This amount is the second largest portion of the total $4.399 billion dollars distributed, as of the date above, for all funds allocated to reimburse people and businesses harmed by the oil spill. The largest category was in Business Economic Loss, payments in this category totaled about $2.416 billion (Deepwater Horizon Economic Settlement 2015).

It should be noted that payments for cleanup operations in the VOO program and payments made through the Seafood Compensation Program were anticipated to increase the amount of money in the economy. It is believed that this helped to offset some of the losses to the seafood industry.

However, there were many other precursors, including rising fuel costs and hurricane damage (BOEM 2014 and U.S. Small Business Administration 2013), and the many other factors mentioned in this report, that determine the impact on an individual from the Seafood Compensation Program.

The Seafood Compensation Program was examined in this study, but claims estimates were not directly used in the model. Instead, examination of the program allowed for understanding and recognizing the nature of impacts, and the framework of the program assisted in structuring species categories and establishing the temporal period for the study.

Chapter Four: Economic Impact Model

This chapter begins with a review of the associated impact model literature that was used to determine the model structure and present a solid rationale for model choice and design. The chapter details the development and construction of the custom I/O impact model, and gives an overview of the multiplier construction, trade flows, margins, model structure, and assumptions. The methodology behind the model is presented, along with the model's assumptions and the source of the data behind the customization of the model. Options for input data are reviewed and set based on the time periods established by the settlement, and two different market scenarios are developed (market dynamic and market constant) that estimate impacts based on the dockside value changes.

4.1 Selection of Base Model

In an attempt to estimate the economic losses to the Gulf of Mexico seafood industry caused by the *Deepwater Horizon* oil spill, it is first necessary to identify whether to estimate the loss in *economic value* or the *economic impact* of the oil spill. Clarifying the difference between the terms "economic value" and "economic impact" is necessary, because they refer to different concepts that are uniquely suited for evaluating different types of changes in economies.

If a reduction in *economic value* were used to capture the effects of the oil spill on the Gulf coast region, the losses would be measured as the change in market value of seafood, less the value of fishermen wages, fuel, supplies, boat depreciation, and other resources that were not used to catch the seafood. This net change reflects the social welfare loss from the seafood industry (that could be added to recreational losses and non-market values), which is useful to policy makers who are considering how much future spending is justified to restore stocks (to regain the losses) or to prevent potential losses from future spills. Economic values are the basis of cost-benefit analysis of alternative projects or policies.

On the other hand, an *economic impact* analysis of the oil spill would capture the reduction in total economic activity (measured in jobs, personal income, sales volume, etc.) within a region and the distributional effects across sectors in the economy. The total economic impact of a contraction in seafood harvesting, including the secondary impacts on local employees and companies, is a measure of economic activity levels (as distinct from social or economic value). Economic impact analysis includes direct impacts on basic industries, secondary impacts on support industries, and finally the impacts on spending by labor employed in these industries. Because one of the major objectives of this study was to capture supply chain effects, we determined that calculating the economic impact of the oil spill to the Gulf region economy is the appropriate methodology for this assessment.

4.1.1 Types of Economic Models

Economic impact models are a representation of all the transactions in an economy, and allow analysts to outline the relationships between the production of goods and their final consumers. There are several approaches that can be employed to examine the economic impacts to the fisheries supply chain from exogenous shocks such as the oil spill. These approaches include models of the following four types: (1) Input-output (I/O), (2) Social Accounting Matrix (SAM), (3) Computable General Equilibrium (CGE), and (4) Econometric. Each is discussed briefly below to explain the strengths and weaknesses of each with respect to the overall selection criteria for this study.

The first type of impact models are I/O models; these models have been in use the longest of all types of economic impact models. As a result, they are used most frequently. These models take an accounting representation of the economy and translate exogenous demand shocks (such as a sudden drop in sales of seafood) into economic impacts (Kraybill 1994). The demand shocks must be estimated outside the I/O model and the estimated shocks are translated into economic impacts using multipliers generated in the I/O model to capture effects throughout the supply chain (Seung and Waters 2006).

I/O models (at the county, state, or national level) can estimate impacts for any type of demand shock, because they are based on a set of economic accounts that are updated every year; that is, the software is available for purchase each year. Because they are based on readily available data, they are simple and quick to use. On the other hand, commodity prices within the I/O model are fixed. Additionally, factor substitution in production is not allowed, nor is commodity substitution in demand. Because none of these items are allowed to vary within the model as a result of the demand change, I/O models can overestimate impacts. This is because the model cannot account for the behavioral changes of individuals and firms to compensate (and hence partially offset) the demand shock.

SAMs are an extension of I/O models that are expanded to include more details on income distributions. As a result, SAMs have the same drawbacks as I/O models, but also require more data (West 1995). The IMPLAN software package, however, includes a SAM, and the user can specify whether to use multipliers that incorporate the SAM data (MIG 2013). Because IMPLAN includes a SAM, most IMPLAN-based I/O analyses incorporate the SAM information. Generally, SAMs are also the starting point for the creation of CGE models.

CGE models overcome the fixed price model limitations of both I/O and SAM approaches. The CGE model uses basic economic accounts in a simulation model that allows prices and quantities to equilibrate after a demand shock (Rey 2000). Therefore, factor and commodity substitutions are captured. As a result, they can also estimate welfare impacts (i.e., changes in distribution of income effects across industries). On the negative side, CGE models require massive amounts of economic data, including demand and supply elasticities (i.e., the responsiveness of individuals and firms to changes in prices). CGE models also require complex and time consuming modeling and calibration. They also could underestimate impacts. The development of CGE models for fisheries would be extremely complicated because of the lack of available detailed data on fisheries supply chain sectors, and the responsiveness of each following the oil spill. Building such a model is beyond the scope of this project.

Finally, econometric models use regression-based approaches to estimate economic impacts. They are statistically rigorous, stochastic, and can forecast changes into the future. They require both time series and cross section data, and they require the most data of all the model types discussed here. Finally, when econometric approaches are used to estimate economic impacts, they can only estimate total impacts and have no ability to examine inter-industry linkages. Econometric models were not considered appropriate for this project.

Table 9 summarizes the strengths and weaknesses of these approaches. Though a couple of the approaches were ruled out due to complexity or unsuitability based on the objectives of the study, the table provides a mechanism to help with final model selection discussed below.

Table 9. Impact Model Types, Strengths and Weaknesses.

Methodology	Strengths	Weaknesses
Input Output (I/O)	Detailed inter-industry linkages Simple structure Flexible/adaptable Easily integrated with other approaches Starting point for CGE	Linear structure Static No supply constraint No price response
Social Accounting Matrix (SAM)	Same as above More details on interdependency, particularly for households	Same as I/O Large data requirements Overestimates impacts
Computable General Equilibrium (CGE)	Non-linear Can be stochastic Includes price effect Includes supply constraint Includes supply and demand substitution	Too flexible Even larger data needs Calibration challenging Huge analytical lift Underestimates impacts
Econometric	Statistically rigorous Stochastic Ability to forecast	Largest data requirements (time series and cross section) Total impacts only No ability to examine inter-industry linkages

Source: (Kraybill 1994, West 1995, Rey 2000)

After considering the modeling criteria established earlier, and the general strengths and weakness summarized in Table 9, we decided to use the I/O approach augmented with SAM data through the use of IMPLAN multipliers.

Though there are other choices for analyzing economic impacts, such as the ratio between total regional employment and fishing employment (Hartman 2002), the impacts are restricted in terms of metrics of economic activity generated, metrics that are available using the I/O output. In addition, assessing the economic impacts of commercial and recreational fisheries has also involved models that join economic and biological and/or ecological considerations. The underlying premise is that understanding natural resource public policy implications requires an understanding not only of economic effects and impacts on ecosystems, but also the interaction between these disciplines. These models represent a substantial departure from those that deal exclusively with economic impacts suffered by industries (the focus of this study).

4.1.2 The I/O Platform and Alternative Models

The general use of methodologies based on I/O to estimate economic impacts is made possible by the commercial availability of I/O models that can be adapted to the needs of many different kinds of analyses. A number of models are available, but Regional Input-Output Modeling System (RIMS) II, IMPLAN, and Regional Economic Modeling, Inc. (REMI) appear to be the most widely used in the estimation and analysis of economic impacts (Kirkley 2011).

These models offer broadly similar capabilities but have distinct characteristics. The U.S. Department of Commerce developed and offers RIMS II. IMPLAN was originally developed for the U.S. Forest Service and is now maintained by IMPLAN Group, LLC. Developed by Regional Economic Modeling, Inc., REMI combines an I/O model with econometric models that provide added capabilities, particularly a dynamic component that allows components of the model (e.g., population, factor prices) to change as the regional economy responds to new final demands. RIMS II and IMPLAN may be purchased by the user; REMI can only be leased (Lynch 2000).

IMPLAN is currently used almost exclusively for economic impact studies (Murdock et al. 2002). IMPLAN represents a middle ground between the simplicity and inflexibility of RIMS II and the complexity, cost, and substantial data requirements of REMI. IMPLAN is purchased as a set of software and datasets that allows the user to define regions and customize the I/O model. More recent versions of IMPLAN, particularly Version 3.0, allow the modeler even more flexibility to change the model and add sectors (MIG 2013). This flexibility and cost-effectiveness has helped IMPLAN become the industry standard for the estimation of economic impacts not only for commercial and recreational fishing, but also many other economic activities.

Economic impact models use final consumer purchases to track industry activity in the supply chain backwards from the consumer (Miller and Blair 1985). Unfortunately, retail data on consumer purchases of seafood is difficult to obtain, particularly from restaurants (Kirkley 2011). Instead, analysts often have access only to purchases made at various places in the supply chain before the product reaches the consumer. As a result, a special economic impact model has to be constructed to examine the typical economic linkages down the supply chain from the fisherman and the linkages forward in the supply chain to the consumers.

To examine economic impact forward of fishermen, price mark-ups or margins for the sectors forward in the supply chain need to be specified in order to determine the value entering the next industry link forward. For instance, the nationwide average processor mark-up is used to increase the landed price to the value the wholesaler would pay the processor. This procedure is repeated until the value paid by the consumer is estimated. Steinback (2004) has shown that this is mathematically equivalent to modeling the demand shock backwards.

Commercial fisheries sectors are not well described in the standard IMPLAN industry because of the relative small size of the fishing industry and the lack of standardized cost and earnings data on fisheries sectors. As a result, most fishery economic impact analysis first relies on modifying existing economic impact models or creating new economic impact models. The model developed by Kirkley (2011) can be adapted for use across the fisheries wholesale sector backwards and is one of the models discussed below.

In general, fishery impact models can be classified into three categories: coefficient models, spreadsheet models, or fully integrated models. The Fishery Economic Assessment Model (FEAM) is a coefficient model (Carter and Radtke 1986). The NMFS national model is a spreadsheet model (Kirkley 2011) and the Northeast Fisheries Science Center (NEFSC) model is a fully integrated model (Woods Hole Oceanographic Institute 2000).

The FEAM is based on IMPLAN and was developed for the West Coast Fisheries Development Foundation (Carter and Radtke 1986). FEAM was constructed to estimate regional impacts of fishery management changes by combining IMPLAN data with landings and other industry data focusing specifically on income impacts (Research Group 2000). As mentioned above, IMPLAN lacks detail on commercial fishing and processing sectors. FEAM addresses this shortcoming by constructing expenditure coefficients for these sectors. The model apportions fishery expenditures to existing IMPLAN sectors, such as fuel, labor, and other supplies.

Landings data drives the FEAM, and the model uses the Pacific Coast Fisheries Information Network standardized landings databases that include information on landing port, fleet characteristics, and onshore businesses. FEAM has a graphical user interface and the user can use menu selection to conduct analyses. These menus allow for some customization by changing model assumptions.

The model then estimates personal income associated with the volume and value of landings (or predicted change in landings). Because of its structure, FEAM calculates income estimates by geographic location. IMPLAN is organized around counties as a geographic delimiter, so FEAM impacts are also associated with the county of landing based on the location of the port of landing.

This, however, leads to one of the major criticisms of FEAM. The model does not track the flow of income in and out of counties, and assumes all activities accrue to the county. Therefore, FEAM may overestimate the impacts within the landing county and underestimate the impacts outside the landing county (Pacific Fishery Management Council 2004). Additionally, very little is known about how FEAM generates the commercial fishery-specific coefficients that interface with IMPLAN (Seung and Waters 2006). Regardless of these drawbacks, FEAM has been used numerous times for fishery economic impact estimation, mainly because of its ease of use and its linkage to readily available and standardized landings data (Leeworthy and Wiley 2000).

The NEFSC model is one of the most detailed disaggregated IMPLAN based models ever created for any sector. Instead of incorporating the commercial fisheries sector into coefficients as in FEAM, or building production functions that interface with IMPLAN multipliers as in the U.S. National Impact Model (USNM), the NEFSC model creates a series of additional sectors by region within the existing IMPLAN data, and thereby retains the full functionality of IMPLAN.

At the time of the NEFSC model's creation, base IMPLAN contained 528 sectors (Woods Hole Oceanographic Institute 2000). The NEFSC model included an additional 24 sectors across 11 coastal sub-regions, bringing the total sector count to 793 sectors (Woods Hole Oceanographic Institute 2000). In each region, 17 gear type-based seafood harvesting, dealer, processing, water transportation, shipbuilding and repair, and warehousing sectors were defined. The harvesting sectors were created using detailed industry cost and earnings surveys. The other sectors were constructed using survey data, published data, and informal industry interviews. These sectors were created in the IMPLAN format and the base IMPLAN data tables were edited to include these additional sectors. The model can be created within IMPLAN and the multipliers generated using the full functionality of IMPLAN.

The biggest strength of building these sorts of models is that the model retains all the functionality of IMPLAN, including the ability to trace all the inter-sector relationships. No other method described here allows this level of impact result disaggregation. However, this level of detail comes at a great cost in terms of data needs and model construction time. Creating such a model is beyond the scope of this project, and indeed, is usually beyond the scope of any economic impact project.

The review of I/O models shows that modifying IMPLAN and/or relying on base IMPLAN data and multipliers is the most flexible, most adaptable method, and the method best suited for this project. Within those approaches, adding new sectors to the base IMPLAN data is the best method retaining all the IMPLAN functionality, but is cost prohibitive and requires data that simply does not exist in the Gulf. Instead, spreadsheet models require less data and can be constructed more quickly. Though built external to IMPLAN, they are constructed using IMPLAN data and retain the ability to examine the impacts in the supply chain across the entities of concern to this project. However, they do not allow the disaggregation of those impacts to the ancillary industries.

In addition, BOEM already uses spreadsheet-type impact models like the U.S. National Model. MAG-PLAN is a large, multi-region model that calculates the economic impact of oil and gas exploration, drilling and production operations in the Gulf. Its construction is very similar to the U.S. National Model. One benefit of these types of models is their scalability. New sectors can be added easily. As product flow data improves or changes, the model can be quickly modified to take advantage of the new or better information.

4.2 I/O Model Development

Traditional I/O modeling relies on input of final demand that then trickles through the supply chain back to the product's origin. Typically, economic impact models begin an impact analysis by introducing a shock to a final demand sector. In the case of seafood, it would be ideal to present the change in consumer demand that resulted from the spill, but that information is impossible to obtain. Steinback (2004) showed that a backward linked model that begins with a shock to the harvesting sector produces the same results as starting with a final demand shock. Backward linked models start with landings and "push" those landings through each link of the supply chain. In fisheries, because almost no data exists on final demand or, more importantly in this case, final demand impacts resulting from the oil spill, the analysis must start with changes in the value of landings. For each link in the chain backward, only the value added, or margin, for that sector is included in the flow. Additionally, only the portion of the value added that accrues within the region is included.

In summary, the economic impact model will be a backward-linked model, which means impacts are calculated with losses from the harvest sector. This section details the multiplier construction, trade flows, and margins for this model. The harvesting sector and distribution sector multipliers will be obtained from the U.S. National Impact Model. Figure 51 shows the general structure of the impact model used for this project. The six sectors include: (1) Harvesters, (2) Dealers, (3) Processors, (4) Distributors, (5) Markets, and (6) Restaurants. Figure 51 shows the directional flow of seafood products and indicates where the multipliers for each link in the supply chain are sourced or constructed. Harvester and Distribution multipliers are obtained from the U.S. National Model (Kirkley 2011). Market and Restaurant multipliers are obtained from the IMPLAN model. The multipliers for the dealer, processor, market, and restaurant sectors will be obtained from the data contained in the 2012 IMPLAN model, but modified with data collected by the Gulf States Marine Fisheries Commission (Gulf Commission) data for the dealer and processor sectors. IMPLAN contains only a single processing sector. This processing sector will be heavily modified to create two new sectors: one for the dealer function and one for the processing function. The links in this chain are tied together using product flow and margin data from those same reports (Miller 2014a; Miller 2014b). Not shown in Figure 51 are exports; however, the model includes the leakages in the supply chain due to exports, and exports leave the supply chain at each sector downstream of the consumer. The trade component of the model is detailed below and referenced in the “Trade Flows” in Figure 51.

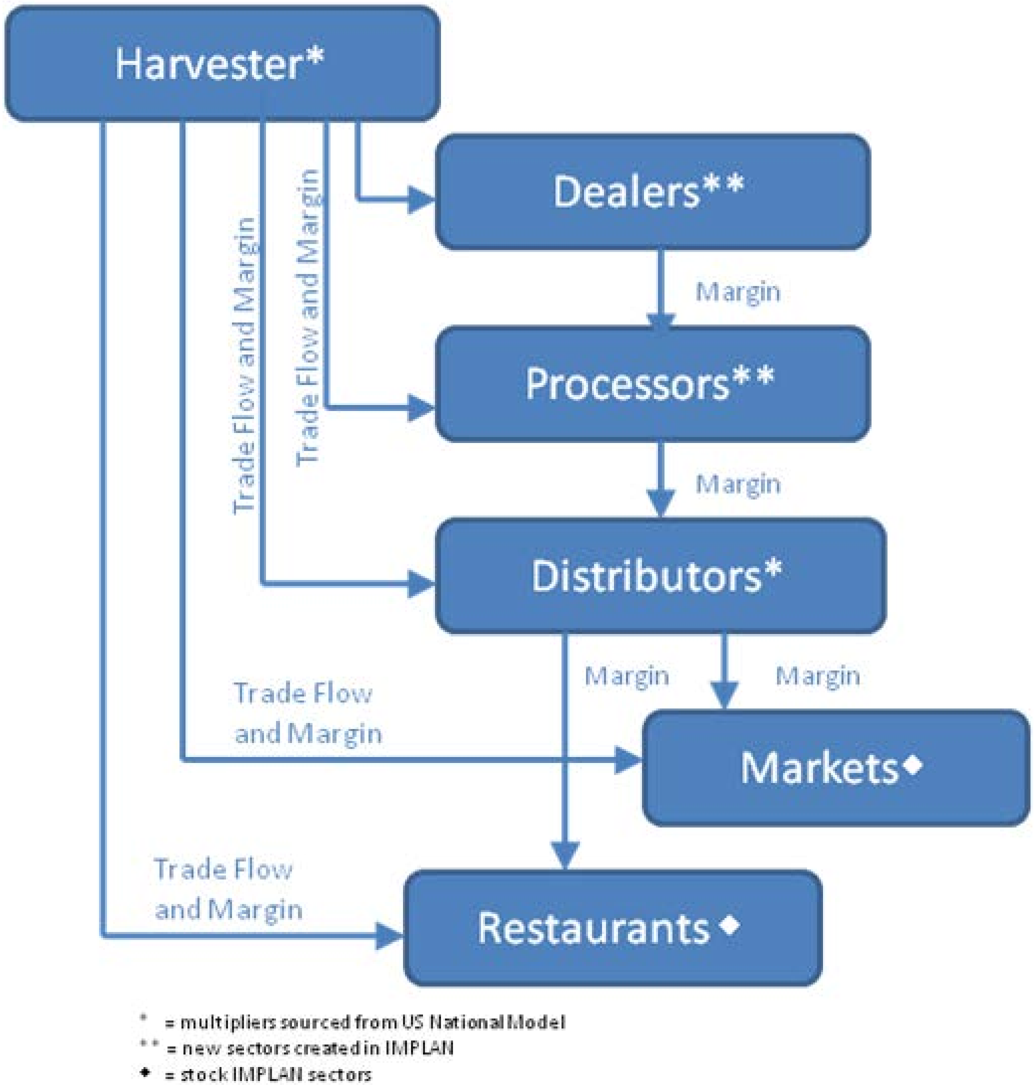


Figure 51. General Schematic of I/O Model Components, Product Flows, and Data Sources

4.2.1 U.S. National Impact Model

USNM was developed in response to a lack of basic data on fishery supply chain sectors in the basic input output accounts for the country maintained by the Department of Commerce. Because of this basic lack of data, NMFS developed a backward-linked model of the U.S. seafood supply chain by species group/gear type harvesting sectors. This model disaggregated harvesting into ten species groupings based on gear type, similar production technologies, and similar cost structures across these groupings (see Table 10 below).

That lack of data regarding fishery supply chain sectors exists today, although is it slightly better. IMPLAN now contains seafood harvesting and seafood processing sectors, but the cost and earnings data used to construct the gear type/species production functions from the NMFS model are superior, because they were created by those with more knowledge of seafood value chains.

(IMPLAN was originally created for land-based applications.) For this project, the shrimp sector, reef fish sector, crab, reef fish, and menhaden gear type/species production functions were based on cost and earnings data collected directly from those harvesters (Kirkley 2011).

The USNM is a true spreadsheet model; it was created in Microsoft© Excel©. The majority of the models examined for this study are of this type. This report will not discuss each model examined, because the USNM is the best example of the type. Additionally, the USNM is the best-documented model of this type. The USNM also provides the basic structure and much of the data used in the creation of the model used for this project.
The USNM contains a series of six linked worksheets, and general model operation is diagrammed in Figure 52. The model contains macros that download current NMFS online landings data and allocate the landed value into species/gear type sectors. The model then uses a backward linking or margining process to allocate demand to processor/dealer, wholesaler, and retail sectors. The model then outputs total sales, value-added, income and employment by harvesting, processing, wholesaling and retailing sectors. The retail sector is divided into grocery stores and restaurants.

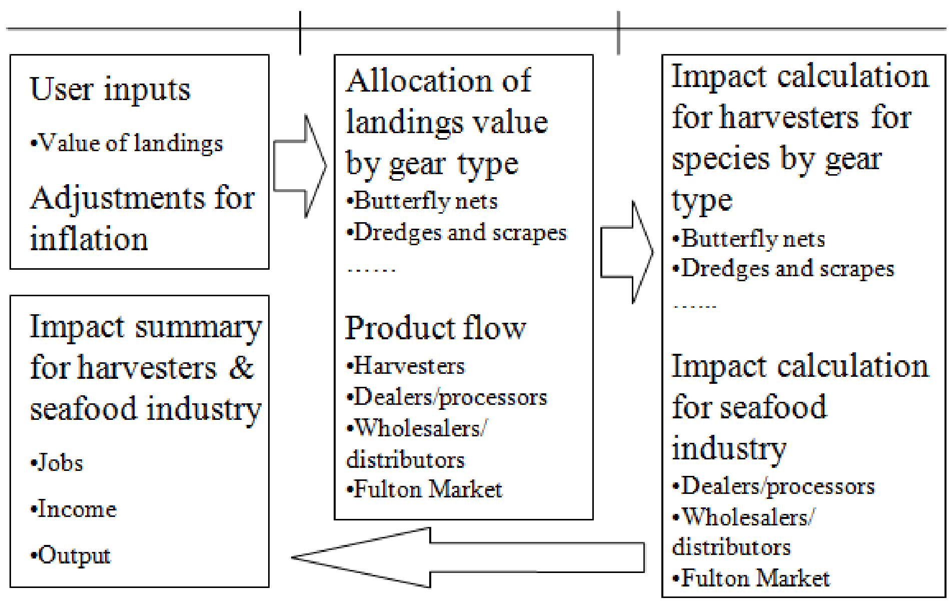


Figure 52. Overview of National I/O Model (Kirkley 2011)

The model creates 18 gear-based sectors; shrimp, crab, lobster, East Coast groundfish, highly migratory species, reef fish, West Coast groundfish, halibut, menhaden/industrial, salmon, sea scallop, surf clam/ocean quahog, other trawl, all other finfish, all other shellfish, freshwater, inshore and miscellaneous and bait. Those sectors include the following gears: butterfly nets, dredges and scrapes, gill and trammel nets, hoes, tongs, picks, rakes and hooks, hand lines, longlines and trolling, pots and traps, pound, fyke, hoop nets, haul or purse seines, trawls, and miscellaneous not-otherwise-specified gears. Cost and earnings data from NMFS surveys, published sources, and key informant interviews were used to build spreadsheet-based "production functions" for each of these gear types. These production functions are a linear spending of landed revenue into IMPLAN sectors.

Summarized from Kirkley (2011), NMFS provides landings data and these species were aggregated to increase modeling tractability. The landings scenarios analyzed here were first grouped into similar groupings for the same reasons. The USNM is designed to take these aggregated landings and estimate the economic impacts from the harvester to the consumer.

Landed revenue is allocated to these gear types by species group aggregations listed in Table 10. Landings from NMFS are first aggregated into these groups. Then the landed value (revenue) in each of these 18 groups is allocated across the ten gear type production functions pertinent to Gulf species aggregated for this analysis. The species/gear groupings were designed to reflect a general understanding of fish and seafood products. In some cases, a given species (e.g., shrimp) is sufficiently important to warrant its own category, particularly in the Gulf. On the other hand, many species are either byproducts in another species' production process, or belong to a fishery that is so small that cost and earning data will likely never be collected. In those cases, those species have been included in the "all other finfish" category. Because the NMFS landings data report gear used to harvest fish and there are many gear types used, a similar aggregating strategy was used to condense gear types, and then species groups were combined with gear types used most frequently to target those species.

For this spreadsheet model, the harvester multipliers by species/gear type were taken directly from the USNM. The multipliers for the seafood distribution sector were also taken from the USNM. There is no seafood distribution sector in IMPLAN, so Kirkley (2011) aggregated several IMPLAN distribution sectors.

Table 10. Species Groups and Gear Types

Species group	**Major species in group**
Shrimp	All shrimp
Crab	All crab except blue crab
Lobster	American lobster
East Coast Groundfish	Cod, flounder, goosefish, haddock, hake, plaice, pollock, shark (dogfish)
HMS	Shark (other than dogfish), swordfish, tuna
Reef Fish	Gag, grouper, mackerel (king & Spanish), snapper, tilefish
West Coast Groundfish	Cod, hake, pollock, rockfish, sablefish, sole, whiting
Halibut	All halibut
Menhaden/Industrial	Alewife, ladyfish, menhaden
Salmon	All salmon
Sea Scallop	All scallop
Surf Clam/Ocean Quahog	Surf clam, ocean quahog, quahog
Other Trawl	Anchovies, croaker, herring, mackerel (other than king & Spanish), mullet, sardine, shad, squid
All Other Finfish	Amberjack, drum, hind, pompano, porgy, scad, sea bass, tautog

All Other Shellfish	Clam, spiny lobster, mussel, oyster, sea urchin, snail (conch)
Freshwater	Catfish, crawfish, perch, tilapia, trout
Inshore and Miscellaneous	Bass, blue crab, seaweed, sponge
Bait	Worms, bait fish

Source: (Kirkley 2011)

From the harvester forward, industry margins, also called mark-ups or value added, are applied to the revenues entering in the previous link in the supply chain. The marked up value is then applied to the appropriate IMPLAN sector. For instance, a dealer/processor buys product from a harvester. That dealer/processor adds value to that product at an estimated 65%. That is, if the dealer/processor purchased that fish for $1, she sells it to the next link in the supply chain for $1.65. It is only the value added, or $0.65, that is then applied to the dealer/processor sector in IMPLAN. The original $1 is applied to the harvesting sector described above. This process continues until that $1 of seafood has been carried through the supply chain all the way to the consumer. The total impact is therefore the sum of the impacts across all of these seafood supply chain sectors. As long as only the margined amounts, or value added amounts, are used in the analysis, no double counting occurs.

After exhausting all harvester cost data, production functions could not be constructed for all gear types in the USNM (Kirkley 2011). In addition, as much as 33% of reported landings do not list a gear type, and 6% list “combined, unspecified” in 2001. To handle the unallocated landings within the USNM, the model distributes these unspecified landings using the proportions of the total across all other gear types from the specified gears.

Finally, the USNM did not construct Gulf regional multipliers for either the harvester sectors or the wholesale sector. The USNM constructed state level and U.S. level multipliers. Because this project requires a Gulf regional multiplier, the U.S.-level multipliers were used as proxies for Gulf regional multipliers. It is likely that this substitution overstates the actual impact for the harvesting and distribution sectors at the Gulf region level. However, it is likely the overstatement is slight, considering the data from the Gulf Commission reports detailed below (Miller et al. 2014a and 2014b). Those reports indicate that majority of the seafood that is not exported out of the U.S. stays within the region for dealing and processing. Because the Gulf region has a well-developed fisheries equipment supply industry, it is likely that leakages out of the Gulf region in the indirect phase are small. Both of these facts indicate that the difference between a Gulf region multiplier would not be very much smaller than the U.S. Region multipliers used for both the harvester and distribution sectors.

The model has the limitations listed above, but these limitations have very little impact on the use of this model for Gulf fisheries for several reasons. First, gear type will be specified for all landings and so the proration of unspecified gears will not be necessary. Second, only butterfly nets and hand oyster gear, gears proxied in the model, are used in the Gulf. Both of these gears are used on a very limited basis. Third, the cost and earnings data and the product flow data for shrimp in this model come from Gulf studies.

4.2.2 IMPLAN Modeling: Dealer, Processor and Retail Multipliers

IMPLAN is a commercially-available software tool that takes government labor and business transaction data and creates a series of national input/output structural matrices. The software is a user-friendly interface to these structural matrices that allows the analysis of regional economic impacts by state, and those underlying data matrices are updated annually, usually lagging two years behind the current year. This project will use 2012 IMPLAN data because it was the most recent data available when this project began. This software is widely accepted as the industry standard for regional economic impact modeling and is widely used in the private sector and across many government agencies.

IMPLAN is a software tool that takes their proprietary input-output tables and allows the user to edit those tables, define the analysis region and construct multipliers based on those changes. For this analysis, an IMPLAN model was created for each state and for the Gulf region as a whole. IMPLAN has also added the flexibility to heavily edit nearly all the data within their model including creating new sectors. Since the USNM was created, IMPLAN has added a seafood processing sector to the sectoring scheme used. As a result, this model uses the 2012 IMPLAN seafood processing sector as the template for both dealers and seafood processing sectors using the Gulf Commission reports (Alexander et al. 2014a, 2014b).

Though the harvesting sectors were created by state and species, the other sectors in the supply chain are disaggregated only by state. That is, each state model contains ten harvester sectors by species that interface with a single dealer, processor, wholesale and retail sector. The Commission survey did not achieve a high enough response rate to disaggregate the dealer, processor, wholesale, and retail sectors by species. This is assumed to have very little impact on the multipliers produced in the model as, typically, the farther up the supply chain from the harvester one goes, the less species-specific their production process. For instance, shrimp-only processing facilities exist, but there are no shrimp-only restaurants or shrimp-only seafood counters in the grocery store. Even if there were a shrimp-only restaurant, it is unlikely that its cost structure would be any different than any other restaurant with similar costs for the main dish. However, a shrimp processing plant is likely to have different cost structures and potentially different multipliers than a processor that handled all seafood products. It is assumed that the impact of having a single processing sector in each state and for each species is small.

4.3 Construction of Overall Impact Model Structure

This section details how the completed multipliers for each species harvesting sector are assembled after creating the other sector multipliers using trade flows and margins to create the total model of the Gulf seafood supply chain. This section will address the pitfalls and assumptions found in putting together these types of complex impact models. Sections below detail avoiding double counting, creating the remaining supply chain sector multipliers, developing trade flows, developing sector margins and detailing the assumptions necessary to use this modeling framework.

4.3.1 Avoiding Double Counting

To correctly estimate a backward linked model, the multipliers must be modified for each link in the chain to prevent purchases from the previous link in the chain in order to prevent double counting. For instance, to create the dealer multiplier, the harvesting sector must be shut off because the harvesting impacts have already been accounted for in the harvesting multiplier. Again, for the processor, both the dealer sector and the harvesting sector would need to be shut off when creating the processor multiplier to avoid double counting for those fish that moved from the harvester to the dealer to the processor. To avoid double counting, the regional purchase coefficient for each sector already accounted for is set to zero. The model for each state and the region is re-inverted and the multipliers are re-created. This creates a complicated matrix of multipliers, because this model allows product to skip various links in the chain, as reported in the product flow data from the Gulf Commission reports.

4.3.2 Creating Dealer, Processor, Distributor and Retail Sectors

The market and restaurant multipliers were created first. To create the restaurant multipliers, any seafood purchasing was turned off in the base model, as described above, and the multipliers reconstructed. This process was repeated for dealers and processors. The multipliers for each state and the entire Gulf across the three impact types (direct, indirect and induced) and the four impact metrics (total sales, value added, income and employment) were exported to the multiplier database created above for harvesters and distributors.

Next, the processing and dealer sectors were created by modifying the IMPLAN processing sector using the Gulf Commission reports for each sector. IMPLAN uses sector “production functions” to represent the spending pattern for each sector. These production functions are the heart of economic impact modeling. They are not production functions in the traditional econometric sense, but are a proportional representation of spending patterns for that sector. That is, an IMPLAN production function describes what a sector is required to purchase from all other sectors to produce $1 worth of total sales. The data from the Gulf Commission reports on input purchasing behavior was converted from average dollars spent to percent of total expenditures as in Kirkley (2011), because the IMPLAN production functions are built in percentage form. Once these percentage production functions were created for each state and the entire region, the IMPLAN processing sector’s production function was modified to account for the more accurate data.

The most striking finding in comparing the base IMPLAN data to the Commission data is that the Commission report found that processors and dealers spent a higher percentage of their input expenditures on purchasing seafood inputs than the IMPLAN data indicated. Because the Regional Purchase Coefficients for harvesters were zeroed to avoid double counting, this had the effect of pulling those multipliers down from the IMPLAN estimates in the model.

After the production functions had been modified, employment information, also supplied in the Commission reports, was also modified in IMPLAN. Using total output for each sector and total employment in each state, output value per worker was modified to reflect the Commission data. Output value per worker is a major driver of employment and induced impact multipliers. The total number of employees was also modified in IMPLAN based on the data in the Commission reports. Once these two modifications to production functions and employment were made, the multipliers were re-created for each state and the region as a whole.

Though the Commission data was not reported at the state level, updating the production functions for each state in IMPLAN based on Gulf-wide production functions generates different multipliers in each state, because each state has a different industry structure and because the output per worker and total employees was different for each state. The Commission reports did not report balance sheets at the state level due to low sample sizes and potential confidentiality issues.

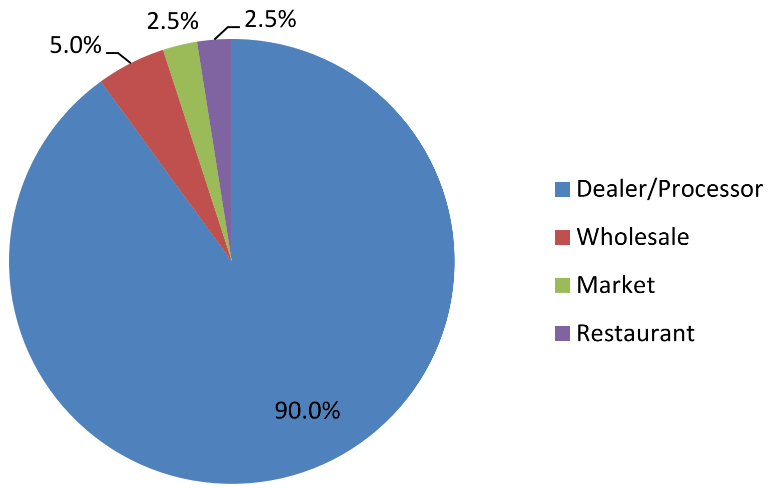
The same process was used to construct the dealer sector using the IMPLAN processing sector. Using the processing sector as a proxy for the dealer sector was necessary because the commission reports did not contain enough data to construct a completely new sector and the dealer and processing sectors are typically quite similar, with some dealers acting as dealer/processors. The Kirkley (2011) model used only one sector, a combined dealer/processor sector.

Again, after these modifications were made to each sector and in each state, the matrices were re-inverted, re-creating the model and social accounting matrices, and the multipliers were then re-created. This was done for each state and the region as a whole. The multipliers, three for each impact type and four for each impact metric, were exported and added to the matrix of multipliers referred to above.

4.3.3 Product Flows

After the multipliers have been created, trade flows are used to direct the flow of seafood to each link in the chain as shown in Figure 51. The trade flows are used as a road map to direct the margined values from the previous sector into the next sector in the chain. The Commission reports were very helpful: they illustrate the complex patterns seafood takes from the harvester to the consumer. All Dealer and Processor trade flows come from the Commission report, and the harvester and wholesale trade flows were sourced from the USNM. The model constructed for this study takes full advantage of that information, allowing for a complicated flow that skips certain links in the chain at certain times. All direct-to-public sales are applied to the markets multiplier using the markets margin. This assumes that the harvester, dealer, processor, or wholesaler that sells directly to the public has a similar cost structure as the market sector in IMPLAN. The impact of this assumption is unknown; however, it is likely very small.

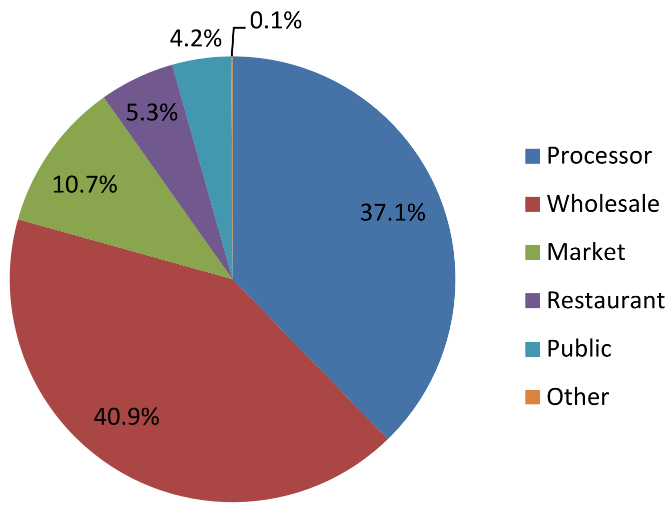
USNM product flows were averaged at the U.S. level and used for harvester and wholesale sectors, because this information was not available from the Commission reports. The flows for the processor and dealer sectors were taken from the Commission reports. The flows were not published at the state level due to small sample sizes and potential issues with confidentiality in the Commission reports. Across all states, the Gulf region average trade flows were used for processors and dealers. In all cases it was assumed that “Other” in the Commission report was a direct to consumer sale. This likely biased the multipliers upwards, because some of this “Other” category was probably business or family gifts or barter in the community generating no additional economic activity. Figure 53 displays who the harvester sells to and by what percentage of the landed seafood. It was assumed, as in the USNM, that 100% of harvester to dealer transactions stays in the state of harvest. The USNM did not separate the dealer and processor sectors, as this model has done. As a result, the flow of seafood going to the dealer/processor sector in the USNM was assumed to be divided equally between the two separated dealer and processing sectors in this model. This model used the harvester trade flows in the USNM for the Gulf region, where 90% of all landed seafood is assumed sold to a dealer/processor, with 45% being a dealer sector and 45% flowing to the processing sector. Only 5% goes directly to wholesale, only 2.5% is sold directly to restaurants, and 2.5% is sold directly to markets.



Source: (Kirkley 2011)

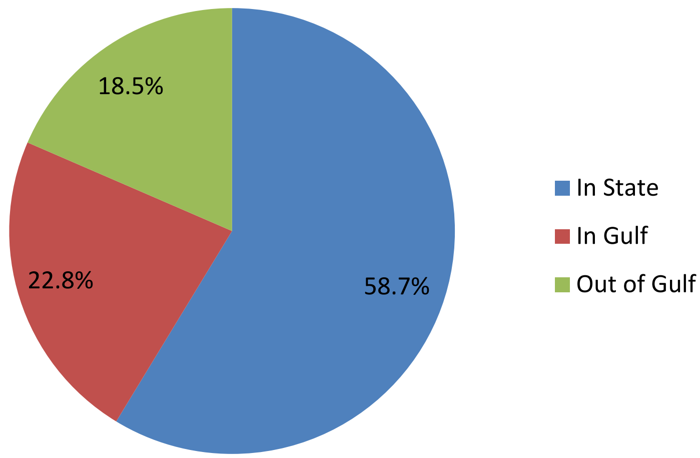
Figure 53. Harvester Sales to These Sectors by Percent of Value

Figure 54 details the sectors the dealer sells to and the percentage of sales going to each sector. In the Gulf, 40.9% of seafood by value is sold directly to the wholesale sector and 37.1% is sold to processors. Of the approximately 20% remaining, 10.7% is sold to markets, 5.3% directly to restaurants, and 4.2% to consumers. Figure 55 details the flow of the seafood products from the dealer regionally. The majority, 58.7%, of the seafood leaving the dealers stays in the state where it was landed, 22.8% leaves the state but stays in the Gulf region, and 18.5% leaves the Gulf region entirely and is considered a “leakage” from the model (i.e., no further economic activity is included in the model calculations).



Source: (Kirkley 2011)

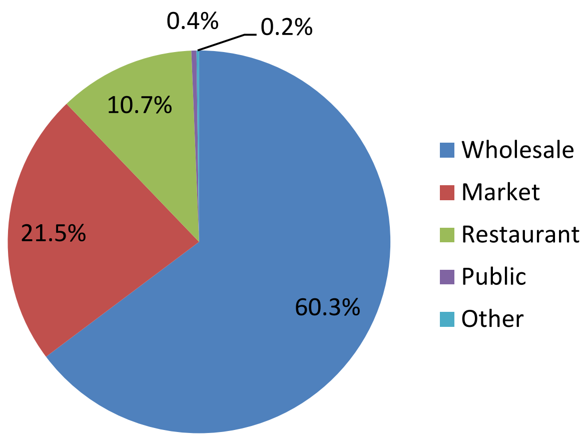
Figure 54. Dealer Sales to These Sectors by Percent of Value



Source: (Kirkley 2011)

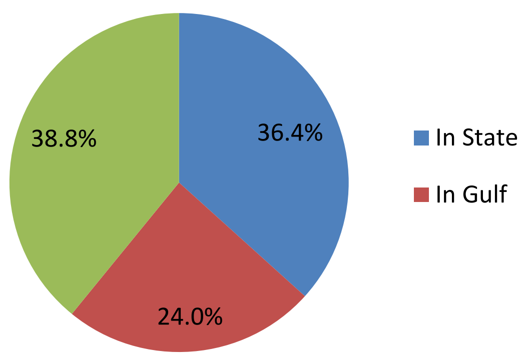
Figure 55. Destination of Seafood When it Leaves Dealer

The next link in the supply chain, processing, is detailed in Figure 56. The majority, 60.3%, of processed product flows into the wholesale sector, as one would expect. The next largest amount, 21.5%, flows to the market sector and 10.7% flows to the restaurant sector. Only 0.4% and 0.2% flow directly to the consumer and other, respectively. Figure 57 details where, regionally, processed product goes: 36.4% stays in the state it was landed, an additional 24.0% stays in the Gulf region, and 38.8% leaves the Gulf region.



Source: (Kirkley 2011)

Figure 56. Processor Sales to These Sectors by Percent of Value

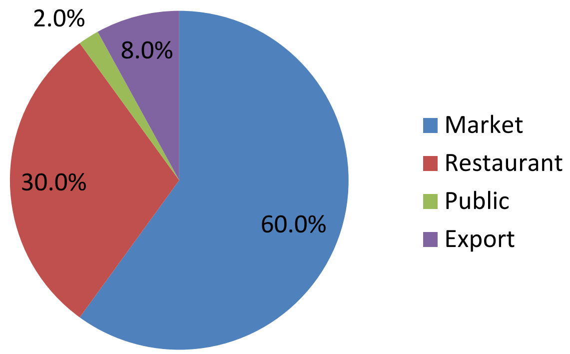


Source: (Kirkley 2011)

Figure 57. Destination of Seafood When it Leaves Processor

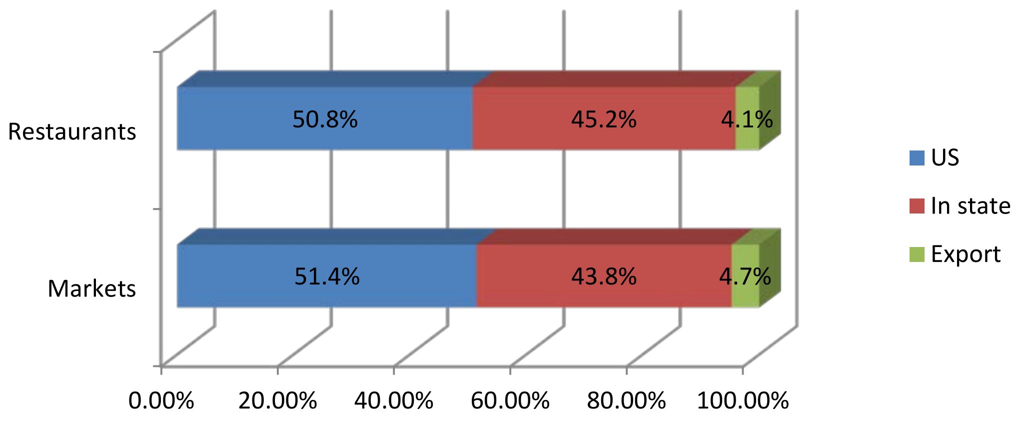
Figure 58 shows that 60% of the product entering the distribution sector passes to markets, 30% goes to the restaurant sector, 2% goes directly to the public, and 8% goes to export. These figures are taken from the USNM and are fixed for every state in the U.S. Figure 59 details the trade flows within the region from wholesale to the two retail sectors. Wholesale trade flow was taken from the USNM. Because that model did not construct a Gulf subregion, as discussed above, it is unknown how much product stays within the Gulf region during wholesale distribution. Figure

59 indicates that 43.8% of 60% of seafood product entering the distribution sector goes to markets in the state where that seafood was caught. Figure 59 also indicates that 45.2% of the 30% of the seafood entering the distribution sector passes through to the restaurant sector in the state where the seafood was caught. For the purposes of this model, it is assumed that 100% of the portion that stays in the U.S. also stays in the Gulf region. This assumption will produce a multiplier for these sectors that is larger than the true multiplier if any of that seafood is sold outside the Gulf region.



Source: (Kirkley 2011)

Figure 58. Wholesale Sales to These Sectors by Percent of Value



Source: (Kirkley 2011)

Figure 59. Destination of Seafood When It Leaves Wholesale

4.3.4 Margins

Margins are the next link in the creation of the model. For a backward-linked model, only the margin is passed forward to the next link in the chain. The margin is the amount of value added to the product in the current link in the supply chain. It is often called mark-up at the retail level. Margin information can be very difficult to obtain quantitatively, because businesses view their margins as proprietary. In this effort, the margins for the distribution, restaurant, and market participants are taken from the USNM. Margins for the dealer and processor sectors come from the Gulf Commission reports and are averaged across the Gulf region. Table 11 contains the margins used for this model. Blanks in the table means the data is not included in that particular source.

Table 11. Supply Chain Margins by Value Chain Sector and Source

Sector	Markup Commission Report	U.S. National Model
Dealer	16.4%	128.9%
Processor	27.7%	
Distribution		62.7%
Restaurant		182.4%
Markets		33.4%

Because of globalization, increases in imports, and increasing prices for high-quality domestic seafood, it is widely held that margins in the retail sectors have been trending downward (Kirkley 2011). It is likely that the margins in the USNM overstate current industry margins, which have the effect of increasing the impacts from this model over what they would be with more up to date margins. This difference can be seen in Table 11. The dealer margin from the Gulf Commission is nearly eight times smaller than the dealer/processor margin from the USNM. Even if the margins for the dealers and processors from the Commission Reports are combined, they are still nearly three times lower than the USNM margins.

4.3.5 General Model Assumptions

Beyond the assumptions listed above in each individual section, there are some general assumptions for all I/O models that also apply. All I/O models are linear representations of complex systems. Therefore, many simplifications and generalizations were made to construct this model. Additionally, all I/O models are static. They are created using data from a period in time that do not allow prices to change or production functions to adjust to change in product volume or product price.

All I/O models assume constant returns to scale. That is, the same quantity of inputs is needed for each unit of output. This holds for all productions levels. All I/O models assume there are no supply constraints. That is, there are limitless raw materials, and there is no demand change large enough to consume all the supply of any input. This is less of a concern for examining reductions in supply, as were examined here.

All I/O models assume that supply and demand are fixed. Because supply and demand changes may precipitate changes in an industry’s cost structure and product flows, I/O models based on static data cannot capture these changes. A sector’s production function is a weighted average of the inputs required for the production of the primary product and all of the sector's by-products. This is a common limitation of I/O modeling, and has little impact if supply and demand are not changing. However, this spill and the subsequent closures and marketing campaigns likely had some impact. This assumption means that no industry in the supply chain will adjust their production technology. That is, for example, dealers and processors may have changed the types of things they produced based on changes in availability of inputs post-spill or changes in prices of inputs post-spill.

Similarly, I/O models are not dynamic from a price standpoint. This is part of the reason two scenarios are presented in the results in the next chapter. The first scenario looks at what happened a year on, and the second scenario tries to hold price effects constant. Reductions in supply drive prices upward. Exogenous shocks, like those in the import shrimp market discussed previously, can also drive domestic prices up. Seafood safety concerns likely decreased demand, pushing prices downward. Seafood marketing campaigns likely partially offset (to an unknown degree) seafood safety concerns, having a positive price effect. I/O models cannot capture these effects internally, and this effort focuses on using scenarios that help illustrate the impact of the dynamism of prices.

4.4 Derivation of Input Data

The periods used in the Settlement Agreement (2012) were reviewed to determine the baseline periods for this study. The scenarios presented below were developed in line with the three baseline periods: 2009; the average of 2008 and 2009; and the average of 2007, 2008, and 2009. The use of these baseline time periods is discussed in Section 3.10 of this report relative to the Seafood Compensation Program.

Based on the examination of the baseline periods compared to 2010, we determined that the 2009 period appeared to be the most representative period for this study. Using 2009 as the baseline year allows for comparison to the closest time period and enables basic calculations of the two scenarios that have been chosen. For this research, the established baseline periods were further developed by creating two scenarios using 2009 as the baseline, one based on the change in dockside revenue, Market Dynamic, and the other based on the change in dockside revenue but holding price constant at 2009 levels, Market Constant. This second scenario was developed to capture the change in landings with the intent to rule out all other market changes, all other things being held the same.

Table 12 presents the harvester revenue changes relative to the 2010 period across the scenarios considered for this study. It is apparent that the least negative harvester revenue scenario is the Market Dynamic scenario, with a $7.5 million dollar loss, and the Market Constant scenario is the largest, with a $141.1 million dollar loss. These two scenarios best represent a low estimate and high estimate of the dockside revenue impacts, and so were used in the model as input data to simulate impacts down the supply chain.

Table 12. Change in Dockside Revenue of Baseline Options

Species	Market Constant (2009)	Market Dynamic (2009)	2008–2009 Average	2007–2009 Average
Shrimp	-$79,875,900	$15,622,579	-$10,868,692	-$16,075,751
Blue crab	-$8,774,918	-$2,408,376	-$943,814	-$1,741,477
Oysters	-$21,855,409	-$18,909,982	-$14,624,461	-$11,071,846
Menhaden	-$18,006,707	-$10,654,667	-$11,146,529	-$8,475,872
Reef fish	-$5,901,930	-$4,131,149	-$3,798,319	-$2,764,298
Pelagic finfish	-$5,562,246	-$6,502,469	-$5,573,132	-$4,809,847
Other crustaceans	$1,150,730	$21,189,942	$20,300,920	$12,732,634
Bait	-$758,340	-$325,910	-$427,051	-$130,682
Other shellfish	$207,530	$62,652	$76,349	$41,135
Miscellaneous finfish	-$1,696,938	-$1,395,770	-$2,570,569	-$2,299,290
Totals	**-$141,074,128**	**-$7,453,150**	**-$29,575,298**	**-$34,595,294**

Source: NMFS Commercial Landings Statistics

4.4.1 Scenario 1: Market Dynamic: Change in Reported Dockside Value

The first scenario relied on the reference periods established in the lawsuit. The lawsuit established the period from May 2010 to December 2010 as the damage period. Earlier in the report, the three baseline periods were detailed, comparing the 2007–2009 average landings, 2008–2009 average landings, and 2009 landings during the same months. It was found that the difference in landings was smallest when comparing May–December 2009 with May–December 2010. This was chosen as the lower bound estimate of economic impacts.

This scenario (Table 13) examines what happened immediately following the spill. Note that negative values are decreases in revenue, and positive values are increases in revenue. This scenario takes into account, but does not control for, the dynamics that occurred across most fisheries due to both the short-term reduction in seafood supply and the price increases due to exogenous changes in imports. Several markets experienced price shifts due to global seafood market changes that are captured in this scenario. Overall, summing across all the cells in Table 13, the Gulf experiences a loss of $7.5 million. Under this scenario, the largest loss was across Oysters in Louisiana ($21.5 million). The largest gain was shrimp in Texas ($37.7 million).

Table 13. Scenario 1: Market Dynamic Input Data

Scenario 1 Input Data	Alabama	Florida (West Coast)	Louisiana	Mississippi	Texas	Species Group Total
Shrimp	-$12,637	$3,967	-$9,477	-$3,918	$37,689	**$15,623**
Blue crab	-$201	$2,277	-$5,472	-$91	$1,078	**-$2,408**
Oysters	$0	-$7	-$21,545	-$2,724	$5,367	**-$18,910**
Menhaden	-$30	$4	-$878	-$9,751	$0	**-$10,655**
Reef fish	-$725	-$2,789	-$1,523	$0	$905	**-$4,131**
Pelagic finfish	-$4	-$1,359	-$5,139	$0	$0	**-$6,502**
Other crustaceans	$0	$24,380	-$3,139	$0	-$51	**$21,190**
Bait	-$90	-$500	$187	$12	$65	**-$326**
Other shellfish	-$48	$131	-$21	-$9	$9	**$63**
Miscellaneous finfish	-$120	-$1,200	-$43	-$146	$112	**-$1,396**
State Total	**-$13,856**	**$24,904**	**-$47,050**	**-$16,626**	**$45,175**	**-$7,453**

(Dollar Values are in Thousands of $US)

4.4.2 Scenario 2: Market Constant: Change in Reported Landings Valued at Pre-Spill Price

The second scenario attempts to examine the change in the industry holding prices constant and focusing simply on the reduction in landings. The scenario was constructed by taking the percent reduction by species in landed volume between the reference periods in 2009 and 2010 and applying that percent reduction to 2009 landed value. The percent reduction was calculated for each species group and was run through the model by species. This, in effect, holds prices constant and looks at the loss only in landings terms. As a result, this scenario represents an upper bound on the impact of the spill on local fishing communities, whereas the previous scenario examines the impact of what happened, including the impact that increased prices, both from the reduction in supply from the spill and from other exogenous market factors.

As can be seen in Table 14, under this scenario, the biggest loss was across shrimp in Louisiana ($36.2 million). The largest gain was other crustaceans in West Florida ($4.8 million). In West Florida there were some large increases in revenue attributed to spiny lobster which appeared to have created this gain. Across this entire scenario, the loss to the Gulf seafood supply chain is $141.0 million.

Table 14. Scenario 2: Market Constant Input Data

Scenario 2 Input Data	Alabama	Florida (West Coast)	Louisiana	Mississippi	Texas	Species Group Total
Shrimp	-$19,483	$2,332	-$36,159	-$6,983	-$19,583	**-$79,876**
Blue crab	-$279	$2,697	-$11,964	-$98	$870	**-$8,775**
Oysters	$0	-$779	-$22,397	-$2,814	$4,134	**-$21,855**
Menhaden	-$27	-$8	-$8,517	-$9,455	$0	**-$18,007**
Reef fish	-$719	-$4,440	-$1,512	$0	$769	**-$5,902**
Pelagic finfish	-$4	-$416	-$5,142	$0	-$1	**-$5,562**
Other crustaceans	$0	$4,779	-$3,577	$0	-$51	**$1,151**
Bait	-$203	-$790	$181	$5	$49	**-$758**
Other shellfish	-$60	$281	-$18	-$10	$14	**$208**
Miscellaneous finfish	-$203	-$165	-$1,111	-$229	$11	**-$1,697**
State Total	**-$20,979**	**$3,491**	**-$90,216**	**-$19,583**	**-$13,789**	**-$141,076**

(Dollar Values are in Thousands of $US)

It is difficult to compare the multipliers used in this analysis to those in USNM for a number of reasons. First, Fisheries Economics of the United States (FEUS) does not publish species-specific estimates in their impact estimates, and so only aggregate totals can be compared. As the size of the impacted region increases, more goods and services can be supplied within the region, increasing the multipliers as more transactions take place in-region. As a result, the U.S. level multipliers will simply be higher. Looking at the latest FEUS, the aggregate multiplier for the U.S. across all sectors is roughly 9.9, whereas the Gulf region multiplier implied in Table 14 above is 6.8 (NMFS 2014). Because the harvester sectors are taken from the FEUS model, the difference lies in the other sectors, trade flows and margins. As shown above in Table 11, the dealer margin from the Gulf Commission reports (Miller et al. 2014b) is nearly eight times lower than the margin used in the FEUS model. Also, the Gulf Commission report shows more product skipping over sectors in the supply chain, at every link, and delivering the goods directly to the consumer. This acts to reduce the overall impact, but it does enhance impacts in lower links of the chain. Finally, the restaurant sector multipliers in FEUS represent about 67.7% of the total impact in the USNM supply chain, which is widely recognized as too high. Within this model the total impact attributable to the restaurant sector is 11.1% of the total impact across all sectors, which is in line with estimates for the restaurant sector in the economy.

Chapter Five: Model Results

5.1 Overall model results by scenario

The total results by impact type are first reported for each scenario and then results are discussed by impact type (direct, indirect, and induced). Direct impacts describe the economic activity generated by the initial purchase of the good or service. Indirect impacts describe the activity generated as businesses purchase the goods and services necessary to provide the purchased seafood. Induced impacts describe the spending of incomes by employees and owners generated by the purchase of seafood. Results are also discussed by the measure of economic activity (sales, value added, income and employment) and sector (harvester, dealer, processor, distributer, market, and restaurant).

5.1.1 Scenario 1: Market Dynamic: Change in Reported Dockside Value

The lower bound estimates of the economic impact of the DWH oil spill to the Gulf seafood industry the impact of the spill are summarized in Table 15 by sector, impact measure and impact type. Overall, the entire seafood supply chain lost 740 jobs, $51.7 million in sales, $21.4 million in value added, and $21.6 million in income during the 8-month damage period. The harvesting sector was estimated to have experienced the largest losses, losing 449 jobs, $20.1 million in sales, $7.9 million in value added, and $11.9 million in income under this conservative scenario.

Table 15. Scenario 1 Results

Sector	Economic Activity Measure	Impact Type			Total
		Direct	Indirect	Induced	
Harvester	Sales	-$5,063	$1,020	-$16,070	-$20,114
	Value Added	-$3,572	$1,113	-$5,473	-$7,932
	Income	-$8,049	-$2,256	-$1,553	-$11,858
	Employment	-335	4	-118	-449
Dealer	Sales	-$3,557	-$249	-$454	-$4,261
	Value Added	-$477	-$131	-$279	-$887
	Income	-$417	-$82	-$153	-$652
	Employment	-21	-3	-3	-28
Processor	Sales	-$4,877	-$737	-$734	-$6,348
	Value Added	-$654	-$398	-$451	-$1,503
	Income	-$572	-$234	-$247	-$1,053
	Employment	-29	-7	-6	-42
Distributor	Sales	-$3,533	-$1,225	-$4,956	-$9,714
	Value Added	-$2,234	-$375	-$1,535	-$4,143
	Income	-$1,483	-$1,018	-$1,079	-$3,580
	Employment	-38	-7	-36	-82
Market	Sales	-$3,178	-$861	-$1,591	-$5,630
	Value Added	-$2,275	-$551	-$1,012	-$3,838
	Income	-$1,659	-$295	-$549	-$2,503
	Employment	-55	-6	-13	-74
Restaurant	Sales	-$2,877	-$1,135	-$1,650	-$5,662
	Value Added	-$1,661	-$618	-$816	-$3,095
	Income	-$1,117	-$343	-$448	-$1,908
	Employment	-49	-7	-10	-66
Total	Sales	-$23,087	-$3,187	-$25,455	-$51,729
	Value Added	-$10,873	-$960	-$9,566	-$21,399
	Income	-$13,297	-$4,229	-$4,029	-$21,554
	Employment	-527	-26	-187	-740

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

Overall and across all sectors, the harvesting sector generates most of the change in economic activity. The harvesting sector's value added loss highlights the confounding market responses after the spill. Typically, value added exceeds income, by definition. But because there were revenue increases across species groups with relatively low value added multipliers (supply chain multipliers for each state and the Gulf region are provided in the Appendix), and revenue declined for species with relatively high value added multipliers, value added losses for harvesters were lower than income for the harvesters when summed across all species.

5.1.2 Scenario 2: Market Constant: Change in Reported Landings Valued at Pre-Spill Price

As evidenced in Table 16, when focusing only on landings reductions and holding prices constant at 2009 levels (the higher bound estimates), the estimated economic losses are much larger. Overall, under this price-constant scenario, the spill cost Gulf communities $952.9 million in sales, $392.7 million in value added, $309.8 million in income, and 9,315 jobs. The majority of this impact is absorbed by the harvesters, who lost $354.5 million in sales, $137.8 million in value added, $126.3 million in income, and 3,809 jobs. Though USNM combines dealers and processers into one sector, they were split for this modeling exercise. Together, they would comprise the second most impacted group, with the dealers and processors losing $80.6 million and $120.1 million in sales, respectively, for a combined loss of $200.7 million in sales and 1,325 jobs during the 8-month damage period. By separating those two sectors, distributors are the second hardest hit with a $183.8 million loss in sales.

Table 16. Scenario 2 Results

Sector	Economic Activity Measure	Impact Type			Total
		Direct	Indirect	Induced	
Harvester	Sales	-$128,258	-$74,110	-$152,144	-$354,512
	Value Added	-$69,985	-$24,023	-$43,774	-$137,782
	Income	-$59,860	-$24,552	-$41,857	-$126,268
	Employment	-2,338	-355	-1,116	-3,809
Dealer	Sales	-$67,326	-$4,720	-$8,597	-$80,644
	Value Added	-$9,032	-$2,482	-$5,278	-$16,792
	Income	-$7,893	-$1,550	-$2,895	-$12,338
	Employment	-404	-56	-66	-527
Processor	Sales	-$92,319	-$13,944	-$13,893	-$120,156
	Value Added	-$12,385	-$7,540	-$8,529	-$28,454
	Income	-$10,823	-$4,437	-$4,679	-$19,938
	Employment	-554	-137	-107	-798
Distributor	Sales	-$66,882	-$23,178	-$93,814	-$183,874
	Value Added	-$42,277	-$7,097	-$29,047	-$78,421
	Income	-$28,073	-$19,271	-$20,422	-$67,766
	Employment	-715	-140	-688	-1,543
Market	Sales	-$60,161	-$16,288	-$30,122	-$106,572
	Value Added	-$43,054	-$10,430	-$19,165	-$72,648
	Income	-$31,408	-$5,578	-$10,387	-$47,374
	Employment	-1,036	-116	-240	-1,391
Restaurant	Sales	-$54,460	-$21,487	-$31,224	-$107,171
	Value Added	-$31,442	-$11,695	-$15,444	-$58,581
	Income	-$21,137	-$6,499	-$8,470	-$36,106
	Employment	-925	-128	-193	-1,246
Total	Sales	-$469,406	-$153,728	-$329,794	-$952,929
	Value Added	-$208,174	-$63,267	-$121,236	-$392,678
	Income	-$159,193	-$61,888	-$88,709	-$309,791
	Employment	-5,972	-933	-2,411	-9,315

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.2 Shrimp

Changes in the shrimp markets throughout the post-spill Gulf are displayed in Table 17. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, some states experienced large losses in response to activities occurring in the import market. For instance, sales dropped in Alabama ($62.6 million), Louisiana ($47.7 million), and Mississippi ($20.2 million). However, in areas less affected by the spill and spill closures, Texas and West Florida, total sales from shrimp harvests increased. Shrimp landings drove total sales in West Florida to increase

$21.7 million and total sales in Texas to increase $209.8 million under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net increase in economic activity from shrimp harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity rose, supporting $105.2 million in total sales, $43.3 million in value added, $33.4 million in income and 990 jobs.

Under Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by shrimp declined. If prices are held constant at 2009 levels, total sales dropped $538.1 million, value added dropped $221.6 million, income dropped $171.0 million, and 5,062 jobs were lost Gulf-wide. This makes the shrimp market the loss leader under the Market Constant Scenario across all species modeled individually in this analysis. Under this scenario, all states but West Florida lost economic activity; Louisiana lost $181.8 million, Texas lost $109.0 million, Alabama lost $96.6 million, and Mississippi lost $36.0 million. West Florida increased $12.8 million in total sales.

Comparing these two results demonstrates that two things happened post spill. First, harvest effort shifted to areas less affected or not affected by the spill, as evidenced by West Florida, showing positive impacts under both scenarios, and Texas, showing more positive impacts under the Market Dynamic Scenario than negative impacts under the Market Constant Scenario. Second, the fact that Texas showed negative results under the Market Constant Scenario also demonstrates there was a significant price effect. That is, as post-spill shrimp volumes fell domestically and imports began to fall, the drop in supply pushed prices upward. Some of this price effect may also be due to aggressive post-spill marketing of Gulf shrimp.

Table 17. Shrimp Economic Model Results

Shrimp		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-486	-$19,493	-$9,011	-$7,272	-749	-$30,051	-$13,893	-$11,211
AL	Dealer	-26	-$6,801	-$974	-$750	-41	-$10,485	-$1,501	-$1,156
AL	Processor	-45	-$10,046	-$1,721	-$1,230	-69	-$15,487	-$2,653	-$1,896
AL	Distributor	-100	-$10,171	-$6,071	-$5,020	-154	-$15,680	-$9,359	-$7,739
AL	Market	-125	-$8,363	-$5,642	-$3,656	-192	-$12,892	-$8,698	-$5,637
AL	Restaurant	-114	-$7,772	-$4,193	-$3,366	-176	-$11,981	-$6,464	-$5,189
AL	Total	-896	-$62,646	-$27,612	-$21,294	-1,381	-$96,576	-$42,568	-$32,828
W FL	Harvester	109	$6,753	$3,447	$2,489	64	$3,970	$2,026	$1,463
W FL	Dealer	15	$2,233	$301	$175	9	$1,313	$177	$103
W FL	Processor	22	$3,368	$582	$335	13	$1,980	$342	$197
W FL	Distributor	33	$3,409	$1,905	$1,692	20	$2,004	$1,120	$994
W FL	Market	41	$3,187	$2,162	$1,423	24	$1,874	$1,271	$836
W FL	Restaurant	34	$2,779	$1,672	$1,045	20	$1,634	$983	$614
W FL	Total	254	$21,729	$10,069	$7,159	150	$12,775	$5,919	$4,207
LA	Harvester	-284	-$14,864	-$8,049	-$5,509	-1083	-$56,710	-$30,709	-$21,019
LA	Dealer	-39	-$5,436	-$1,376	-$1,000	-151	-$20,739	-$5,248	-$3,815
LA	Processor	-53	-$7,707	-$2,039	-$1,427	-201	-$29,404	-$7,779	-$5,445
LA	Distributor	-78	-$7,405	-$4,553	-$3,813	-296	-$28,251	-$17,369	-$14,548
LA	Market	-92	-$6,323	-$4,275	-$2,767	-352	-$24,123	-$16,309	-$10,557
LA	Restaurant	-83	-$5,928	-$3,355	-$2,148	-316	-$22,616	-$12,802	-$8,195
LA	Total	-629	-$47,663	-$23,647	-$16,664	-2,399	-$181,843	-$90,216	-$63,579
MS	Harvester	-96	-$6,839	-$3,025	-$2,197	-171	-$12,188	-$5,391	-$3,916
MS	Dealer	-15	-$2,148	-$350	-$262	-27	-$3,828	-$623	-$467
MS	Processor	-23	-$3,242	-$635	-$430	-41	-$5,777	-$1,132	-$766
MS	Distributor	-31	-$3,140	-$1,882	-$1,550	-56	-$5,595	-$3,354	-$2,762
MS	Market	-36	-$2,503	-$1,707	-$1,088	-65	-$4,461	-$3,042	-$1,939
MS	Restaurant	-35	-$2,325	-$1,260	-$785	-63	-$4,144	-$2,245	-$1,399
MS	Total	-236	-$20,197	-$8,859	-$6,312	-423	-$35,993	-$15,787	-$11,249

Shrimp		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
TX	Harvester	764	$69,903	$32,751	$24,683	-397	-$36,321	-$17,017	-$12,825
TX	Dealer	126	$20,397	$3,578	$2,712	-66	-$10,598	-$1,859	-$1,409
TX	Processor	193	$30,697	$6,542	$4,659	-101	-$15,950	-$3,399	-$2,421
TX	Distributor	305	$33,232	$18,104	$15,852	-159	-$17,267	-$9,407	-$8,237
TX	Market	367	$29,274	$19,977	$13,053	-191	-$15,210	-$10,380	-$6,782
TX	Restaurant	323	$26,247	$15,301	$9,383	-168	-$13,638	-$7,950	-$4,875
TX	Total	2,078	$209,750	$96,253	$70,342	-1,082	-$108,984	-$50,012	-$36,549
Gulf	Harvester	380	$38,968	$15,121	$13,124	-1945	-$199,237	-$77,311	-$67,103
Gulf	Dealer	58	$8,930	$1,860	$1,366	-298	-$45,660	-$9,507	-$6,986
Gulf	Processor	88	$13,306	$3,151	$2,208	-452	-$68,032	-$16,111	-$11,289
Gulf	Distributor	171	$20,362	$8,684	$7,504	-874	-$104,109	-$44,402	-$38,369
Gulf	Market	154	$11,802	$8,045	$5,246	-788	-$60,341	-$41,133	-$26,823
Gulf	Restaurant	138	$11,868	$6,487	$3,998	-706	-$60,680	-$33,168	-$20,443
Gulf	Total	989	$105,236	$43,348	$33,446	-5,063	-$538,059	-$221,632	-$171,013

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.3 Blue Crab

Overall, blue crab is a much smaller industry than shrimp. Table 18 demonstrates the complex dynamics occurring in the blue crab market region-wide post spill. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, some states took large losses, even though prices were allowed to change in response to activities occurring in the import market. For instance, sales dropped in Alabama ($1.0 million), Louisiana ($28.4 million), and Mississippi ($465,000).

However, in areas less affected by the spill and spill closures, Texas and West Florida, total sales from blue crab harvests increased. Blue crab landings drove total sales in West Florida to increase $12.5 million and total sales in Texas to increase $5.9 million under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net decrease in economic activity from blue crab harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity fell, losing $16.3 million in total sales, $6.8 million in value added, $5.5 million in income, and 165 jobs.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by blue crab is markedly down. If prices are held constant at 2009 levels, total sales dropped $59.5 million, value added dropped $24.8 million, income dropped $19.9 million, and 602 jobs were lost Gulf-wide. Under this scenario, all states but West Florida and Texas lost economic activity. Louisiana lost $62.1 million, Alabama lost $1.4 million, and Mississippi lost $505,000. West Florida gained $14.8 million in total sales, which is more than the Market Dynamic scenario, suggesting that West Florida volumes rose post-spill while prices fell. Texas gained $4.7 million, suggesting that volumes increased in Texas but prices were only up slightly.

Table 18. Blue Crab Economic Model Results

Blue Crab		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-4	-$348	-$140	-$133	-6	-$483	-$195	-$184
AL	Dealer	0	-$108	-$15	-$12	-1	-$150	-$22	-$17
AL	Processor	-1	-$160	-$27	-$20	-1	-$222	-$38	-$27
AL	Distributor	-2	-$162	-$97	-$80	-2	-$225	-$134	-$111
AL	Market	-2	-$133	-$90	-$58	-3	-$185	-$125	-$81
AL	Restaurant	-2	-$124	-$67	-$54	-3	-$172	-$93	-$74
AL	Total	-11	-$1,035	-$436	-$357	-16	-$1,437	-$607	-$494
W FL	Harvester	46	$3,939	$1,588	$1,504	54	$4,665	$1,881	$1,782
W FL	Dealer	8	$1,282	$173	$100	10	$1,518	$205	$119
W FL	Processor	13	$1,933	$334	$192	15	$2,290	$396	$228
W FL	Distributor	19	$1,957	$1,094	$971	23	$2,318	$1,295	$1,150
W FL	Market	24	$1,830	$1,241	$817	28	$2,167	$1,470	$967
W FL	Restaurant	20	$1,596	$960	$600	23	$1,890	$1,137	$711
W FL	Total	130	$12,537	$5,390	$4,184	153	$14,848	$6,384	$4,957
LA	Harvester	-110	-$9,466	-$3,816	-$3,615	-240	-$20,696	-$8,344	-$7,904
LA	Dealer	-23	-$3,138	-$794	-$577	-50	-$6,862	-$1,736	-$1,262
LA	Processor	-30	-$4,450	-$1,177	-$824	-66	-$9,729	-$2,574	-$1,802
LA	Distributor	-45	-$4,275	-$2,629	-$2,202	-98	-$9,348	-$5,747	-$4,814
LA	Market	-53	-$3,651	-$2,468	-$1,598	-116	-$7,982	-$5,396	-$3,493
LA	Restaurant	-48	-$3,423	-$1,937	-$1,240	-105	-$7,483	-$4,236	-$2,712
LA	Total	-309	-$28,403	-$12,821	-$10,056	-675	-$62,100	-$28,033	-$21,987
MS	Harvester	-2	-$157	-$63	-$60	-2	-$170	-$68	-$65
MS	Dealer	0	-$50	-$8	-$6	0	-$54	-$9	-$7
MS	Processor	-1	-$75	-$15	-$10	-1	-$81	-$16	-$11
MS	Distributor	-1	-$73	-$43	-$36	-1	-$79	-$47	-$39
MS	Market	-1	-$58	-$39	-$25	-1	-$63	-$43	-$27
MS	Restaurant	-1	-$54	-$29	-$18	-1	-$58	-$32	-$20

Blue Crab		Scenario 1				Scenario 2			
State	**Sector**	**Employment**	**Total Sales**	**Value Added**	**Income**	**Employment**	**Total Sales**	**Value Added**	**Income**
MS	Total	-6	-$467	-$197	-$155	-6	-$505	-$215	-$169
TX	Harvester	22	$1,866	$752	$712	17	$1,504	$607	$575
TX	Dealer	4	$584	$102	$78	3	$471	$83	$63
TX	Processor	6	$878	$187	$133	4	$708	$151	$108
TX	Distributor	9	$951	$518	$454	7	$767	$418	$366
TX	Market	11	$838	$572	$373	8	$676	$461	$301
TX	Restaurant	9	$751	$438	$268	7	$606	$353	$217
TX	Total	61	$5,868	$2,569	$2,018	46	$4,732	$2,073	$1,630
Gulf	Harvester	-71	-$6,104	-$2,461	-$2,331	-258	-$22,240	-$8,966	-$8,493
Gulf	Dealer	-9	-$1,377	-$287	-$211	-33	-$5,016	-$1,044	-$767
Gulf	Processor	-14	-$2,051	-$486	-$340	-50	-$7,474	-$1,770	-$1,240
Gulf	Distributor	-26	-$3,139	-$1,339	-$1,157	-96	-$11,437	-$4,878	-$4,215
Gulf	Market	-24	-$1,819	-$1,240	-$809	-87	-$6,629	-$4,519	-$2,947
Gulf	Restaurant	-21	-$1,830	-$1,000	-$616	-78	-$6,666	-$3,644	-$2,246
Gulf	Total	-165	-$16,320	-$6,813	-$5,464	-602	-$59,462	-$24,821	-$19,908

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.4 Oysters

Table 19 demonstrates the complex dynamics occurring in the post-spill oyster market region-wide. Alabama does not harvest or process oysters, so it has been omitted. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, all states except Texas took large losses, even though prices were allowed to change in response to activities occurring in the import market. For instance, sales dropped in West Florida ($40,000), Louisiana ($111.5 million), and Mississippi ($14.0 million).

However, in Texas, an area less affected by the spill and spill closures, and unaffected by the Mississippi River releases, total sales from oyster harvests increased. Oyster landings drove total sales to increase $29.1 million in Texas under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net decrease in economic activity from oyster harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity fell, losing $127.7 million in total sales, $52.9 million in value added, $42.9 million in income and 1,277 jobs. Across all the species comparisons, this is the largest Gulf-wide loss under the Market Dynamic Scenario.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by oyster harvests dropped, but by less than would be expected given the results across other species. If prices are held constant at 2009 levels, total sales dropped $147.6 million, value added dropped $61.1 million, income dropped $49.6 million, and 1,476 jobs were lost Gulf-wide. Under this scenario, all states but Texas lost economic activity. Louisiana lost $115.9 million, West Florida lost $4.3 million, and Mississippi lost $14.4 million. Texas gained $22.4 million in total sales. This suggests that Texas received much higher prices for oysters with slightly increased volumes harvested. Overall, it appears that prices increased very slightly in Mississippi and Louisiana post-spill, possibly driven by dramatically reduced harvests. In West Florida, however, it appears prices increased dramatically post-spill, nearly eliminating a $4.3 million dollar loss had prices remained constant at 2009 levels.

Table 19. Oysters Economic Model Results

Oysters		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
W FL	Harvester	0	-$12	-$5	-$5	-15	-$1,336	-$527	-$515
W FL	Dealer	0	-$4	-$1	$0	-3	-$439	-$59	-$34
W FL	Processor	0	-$6	-$1	-$1	-4	-$662	-$114	-$66
W FL	Distributor	0	-$6	-$3	-$3	-7	-$670	-$374	-$332
W FL	Market	0	-$6	-$4	-$3	-8	-$626	-$425	-$280
W FL	Restaurant	0	-$5	-$3	-$2	-7	-$546	-$329	-$205
W FL	Total	0	-$39	-$17	-$14	-44	-$4,279	-$1,828	-$1,432
LA	Harvester	-419	-$36,940	-$14,558	-$14,233	-435	-$38,400	-$15,133	-$14,796
LA	Dealer	-90	-$12,357	-$3,127	-$2,273	-93	-$12,845	-$3,251	-$2,363
LA	Processor	-120	-$17,520	-$4,635	-$3,244	-124	-$18,213	-$4,818	-$3,373
LA	Distributor	-177	-$16,833	-$10,349	-$8,668	-184	-$17,499	-$10,759	-$9,011
LA	Market	-209	-$14,373	-$9,717	-$6,290	-218	-$14,941	-$10,101	-$6,539
LA	Restaurant	-188	-$13,476	-$7,628	-$4,883	-196	-$14,008	-$7,929	-$5,076
LA	Total	-1,203	-$111,499	-$50,014	-$39,591	-1,250	-$115,906	-$51,991	-$41,158
MS	Harvester	-53	-$4,671	-$1,841	-$1,800	-55	-$4,824	-$1,901	-$1,859
MS	Dealer	-11	-$1,493	-$243	-$182	-11	-$1,543	-$251	-$188
MS	Processor	-16	-$2,254	-$441	-$299	-17	-$2,328	-$456	-$309
MS	Distributor	-22	-$2,183	-$1,309	-$1,078	-23	-$2,255	-$1,352	-$1,113
MS	Market	-25	-$1,740	-$1,187	-$756	-26	-$1,798	-$1,226	-$781
MS	Restaurant	-25	-$1,617	-$876	-$546	-25	-$1,670	-$905	-$564
MS	Total	-152	-$13,958	-$5,897	-$4,661	-157	-$14,418	-$6,091	-$4,814
TX	Harvester	104	$9,201	$3,626	$3,545	80	$7,088	$2,793	$2,731
TX	Dealer	18	$2,904	$509	$386	14	$2,237	$392	$298
TX	Processor	28	$4,371	$932	$663	21	$3,367	$718	$511
TX	Distributor	43	$4,732	$2,578	$2,257	33	$3,645	$1,986	$1,739
TX	Market	52	$4,168	$2,845	$1,859	40	$3,211	$2,191	$1,432
TX	Restaurant	46	$3,737	$2,179	$1,336	35	$2,879	$1,678	$1,029

Oysters		Scenario 1				Scenario 2			
State	**Sector**	**Employment**	**Total Sales**	**Value Added**	**Income**	**Employment**	**Total Sales**	**Value Added**	**Income**
TX	Total	291	$29,113	$12,669	$10,046	223	$22,427	$9,758	$7,740
Gulf	Harvester	-538	-$47,502	-$18,720	-$18,303	-622	-$54,900	-$21,636	-$21,154
Gulf	Dealer	-71	-$10,810	-$2,251	-$1,654	-82	-$12,493	-$2,601	-$1,911
Gulf	Processor	-107	-$16,106	-$3,814	-$2,673	-124	-$18,615	-$4,408	-$3,089
Gulf	Distributor	-207	-$24,647	-$10,512	-$9,084	-239	-$28,486	-$12,149	-$10,498
Gulf	Market	-187	-$14,285	-$9,738	-$6,350	-216	-$16,510	-$11,255	-$7,339
Gulf	Restaurant	-167	-$14,366	-$7,852	-$4,840	-193	-$16,603	-$9,075	-$5,594
Gulf	Total	-1,277	-$127,716	-$52,887	-$42,904	-1,476	-$147,607	-$61,124	-$49,585

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.5 Menhaden

Because of the vertical integration of only two companies in the menhaden market, the dynamics are less complicated. Table 20 examines those dynamics region wide by state. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, all states except Florida and Texas took losses, even though prices were allowed to change. Sales dropped in Alabama ($156,000), Louisiana ($4.6 million), and Mississippi ($50.4 million). West Florida total sales increased $20,000. The majority of the directed harvest for this species occurs in Mississippi and Louisiana. Texas landed no menhaden across the periods examined.

In no state did sales from menhaden increase. Overall, the Gulf experienced a net loss in economic activity from menhaden harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity fell losing $72.7 million in total sales, $29.7 million in value added, $24.2 million in income and 786 jobs.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by menhaden was markedly down. With prices held constant at 2009 levels, total sales dropped $122.8 million, value added dropped $50.2 million, income dropped $40.9 million and 1,329 jobs were lost Gulf-wide. Under this scenario, all states lost economic activity; Louisiana lost $44.5 million, West Florida lost $41,000, Alabama lost $140,000, and Mississippi lost $48.9 million. Comparing these two scenarios demonstrates that prices definitely rose in West Florida and Mississippi and fell in Louisiana.

Because they are vertically integrated, impacts in supply chain beyond harvester were likely much less than estimated here, because they simply imported product to make up the difference directly into their processing sector.

Table 20. Menhaden Economic Model Results

Menhaden		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-1	-$53	-$20	-$20	-1	-$48	-$18	-$18
AL	Dealer	0	-$16	-$2	-$2	0	-$15	-$2	-$2
AL	Processor	0	-$24	-$4	-$3	0	-$21	-$4	-$3
AL	Distributor	0	-$24	-$14	-$12	0	-$22	-$13	-$11
AL	Market	0	-$20	-$13	-$9	0	-$18	-$12	-$8
AL	Restaurant	0	-$19	-$10	-$8	0	-$17	-$9	-$7
AL	Total	-1	-$156	-$63	-$54	-1	-$141	-$58	-$49
W FL	Harvester	0	$6	$2	$2	0	-$13	-$5	-$5
W FL	Dealer	0	$2	$0	$0	0	-$4	-$1	$0
W FL	Processor	0	$3	$1	$0	0	-$6	-$1	-$1
W FL	Distributor	0	$3	$2	$2	0	-$7	-$4	-$3
W FL	Market	0	$3	$2	$1	0	-$6	-$4	-$3
W FL	Restaurant	0	$3	$2	$1	0	-$5	-$3	-$2
W FL	Total	0	$20	$9	$6	0	-$41	-$18	-$14
LA	Harvester	-21	-$1,545	-$589	-$580	-202	-$14,991	-$5,711	-$5,626
LA	Dealer	-4	-$503	-$127	-$93	-35	-$4,885	-$1,236	-$899
LA	Processor	-5	-$714	-$189	-$132	-47	-$6,926	-$1,832	-$1,282
LA	Distributor	-7	-$686	-$422	-$353	-70	-$6,654	-$4,091	-$3,426
LA	Market	-9	-$585	-$396	-$256	-83	-$5,682	-$3,841	-$2,486
LA	Restaurant	-8	-$549	-$311	-$199	-74	-$5,327	-$3,015	-$1,930
LA	Total	-54	-$4,582	-$2,034	-$1,613	-511	-$44,465	-$19,726	-$15,649
MS	Harvester	-231	-$17,163	-$6,539	-$6,441	-224	-$16,644	-$6,341	-$6,246
MS	Dealer	-38	-$5,346	-$870	-$653	-37	-$5,184	-$844	-$633
MS	Processor	-58	-$8,067	-$1,580	-$1,070	-56	-$7,823	-$1,532	-$1,038
MS	Distributor	-78	-$7,813	-$4,684	-$3,857	-76	-$7,577	-$4,542	-$3,740
MS	Market	-91	-$6,229	-$4,248	-$2,708	-88	-$6,041	-$4,119	-$2,626
MS	Restaurant	-88	-$5,787	-$3,135	-$1,953	-85	-$5,611	-$3,040	-$1,894

Menhaden		Scenario 1				Scenario 2			
State	**Sector**	**Employment**	**Total Sales**	**Value Added**	**Income**	**Employment**	**Total Sales**	**Value Added**	**Income**
MS	Total	-584	-$50,405	-$21,056	-$16,682	-566	-$48,880	-$20,418	-$16,177
Gulf	Harvester	-370	-$27,478	-$10,468	-$10,312	-626	-$46,438	-$17,692	-$17,428
Gulf	Dealer	-40	-$6,091	-$1,268	-$932	-67	-$10,293	-$2,143	-$1,575
Gulf	Processor	-60	-$9,075	-$2,149	-$1,506	-102	-$15,337	-$3,632	-$2,545
Gulf	Distributor	-117	-$13,887	-$5,923	-$5,118	-197	-$23,470	-$10,010	-$8,650
Gulf	Market	-105	-$8,049	-$5,487	-$3,578	-178	-$13,603	-$9,273	-$6,047
Gulf	Restaurant	-94	-$8,094	-$4,424	-$2,727	-159	-$13,679	-$7,477	-$4,609
Gulf	Total	-786	-$72,674	-$29,719	-$24,173	-1,329	-$122,820	-$50,227	-$40,854

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.6 Reef Fish

Table 21 shows the changes in economic activity to the reef fish industry in the Gulf post-spill. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, some states took large losses, even though prices were allowed to change. For instance, sales dropped in Alabama ($3.7 million), Louisiana ($7.9 million) and West Florida ($15.3 million).

However, in Texas, an area less affected by the spill and fishing closures, total sales from reef fish harvests increased. Reef fish landings drove total sales in Texas to $4.9 million under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net decrease in economic activity from reef fish harvests in the period immediately following the spill, under the Market Dynamic Scenario. Gulf-wide economic activity fell, losing $28.0 million in total sales, $11.5 million in value added, $9.4 million in income and 273 jobs.

Within Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by reef fish was markedly down. With prices held constant at 2009 levels, total sales dropped $39.9 million, value added dropped $16.4 million, income dropped $13.4 million and 391 jobs were lost Gulf-wide. Under this scenario, all states but Texas lost economic activity; Louisiana lost $7.8 million, Alabama lost $3.7 million and West Florida lost $24.4 million. Texas gained by $4.2 million in totals sales. This result was driven by slightly higher prices but also slightly higher volumes landed in Texas.

Table 21. Reef Fish Economic Model Results

Reef Fish		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-14	-$1,250	-$481	-$479	-13	-$1,240	-$477	-$475
AL	Dealer	-2	-$390	-$56	-$43	-1	-$387	-$55	-$43
AL	Processor	-3	-$576	-$99	-$71	-3	-$572	-$98	-$70
AL	Distributor	-6	-$583	-$348	-$288	-6	-$579	-$345	-$286
AL	Market	-7	-$480	-$324	-$210	-7	-$476	-$321	-$208
AL	Restaurant	-7	-$446	-$241	-$193	-6	-$442	-$239	-$192
AL	Total	-39	-$3,725	-$1,549	-$1,284	-36	-$3,696	-$1,535	-$1,274
W FL	Harvester	-52	-$4,809	-$1,850	-$1,842	-83	-$7,656	-$2,946	-$2,933
W FL	Dealer	-10	-$1,570	-$212	-$123	-16	-$2,500	-$337	-$196
W FL	Processor	-16	-$2,368	-$409	-$235	-25	-$3,769	-$651	-$375
W FL	Distributor	-23	-$2,397	-$1,340	-$1,189	-37	-$3,816	-$2,133	-$1,893
W FL	Market	-29	-$2,241	-$1,520	-$1,000	-46	-$3,567	-$2,420	-$1,593
W FL	Restaurant	-24	-$1,954	-$1,176	-$735	-38	-$3,111	-$1,872	-$1,170
W FL	Total	-154	-$15,339	-$6,507	-$5,124	-245	-$24,419	-$10,359	-$8,160
LA	Harvester	-28	-$2,626	-$1,010	-$1,006	-28	-$2,607	-$1,003	-$999
LA	Dealer	-6	-$873	-$221	-$161	-6	-$867	-$219	-$159
LA	Processor	-8	-$1,238	-$328	-$229	-8	-$1,229	-$325	-$228
LA	Distributor	-12	-$1,190	-$731	-$613	-12	-$1,181	-$726	-$608
LA	Market	-15	-$1,016	-$687	-$445	-15	-$1,008	-$682	-$441
LA	Restaurant	-13	-$952	-$539	-$345	-13	-$945	-$535	-$343
LA	Total	-82	-$7,895	-$3,516	-$2,799	-82	-$7,837	-$3,490	-$2,778
TX	Harvester	17	$1,561	$601	$598	14	$1,325	$510	$508
TX	Dealer	3	$490	$86	$65	3	$416	$73	$55
TX	Processor	5	$737	$157	$112	4	$626	$133	$95
TX	Distributor	7	$798	$435	$381	6	$678	$369	$323
TX	Market	9	$703	$480	$313	7	$597	$407	$266
TX	Restaurant	8	$630	$367	$225	7	$535	$312	$191
TX	Total	49	$4,919	$2,126	$1,694	41	$4,177	$1,804	$1,438

Reef Fish		Scenario 1				Scenario 2			
State	**Sector**	**Employment**	**Total Sales**	**Value Added**	**Income**	**Employment**	**Total Sales**	**Value Added**	**Income**
Gulf	Harvester	-113	-$10,438	-$4,016	-$3,998	-161	-$14,912	-$5,737	-$5,712
Gulf	Dealer	-15	-$2,362	-$492	-$361	-22	-$3,374	-$702	-$516
Gulf	Processor	-23	-$3,519	-$833	-$584	-33	-$5,027	-$1,190	-$834
Gulf	Distributor	-45	-$5,384	-$2,296	-$1,984	-65	-$7,692	-$3,281	-$2,835
Gulf	Market	-41	-$3,121	-$2,127	-$1,387	-58	-$4,458	-$3,039	-$1,982
Gulf	Restaurant	-36	-$3,138	-$1,715	-$1,057	-52	-$4,484	-$2,451	-$1,511
Gulf	Total	-273	-$27,962	-$11,479	-$9,371	-391	-$39,947	-$16,400	-$13,390

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.7 Pelagic Finfish

Table 22 lists the economic changes occurring in the post-spill pelagic finfish markets region-wide. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, all states took large losses, even though prices were allowed to change. For instance, sales dropped in Alabama ($21,000), Louisiana ($26.6 million), Texas ($1,000) and West Florida ($7.5 million). Overall, then, the Gulf experienced a net decrease in economic activity from pelagic finfish harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity fell losing $44.0 million in total sales, $18.0 million in value added, $14.7 million in income and 450 jobs.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by pelagic finfishes was markedly down. With prices held constant at 2009 levels, total sales dropped $37.6 million, value added dropped $15.4 million, income dropped $12.6 million and 385 jobs were lost Gulf-wide. Under this scenario, all states lost economic activity; Louisiana lost $26.6 million, Alabama lost $23,000, Texas lost $4,000, and West Florida lost $2.3 million. There is very little difference between the two scenarios in the market for pelagic finfish. Prices and volumes harvested were down in West Florida, though prices were up in Louisiana but volumes were relatively low.

Table 22. Pelagic Finfish Economic Model Results

Pelagic Finfish		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	0	-$7	-$3	-$3	0	-$8	-$3	-$3
AL	Dealer	0	-$2	$0	$0	0	-$2	$0	$0
AL	Processor	0	-$3	-$1	$0	0	-$4	-$1	$0
AL	Distributor	0	-$3	-$2	-$2	0	-$4	-$2	-$2
AL	Market	0	-$3	-$2	-$1	0	-$3	-$2	-$1
AL	Restaurant	0	-$3	-$1	-$1	0	-$3	-$1	-$1
AL	Total	0	-$21	-$9	-$7	0	-$24	-$9	-$7
W FL	Harvester	-28	-$2,336	-$898	-$890	-9	-$715	-$275	-$272
W FL	Dealer	-5	-$765	-$103	-$60	-2	-$234	-$32	-$18
W FL	Processor	-8	-$1,153	-$199	-$115	-2	-$353	-$61	-$35
W FL	Distributor	-11	-$1,168	-$653	-$579	-3	-$357	-$200	-$177
W FL	Market	-14	-$1,092	-$740	-$487	-4	-$334	-$227	-$149
W FL	Restaurant	-12	-$952	-$573	-$358	-4	-$291	-$175	-$110
W FL	Total	-78	-$7,466	-$3,166	-$2,489	-24	-$2,284	-$970	-$761
LA	Harvester	-106	-$8,836	-$3,395	-$3,365	-106	-$8,839	-$3,397	-$3,367
LA	Dealer	-21	-$2,948	-$746	-$542	-21	-$2,949	-$746	-$542
LA	Processor	-29	-$4,179	-$1,106	-$774	-29	-$4,181	-$1,106	-$774
LA	Distributor	-42	-$4,015	-$2,469	-$2,068	-42	-$4,017	-$2,470	-$2,069
LA	Market	-50	-$3,429	-$2,318	-$1,500	-50	-$3,430	-$2,319	-$1,501
LA	Restaurant	-45	-$3,214	-$1,820	-$1,165	-45	-$3,216	-$1,820	-$1,165
LA	Total	-293	-$26,621	-$11,854	-$9,414	-293	-$26,632	-$11,858	-$9,418
TX	Harvester	0	-$1	$0	$0	0	-$1	$0	$0
TX	Dealer	0	$0	$0	$0	0	$0	$0	$0
TX	Processor	0	$0	$0	$0	0	-$1	$0	$0
TX	Distributor	0	$0	$0	$0	0	-$1	$0	$0
TX	Market	0	$0	$0	$0	0	-$1	$0	$0
TX	Restaurant	0	$0	$0	$0	0	$0	$0	$0

Pelagic Finfish		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
TX	Total	0	-$1	$0	$0	0	-$4	$0	$0
Gulf	Harvester	-197	-$16,379	-$6,294	-$6,238	-168	-$14,011	-$5,384	-$5,336
Gulf	Dealer	-24	-$3,717	-$774	-$569	-21	-$3,180	-$662	-$486
Gulf	Processor	-37	-$5,538	-$1,312	-$919	-31	-$4,737	-$1,122	-$786
Gulf	Distributor	-71	-$8,475	-$3,615	-$3,124	-61	-$7,250	-$3,092	-$2,672
Gulf	Market	-64	-$4,912	-$3,349	-$2,184	-55	-$4,202	-$2,864	-$1,868
Gulf	Restaurant	-57	-$4,940	-$2,700	-$1,664	-49	-$4,226	-$2,310	-$1,424
Gulf	Total	-450	-$43,961	-$18,044	-$14,698	-385	-$37,606	-$15,434	-$12,572

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.8 Other Crustaceans

Table 23 demonstrates increases and decreases in the post-spill other crustaceans markets region-wide. This species category contains only four species: crawfish, Florida crab, and slipper and spiny lobster. The crawfish landings come 100% out of Louisiana; 100% of the lobster and 99.5% of all the West Florida crab is harvested in West Florida. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, Louisiana took large losses, even though prices were allowed to change. For instance, crawfish sales in Louisiana dropped ($16.2 million).

However, in West Florida, an area less affected by the spill and spill closures, total sales from spiny lobster and Florida crab increased dramatically. Other crustaceans landings drove total sales in West Florida to $133.7 million under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net increase in economic activity from other crustaceans harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity rose, supporting $142.9 million in total sales, $58.8 million in value added, $45.3 million in income, and 1,329 jobs were gained. This makes other crustaceans the largest positive market in this analysis.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by other crustaceans was markedly up. With prices held constant at 2009 levels, total sales rose $7.8 million, value added rose $3.2 million, income rose $2.5 million and 72 jobs were gained Gulf-wide. However, under this scenario, all states but West Florida lost economic activity; Louisiana lost $18.5 million and Texas lost $279,000. West Florida would have been up by $26.2 million in totals sales. West Florida's increases are attributable to slightly higher volumes and much higher dockside prices.

Table 23. Other Crustaceans Economic Model Results

Other Crustaceans		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
W FL	Harvester	394	$41,614	$16,106	$13,897	77	$8,158	$3,157	$2,724
W FL	Dealer	90	$13,727	$1,851	$1,075	18	$2,691	$363	$211
W FL	Processor	137	$20,698	$3,576	$2,058	27	$4,058	$701	$403
W FL	Distributor	204	$20,955	$11,711	$10,397	40	$4,108	$2,296	$2,038
W FL	Market	254	$19,589	$13,286	$8,745	50	$3,840	$2,605	$1,714
W FL	Restaurant	211	$17,084	$10,279	$6,425	41	$3,349	$2,015	$1,260
W FL	Total	1,290	$133,667	$56,809	$42,597	253	$26,204	$11,137	$8,350
LA	Harvester	-51	-$5,358	-$2,074	-$1,789	-58	-$6,106	-$2,363	-$2,039
LA	Dealer	-13	-$1,800	-$456	-$331	-15	-$2,052	-$519	-$377
LA	Processor	-17	-$2,552	-$675	-$473	-20	-$2,909	-$770	-$539
LA	Distributor	-26	-$2,452	-$1,508	-$1,263	-29	-$2,795	-$1,718	-$1,439
LA	Market	-31	-$2,094	-$1,416	-$916	-35	-$2,387	-$1,613	-$1,044
LA	Restaurant	-27	-$1,963	-$1,111	-$711	-31	-$2,238	-$1,267	-$811
LA	Total	-165	-$16,219	-$7,240	-$5,483	-188	-$18,487	-$8,250	-$6,249
TX	Harvester	-1	-$87	-$34	-$29	-1	-$88	-$34	-$29
TX	Dealer	0	-$27	-$5	-$4	0	-$28	-$5	-$4
TX	Processor	0	-$41	-$9	-$6	0	-$42	-$9	-$6
TX	Distributor	0	-$45	-$24	-$21	0	-$45	-$25	-$22
TX	Market	0	-$39	-$27	-$18	-1	-$40	-$27	-$18
TX	Restaurant	0	-$35	-$21	-$13	0	-$36	-$21	-$13
TX	Total	-1	-$274	-$120	-$91	-2	-$279	-$121	-$92
Gulf	Harvester	502	$52,993	$20,509	$17,697	27	$2,878	$1,114	$961
Gulf	Dealer	79	$12,113	$2,522	$1,853	4	$658	$137	$101
Gulf	Processor	120	$18,048	$4,274	$2,995	7	$980	$232	$163
Gulf	Distributor	232	$27,619	$11,779	$10,179	13	$1,500	$640	$553
Gulf	Market	209	$16,008	$10,912	$7,116	11	$869	$593	$386
Gulf	Restaurant	187	$16,098	$8,799	$5,423	10	$874	$478	$295
Gulf	Total	1,329	$142,879	$58,795	$45,263	72	$7,759	$3,194	$2,459

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.9 Bait

Table 24 shows the changes in the post-spill bait industry region-wide. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, some states took large losses, even though prices were allowed to change. For instance, sales dropped in Alabama ($461,198) and West Florida ($2.7 million).

However, in areas less affected by the spill and spill closures, Louisiana, Mississippi, and Texas, total sales from bait harvests increased. Bait landings drove total sales in Louisiana to $967,943, Mississippi to $59,915, and Texas to $352,754 under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net decrease in economic activity from bait harvests in the year immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity fell, losing $2.2 million in total sales, $904,000 in value added, $703,000 in income and 21 jobs.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by bait decreased. With prices held constant at 2009 levels, total sales dropped $5.1 million, value added dropped $2.1 million, income dropped $1.6 million, and 47 jobs were lost Gulf-wide. The Gulf's decrease in total sales can be attributed to West Florida ($4.3 million) and Alabama ($1 million). However, it should be noted that under this scenario, total sales in Louisiana, Mississippi, and Texas all increased slightly; Louisiana increased $936,826, Mississippi increased $27,006, and Texas increased $263,474. Increases in Louisiana were driven by higher harvest volumes, in Mississippi both prices and volumes were both up slightly, and in Texas increased harvest volumes drove the increase.

Table 24. Bait Economic Model Results

Bait		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-1	-$154	-$59	-$53	-3	-$348	-$134	-$119
AL	Dealer	0	-$48	-$7	-$5	0	-$109	-$16	-$12
AL	Processor	0	-$72	-$12	-$9	-1	-$162	-$28	-$20
AL	Distributor	-1	-$72	-$43	-$36	-2	-$164	-$98	-$81
AL	Market	-1	-$60	-$40	-$26	-2	-$135	-$91	-$59
AL	Restaurant	-1	-$55	-$30	-$24	-2	-$125	-$67	-$54
AL	Total	-4	-$461	-$191	-$153	-10	-$1,043	-$434	-$345
W FL	Harvester	-8	-$855	-$330	-$292	-13	-$1,351	-$522	-$462
W FL	Dealer	-2	-$281	-$38	-$22	-3	-$445	-$60	-$35
W FL	Processor	-3	-$424	-$73	-$42	-4	-$671	-$116	-$67
W FL	Distributor	-4	-$430	-$240	-$213	-7	-$679	-$379	-$337
W FL	Market	-5	-$402	-$272	-$179	-8	-$635	-$431	-$283
W FL	Restaurant	-4	-$350	-$211	-$132	-7	-$554	-$333	-$208
W FL	Total	-26	-$2,742	-$1,164	-$880	-42	-$4,335	-$1,841	-$1,392
LA	Harvester	3	$320	$124	$109	3	$310	$120	$106
LA	Dealer	1	$107	$27	$20	1	$104	$26	$19
LA	Processor	1	$152	$40	$28	1	$147	$39	$27
LA	Distributor	2	$146	$90	$75	1	$142	$87	$73
LA	Market	2	$125	$84	$55	2	$121	$82	$53
LA	Restaurant	2	$117	$66	$42	2	$113	$64	$41
LA	Total	11	$967	$431	$329	10	$937	$418	$319
MS	Harvester	0	$20	$8	$7	0	$9	$3	$3
MS	Dealer	0	$6	$1	$1	0	$3	$0	$0
MS	Processor	0	$10	$2	$1	0	$4	$1	$1
MS	Distributor	0	$9	$6	$5	0	$4	$3	$2
MS	Market	0	$7	$5	$3	0	$3	$2	$1
MS	Restaurant	0	$7	$4	$2	0	$3	$2	$1

Bait		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
MS	Total	0	$59	$26	$19	0	$26	$11	$8
TX	Harvester	1	$111	$43	$38	1	$83	$32	$28
TX	Dealer	0	$35	$6	$5	0	$26	$5	$3
TX	Processor	0	$53	$11	$8	0	$40	$8	$6
TX	Distributor	1	$57	$31	$27	0	$43	$23	$20
TX	Market	1	$51	$34	$23	0	$38	$26	$17
TX	Restaurant	1	$45	$26	$16	0	$34	$20	$12
TX	Total	4	$352	$151	$117	1	$264	$114	$86
Gulf	Harvester	-8	-$816	-$315	-$279	-18	-$1,900	-$734	-$650
Gulf	Dealer	-1	-$186	-$39	-$29	-3	-$433	-$90	-$66
Gulf	Processor	-2	-$278	-$66	-$46	-4	-$646	-$153	-$107
Gulf	Distributor	-4	-$425	-$181	-$157	-8	-$988	-$422	-$364
Gulf	Market	-3	-$246	-$168	-$109	-7	-$573	-$391	-$255
Gulf	Restaurant	-3	-$248	-$135	-$83	-7	-$576	-$315	-$194
Gulf	Total	-21	-$2,199	-$904	-$703	-47	-$5,116	-$2,105	-$1,636

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.10 Other Shellfish

Table 25 shows the complex dynamics occurring in the other shellfish market region wide post spill. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, some states took losses, even though prices were allowed to change in response to activities occurring in the market. For instance, sales dropped in Alabama ($248,000), Louisiana ($108,000), and Mississippi ($45,000). Overall, this is a very small fishery.

However, in areas less affected by the spill and spill closures, Texas and West Florida, total sales from other shellfish harvests increased. Other shellfish landings drove total sales in West Florida to $720,000 and $51,000 in Texas under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net increase in economic activity from other shellfish harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity rose, supporting $423,000 in total sales, $175,000 in value added, $142,000 in income, and five additional jobs.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by other shellfish was markedly up. If prices were held constant at 2009 levels, total sales rose $1.4 million, value added rose $580,000, income rose $471,000, and 14 jobs were gained Gulf-wide. Under this scenario, all but West Florida and Texas lost economic activity; in total sales Louisiana lost $94,000, Alabama lost $308,000, and Mississippi lost $49,000. West Florida gained $1.5 million in totals sales and Texas gained $76,000. This uncharacteristic result, at least as far as all other species markets analyzed here, would have been driven by prices that dropped significantly and harvest volumes that increased dramatically.

Table 25. Other Shellfish Economic Model Results

Other Shellfish		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-1	-$83	-$33	-$32	-1	-$103	-$41	-$40
AL	Dealer	0	-$26	-$4	-$3	0	-$32	-$5	-$4
AL	Processor	0	-$38	-$7	-$5	0	-$48	-$8	-$6
AL	Distributor	0	-$39	-$23	-$19	0	-$48	-$29	-$24
AL	Market	0	-$32	-$22	-$14	-1	-$40	-$27	-$17
AL	Restaurant	0	-$30	-$16	-$13	-1	-$37	-$20	-$16
AL	Total	-1	-$248	-$105	-$86	-3	-$308	-$130	-$107
W FL	Harvester	3	$225	$89	$87	5	$482	$190	$186
W FL	Dealer	0	$74	$10	$6	1	$158	$21	$12
W FL	Processor	1	$111	$19	$11	2	$239	$41	$24
W FL	Distributor	1	$113	$63	$56	2	$242	$135	$120
W FL	Market	1	$105	$72	$47	3	$226	$153	$101
W FL	Restaurant	1	$92	$55	$35	2	$197	$119	$74
W FL	Total	7	$720	$308	$242	15	$1,544	$659	$517
LA	Harvester	0	-$36	-$14	-$14	0	-$31	-$12	-$12
LA	Dealer	0	-$12	-$3	-$2	0	-$10	-$3	-$2
LA	Processor	0	-$17	-$5	-$3	0	-$15	-$4	-$3
LA	Distributor	0	-$16	-$10	-$8	0	-$14	-$9	-$7
LA	Market	0	-$14	-$9	-$6	0	-$12	-$8	-$5
LA	Restaurant	0	-$13	-$7	-$5	0	-$11	-$6	-$4
LA	Total	0	-$108	-$48	-$38	0	-$93	-$42	-$33
MS	Harvester	0	-$15	-$6	-$6	0	-$17	-$7	-$6
MS	Dealer	0	-$5	-$1	-$1	0	-$5	-$1	-$1
MS	Processor	0	-$7	-$1	-$1	0	-$8	-$2	-$1
MS	Distributor	0	-$7	-$4	-$4	0	-$8	-$5	-$4
MS	Market	0	-$6	-$4	-$2	0	-$6	-$4	-$3
MS	Restaurant	0	-$5	-$3	-$2	0	-$6	-$3	-$2

Other Shellfish		Scenario 1				Scenario 2			
State	**Sector**	**Employment**	**Total Sales**	**Value Added**	**Income**	**Employment**	**Total Sales**	**Value Added**	**Income**
MS	Total	0	-$45	-$19	-$16	0	-$50	-$22	-$17
TX	Harvester	0	$16	$6	$6	0	$24	$9	$9
TX	Dealer	0	$5	$1	$1	0	$8	$1	$1
TX	Processor	0	$8	$2	$1	0	$11	$2	$2
TX	Distributor	0	$8	$5	$4	0	$12	$7	$6
TX	Market	0	$7	$5	$3	0	$11	$7	$5
TX	Restaurant	0	$7	$4	$2	0	$10	$6	$3
TX	Total	0	$51	$23	$17	0	$76	$32	$26
Gulf	Harvester	2	$157	$62	$61	6	$521	$205	$201
Gulf	Dealer	0	$36	$7	$5	1	$119	$25	$18
Gulf	Processor	0	$53	$13	$9	1	$177	$42	$29
Gulf	Distributor	1	$82	$35	$30	2	$270	$115	$100
Gulf	Market	1	$47	$32	$21	2	$157	$107	$70
Gulf	Restaurant	1	$48	$26	$16	2	$158	$86	$53
Gulf	Total	5	$423	$175	$142	14	$1,402	$580	$471

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

5.11 Miscellaneous Finfish

Table 26 shows the complex dynamics occurring in the post-spill miscellaneous finfish market region-wide. In Scenario 1, the Market Dynamic Scenario that allows prices to adjust, all states except Texas took large losses, even though prices were allowed to change in response to activities occurring in the market. For instance, sales dropped in Alabama ($616,000), West Florida ($6.6 million), Louisiana ($224,000), and Mississippi ($749,000).

However, in Texas, an area less affected by the spill and spill closures, total sales from miscellaneous finfish harvests increased. Miscellaneous finfish landings drove total sales to $610,490 million in Texas under the Market Dynamic Scenario. Overall, then, the Gulf experienced a net decrease in economic activity from miscellaneous finfish harvests in the period immediately following the spill under the Market Dynamic Scenario. Gulf-wide economic activity fell losing $9.4 million in total sales, $3.9 million in value added, $3.1 million in income, and 89 lost jobs.

In Scenario 2, the Market Constant Scenario, Gulf-wide economic activity generated by miscellaneous finfish decreased, but by less than would have been expected given the results across other species. With prices held constant at 2009 levels, total sales dropped $11.4 million, value added dropped $4.7 million, income dropped $3.8 million, and 110 jobs were lost Gulf-wide. Under this scenario, all states but Texas lost economic activity; Louisiana lost $5.8 million, West Florida lost $905,000 million, Alabama lost $1.0 million, and Mississippi lost $1.2 million. Texas gained $57,000 in total sales. This suggests that Texas would have received higher prices for miscellaneous finfish post spill. Overall, it appears that in the other states, prices would have increased dramatically post spill.

Table 26. Miscellaneous Finfish Economic Model Results

Miscellaneous Finfish		Scenario 1				Scenario 2			
State	Sector	Employment	Total Sales	Value Added	Income	Employment	Total Sales	Value Added	Income
AL	Harvester	-2	-$206	-$79	-$75	-4	-$349	-$134	-$127
AL	Dealer	0	-$65	-$9	-$7	0	-$109	-$16	-$12
AL	Processor	0	-$95	-$16	-$12	-1	-$161	-$28	-$20
AL	Distributor	-1	-$97	-$58	-$48	-2	-$163	-$97	-$81
AL	Market	-1	-$79	-$54	-$35	-2	-$134	-$91	-$59
AL	Restaurant	-1	-$74	-$40	-$32	-2	-$125	-$67	-$54
	Total	-5	-$616	-$256	-$209	-11	-$1,041	-$433	-$353
W FL	Harvester	-21	-$2,062	-$792	-$750	-3	-$283	-$109	-$103
W FL	Dealer	-4	-$675	-$91	-$53	-1	-$93	-$13	-$7
W FL	Processor	-7	-$1,018	-$176	-$101	-1	-$140	-$24	-$14
W FL	Distributor	-10	-$1,031	-$576	-$512	-1	-$142	-$79	-$70
W FL	Market	-12	-$964	-$654	-$430	-2	-$132	-$90	-$59
W FL	Restaurant	-10	-$841	-$506	-$316	-1	-$115	-$69	-$43
W FL	Total	-64	-$6,591	-$2,795	-$2,162	-9	-$905	-$384	-$296
LA	Harvester	-1	-$74	-$28	-$27	-19	-$1,910	-$734	-$695
LA	Dealer	0	-$25	-$6	-$5	-5	-$637	-$161	-$117
LA	Processor	0	-$35	-$9	-$6	-6	-$904	-$239	-$167
LA	Distributor	0	-$34	-$21	-$17	-9	-$868	-$534	-$447
LA	Market	0	-$29	-$19	-$13	-11	-$741	-$501	-$324
LA	Restaurant	0	-$27	-$15	-$10	-10	-$695	-$393	-$252
LA	Total	-1	-$224	-$98	-$78	-60	-$5,755	-$2,562	-$2,002
MS	Harvester	-3	-$251	-$96	-$91	-4	-$393	-$151	-$143
MS	Dealer	-1	-$80	-$13	-$10	-1	-$125	-$20	-$15
MS	Processor	-1	-$121	-$24	-$16	-1	-$189	-$37	-$25
MS	Distributor	-1	-$117	-$70	-$58	-2	-$183	-$110	-$90
MS	Market	-1	-$93	-$64	-$40	-2	-$146	-$100	-$64
MS	Restaurant	-1	-$87	-$47	-$29	-2	-$136	-$74	-$46

Miscellaneous Finfish		Scenario 1				Scenario 2			
State	**Sector**	**Employment**	**Total Sales**	**Value Added**	**Income**	**Employment**	**Total Sales**	**Value Added**	**Income**
MS	Total	-8	-$749	-$314	-$244	-12	-$1,172	-$492	-$383
TX	Harvester	2	$193	$74	$70	0	$18	$7	$7
TX	Dealer	0	$61	$11	$8	0	$6	$1	$1
TX	Processor	1	$92	$20	$14	0	$9	$2	$1
TX	Distributor	1	$99	$54	$47	0	$9	$5	$4
TX	Market	1	$87	$60	$39	0	$8	$6	$4
TX	Restaurant	1	$78	$46	$28	0	$7	$4	$3
TX	Total	6	$610	$265	$206	0	$57	$25	$20
Gulf	Harvester	-35	-$3,515	-$1,351	-$1,278	-43	-$4,273	-$1,642	-$1,554
Gulf	Dealer	-5	-$798	-$166	-$122	-6	-$970	-$202	-$148
Gulf	Processor	-8	-$1,189	-$282	-$197	-10	-$1,445	-$342	-$240
Gulf	Distributor	-15	-$1,819	-$776	-$670	-19	-$2,212	-$943	-$815
Gulf	Market	-14	-$1,054	-$719	-$469	-17	-$1,282	-$874	-$570
Gulf	Restaurant	-12	-$1,060	-$580	-$357	-15	-$1,289	-$705	-$434
Gulf	Total	-89	-$9,435	-$3,874	-$3,093	-110	-$11,471	-$4,708	-$3,761

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

Chapter Six: Summary and Discussion

6.1 Summary of Study Approach and Results

This study gathered various types of economic data in order to analyze the structure of the seafood industry in the Gulf of Mexico and to estimate the impacts of the *Deepwater Horizon* oil spill on the Gulf seafood industry. The study focuses in on the five Gulf states (Alabama, West Florida, Louisiana, Mississippi, and Texas) and segmented the species into ten like category groupings (shrimp, oysters, menhaden, blue crab, reef fish, pelagic finfish, other crustaceans, bait, other shellfish, and miscellaneous finfish). A key goal of the study was to examine the structure of the seafood industry's supply chain and look at how that structure may have changed as a result of the oil spill. Various data sets were collected and merged to provide background information for the time period surrounding the spill, namely 2002–2013, and the data sets were examined for trends. The analysis focused in on the same time periods as in the Settlement Agreement, that is, May to December of 2007; 2008; 2009; and 2010. The eight-month period of May to December of 2010, known as the damage period, was the period over which this study estimated damages. Additional data outside of the damage period and qualitative information relative to long-term impacts were gathered and contributed to the analysis and enhanced our understanding of the model results.

The analysis was conducted using a custom impact model to quantify the economic impacts of the oil spill on the Gulf seafood industry. This model used the change in dockside seafood landings and value to estimate impacts based on the settlement periods and defined spill closure periods as defined in this report. A backward-linking custom impact model was developed using the best available model structure in the literature and enhanced by recent financial and economic reports published by the Gulf Commission. The custom model was then used to examine the economic activity lost to the entire seafood supply chain by calculating impacts based on the change in dockside landings and value from 2009 to 2010 during the damage period. Results were presented by the defined species categories and states and interpreted in context to qualitative research gathered in the study.

Two sets of input data were specified for the empirical calculation of economic impacts in the short-run: Market Dynamic, the change in dockside revenue from 2009 to 2010 for the damage period; and Market Constant, the change in dockside revenue from 2009 to 2010 for the damage period based on 2010 landings and holding 2010 prices constant at 2009 levels. These scenarios were intended to generate a range of viable impact estimates to address market uncertainty and offer an examination of the upper and lower bound revenue loss estimates.

Table 27 summarizes the results of this impact modeling exercise by scenario at the Gulf-wide level. Overall, the oil spill generated between $51.7 and $952.9 million loss in total sales. This loss cost the region $21.4–$392.7 million in value added, $21.6–$309.8 million in income, and 740–9,315 jobs. The harvesting sector bore the brunt of those losses, losing between $20.1–$354.5 million in total sales, $7.9–$137.8 million in value added, $11.9–$126.3 million in income, and 449–3,809 jobs. The dealer sector fared the best, losing $4.3–$80.6 million in total sales, $887,000–$16.8 million in value added, $652,000–$12.3 million in income, 28–527 jobs.

Table 27. Impact Model Summary

Sector	Impact Type	Market Dynamic (Total Impact)	Market Constant (Total Impact)
Harvester	Sales	-$20,114	-$354,512
	Value Added	-$7,932	-$137,782
	Income	-$11,858	-$126,268
	Employment	-$449	-$3,809
Dealer	Sales	-$4,261	-$80,644
	Value Added	-$887	-$16,792
	Income	-$652	-$12,338
	Employment	-$28	-$527
Processor	Sales	-$6,348	-$120,156
	Value Added	-$1,503	-$28,454
	Income	-$1,053	-$19,938
	Employment	-$42	-$798
Distributor	Sales	-$9,714	-$183,874
	Value Added	-$4,143	-$78,421
	Income	-$3,580	-$67,766
	Employment	-$82	-$1,543
Market	Sales	-$5,630	-$106,572
	Value Added	-$3,838	-$72,648
	Income	-$2,503	-$47,374
	Employment	-$74	-$1,391
Restaurant	Sales	-$5,662	-$107,171
	Value Added	-$3,095	-$58,581
	Income	-$1,908	-$36,106
	Employment	-$66	-$1,246
Total	Sales	-$51,729	-$952,929
	Value Added	-$21,399	-$392,678
	Income	-$21,554	-$309,791
	Employment	-$740	-$9,315

(Dollar Values are in Thousands of $US, Employment is in Number of full time jobs)

Although an overall picture of impacts in the Gulf is informative, impacts broken down by species and state proved to be much more explanatory because of the impacts and dynamics reported at the fisheries level. In general, it can be noted that impacts were highest in Louisiana, Mississippi, and Alabama, and dramatically lower, and in some cases nonexistent, in Texas and West Florida. Although each species category has a slightly different outcome depending on the nature of the species location and market, it can be noted that shrimp, followed by oysters and then menhaden, were the top three most impacted species. Blue crab, reef fish, and pelagic finfish are roughly tied for fourth given the results of the two scenarios.

Due to the sheer size and value of the shrimp category, our model revealed the largest impacts across shrimp relative to the other species due to the oil spill closures. Although Louisiana had by far the largest impacts, Mississippi and Alabama also had substantial impacts relative to the size of their fisheries. Results in Texas were interesting because the Market Dynamic scenario indicated positive impacts, whereas the Market Constant scenario showed negative impacts. Through further investigation and research (see Chapter Three), it appears that strong price increases have had a strong positive influence in the Market Dynamic results for Texas. Although much of these price influences can be attributed to supply shortages caused by the spill, it appears some of this price increase can be attributed to exogenous factors, such as the restriction of import supply and a general improvement in the economy during the damage period.

The next-largest impacts have been noted in the oyster category; all states except Texas have been impacted. Louisiana again saw the largest impacts due to the spill, with Mississippi next and smaller impacts in Florida. Because of the historical harvests and the effects of the release of the Mississippi River freshwater diversions in April of 2010, these results are intuitive from a geographical standpoint (see Chapter Three). The difference in impacts between the two scenarios was much less than noted in other species categories due to a much smaller increase in price from 2009 to 2010. Although these impacts are relatively large, longer-term impacts in 2011, 2012, and 2013 are not captured by these results and are presumed to be present given the lower historical harvests (noted in Figure 21).

The third-heaviest impact was felt by the menhaden industry. The menhaden industry is located primarily in Mississippi and Louisiana, and those two states were impacted the most. Because the industry is owned by two vertically-integrated fishing companies and a larger portion of the product produced is not for human consumption, the effects of these impacts and the way the market reacts tend to be slightly different. Although it was indicated in Omega Proteins' annual report that they took a loss as of June 30, 2010, they later indicated that they caught 90 % of the fish they planned on catching for that year. Because of the consolidated nature of this industry, it appears competition for raw material is less competitive than in the other species categories, and this enables processors to simply buy raw material with less risk of losing their customer base to competitive markets. This was one species category that has shown a slight decrease in price across all states that landed product.

Other species categories with negative impacts that could be attributed to specific product markets were blue crab, reef fish, pelagic finfish, and other crustaceans. Although these categories were much smaller in volume and value, in some cases, the relative impact on these categories was significant.

Impacts on blue crab were greatest in Louisiana, followed by Mississippi and Alabama. As indicated with shrimp, it is believed that stronger blue crab prices in 2010 counteracted impacts of the spill in the Market Dynamic scenario. Although some of these price influences can be attributed to supply shortages caused by the spill, it appears that a portion of this price increase could be attributed to exogenous factors, such as a slowing of imported supply and a general improvement in the economy during the damage period. Though harvest volumes were reduced in areas impacted by the spill closures, Florida and Texas had an increase in harvest volume.

Prices seem to increase in all states except Florida. In addition to the impacts captured in this model, some concerns with longer-term ecological effects have been noted in Chapters 2 and 3. However, given the historical downward trend in harvest, it is difficult to differentiate preexisting biological effects from the effects of the oil spill.

Negative impacts on reef fish were largest in West Florida, but also occurred in Louisiana and Alabama. There were positive impacts in Texas, where both landings and revenue increased during the damage period. There was indication from the industry that a notable shift in fishing effort did occur away from the spill area and into Texas, which was bolstered by a successful contract with a major Texas retail chain (Krebs 2014). Although impacts were negative in West Florida, it appears that prices increased in both West Florida and Texas; results in these states show lower impacts with the Market Dynamic scenario and higher relative impacts with the Market Constant scenario. As indicated by an industry source, many of the reef fish fisheries have seen improvement since the spill, showing a notable increase in post-spill landings and revenue (Krebs 2014). An industry source indicated this is due to a combination of factors, such as changes in the management strategy and improved markets (Krebs 2014).

As indicated by harvest data, much of the fishing effort for tuna, the primary species in the pelagic finfish category, decreased during the damage period; this resulted in large impacts relative to the size of the fishery. Pelagic finfish are caught primarily in Louisiana, where impacts to the fishery were relatively dramatic. Smaller negative impacts did exist in West Florida, Alabama, and Texas. Because there was a relatively small difference between the two modeling scenarios, we conclude that prices on the whole did not change much in 2010, although we have noted a notable decrease in prices in West Florida during the damage period. Although overall impacts on this species category were not large in comparison to other categories like shrimp, oyster, and menhaden, the percent decline in economic activity for this category appears to be the largest. Another long-term concern that was noted in Chapter Two, but was not captured in this model, was evidence that the emerging 2010 year class of certain pelagic finfish species may have compromised cardiac function due to exposure to oil and so may demonstrate greater impacts in future harvests.

The other crustacean category consists of three primary species that come from distinct states, enabling clear analysis by each key species in the category. Crawfish are harvested exclusively in Louisiana, but Florida crab and spiny lobster are harvested almost exclusively in Florida. Our model’s ability to break these species down by state allows us to isolate these dramatic differences in the individual species. In summary, crawfish in Louisiana, which were in close proximity to the spill, incurred relatively large negative impacts, but Florida crab and spiny lobster in Florida, which were relatively isolated from the spill, experienced very positive impacts. Although this seems intuitive, the magnitude of the increases in West Florida with Florida crab and spiny lobster were so large it required further investigation. Although results in West Florida for both scenarios showed relatively large positive impacts, the results of the Market Dynamic scenario showed impacts around five times greater; this indicates a large price increase for these species in 2010. Through further investigation and research, as presented in Chapter Three, it appears that extreme price increases and moderate volume increases from 2009 to 2010 in Florida crab and spiny lobster were the primary driver behind the positive impacts of the other crustacean category. Our research, presented in Chapter Three, suggests that much of this price increase can be attributed to exogenous factors, such as unprecedented weak global market demand during the baseline period of 2009, a shift from low-value processed production to higher-value live production, and a general increase in the overall economy during the damage period. This dramatic transformation in the spiny lobster market is believed to have had a large impact on price received by the fisherman and to have driven revenues up notably in the other crustaceans category in recent years. It is important to note that, because of the structural changes in the industry during this period, revenue increases do not always reflect profit increases. Because of the increased cost structure to manage live spiny lobster production, these noted revenue changes have likely been eroded in any profits made by the industry. (Spiny Lobster Review Panel 2015). Further investigation of the crawfish market showed large fluctuations in volume that were highly influenced by external weather events. Although we believe the impacts in Louisiana on crawfish in 2010 are related to the oil spill event, because of the historical volatility of landings and sensitivity to weather events, it could be challenging to prove that these impacts were solely due to the spill event.

6.2 Comparison of Results with Previous Studies

Few analyses have been done to estimate the potential impact of the oil spill on the Gulf seafood industry. In October 2010, Greater New Orleans, Inc. published an analysis commissioned to project the length of time it would take for commercial catches of shrimp, oysters, blue crab, yellowfin tuna, black drum, striped mullet, and menhaden to return to pre-spill levels in Louisiana. To predict recovery time, rates of marine life recovery observed in previous oil spills, such as the 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, were used. The study estimated that projections of revenue losses in the fisheries would likely range from $59 million to $89 million in 2011, $38 million to $56 million in 2012, and $18 million to $27 million in 2013. Using these estimates and projecting out impacts to the larger economy, lost fishing revenues resulting from short-term ecological effects experienced 2011 to 2013 were estimated to be between $285 million to $428 million, to result in the loss of between 2,700 to 4,000 full time employees, and lost employee earnings of between $68 million and $103 million. The Bureau of Economic Analysis RIMS II model multipliers were used to estimate impacts. These estimates were admittedly initial, and future studies were expected to be more comprehensive and could use this analysis as a base.

However, Greater New Orleans, Inc. (2010) report analyzed economic impacts, moratoria, and brand damage. The study surveyed Louisiana fishermen and found that the majority were not interested in pursuing other careers in the wake of the oil spill. It also used these interviews to recommend ways to increase the success of post-disaster programming. Interviews of the public found that five years after Hurricane Katrina tourists still had an interest in visiting Louisiana. However, seafood concerns after the oil spill caused interest in visiting Louisiana to decrease, because seafood is a significant draw for tourists.

In a study commissioned by the GCCF Administrator, Kenneth Feinberg, Tunnell (2011) estimated that most species would experience pre-spill landings levels by 2011. The one exception was for oyster beds, which might experience negative effects for a longer period of time and would not be harvestable until 2012, 2013, or up to ten years.

In 2012, Sumaila et al. published the results of an impact analysis that estimated the potential negative economic effects of the oil spill on commercial and recreational fishing and marine aquaculture in the Gulf. By computing potential losses throughout the fish value chain, they estimated that the commercial fishery would experience present value losses of total revenues, total profits, wages, and economic impact of $0.5–2.7 billion, $0.3–1.4 billion, $0.1–0.8 billion, and $1.5–8.4 billion, respectively, over the next seven years. They estimated that the shrimp fishery would experience the greatest losses of all the commercial fisheries (85% of the total economic impact). They used past landings and the value of those landings from 2000–2005 to estimate those losses.

Posadas (2013) compares commercial landings in Mississippi's fishing sector during the oil spill in 2010 with baseline periods covering the five years before (2000–2004) and the five years after (2005–2009) Hurricane Katrina. In some cases, there was no significant difference between the two baseline periods, and, instead, an average of 2000–2009 landings and revenue was used. The study found that total seafood landings in 2010 were 53% of the average annual amount during the 2000–2009 baseline period. Total seafood revenue in 2010 was about 44% of what it was during the pre-Katrina period, and 56% of what it was during the post-Katrina period. These revenue differences showed that Gulf seafood prices were higher in the pre-Katrina period than they were in the post-Katrina period.

These studies indicate that there are other potential economic impacts not covered in these analyses, including clean-up costs, value of lost oil, natural and environmental damage beyond fisheries impacts, other direct use impacts and non-fish tourism, and non-use existence and option values. In addition, price adjustments and impacts at the consumer level due to product perception and safety concerns may not have been clearly accounted for due to the various exogenous factors mentioned in this report that have influenced markets during this period.

6.3 General Caveats

Specific trends in the harvest data were relevant to the revenue scenarios chosen. The reduction in landing volume due to the spill closures was relatively obvious in the harvest data, but reduction in revenue was not as apparent in the harvest data. The revenue change scenarios in this study were chosen to represent this divergence in the data, and hence the inclusion versus exclusion of exogenous market factors. When considering the use of input data for the model, we chose to use the Market Dynamic scenario to include market and price fluctuations, and the Market Constant scenario to represent a scenario where all market factors except volume were held constant. It was understood that the smaller impacts would be produced with the Market Dynamic scenario because of the notable increase in price which counteracted the fairly substantial drops in landed volumes witnessed.

Although there were specific fisheries and states where prices went down during the damage period, it was apparent from comparison of the two scenarios' results that prices in general in the Gulf as a whole went up during the damage period. From the research presented in Chapter Two and Three, it is believed that that three key factors attributed to this positive price trend: 1.) A shortage of domestic product due to the spill closures, 2.) An increase in the overall activity in the economy, and 3.) A shortage of imported substitute products due various exogenous market factors. Although the overall trend showed a price increase from 2009 to 2010, which can be noted in most key species categories, we did see some price decreases in menhaden and reef fish and some isolated decreases, for example in West Florida for blue crab, pelagic finfish, other shellfish, and miscellaneous finfish.

There is a philosophical debate that should be considered when reviewing the results of the two scenarios that were run through the model. When reviewing the Market Dynamic results, one must consider that impacts being presented do not rule out exogenous effects that have in most cases increased the revenue of the industry participants. Therefore, in general, the Market Dynamic results being presented are believed to underestimate the impacts on the Gulf seafood industry. When reviewing the Market Constant results, one must consider that certain market factors that would normally help minimize the impacts of the fishery closure have been removed. Therefore, it is believed that the Market Constant results overestimate the impacts, because net of all these exogenous factors, the seafood industry was better off than if the market or price was held constant. In the end, it can be debated whether the industry impacts should be based on the end result of what they actually lost in revenue verses what they would have lost if all other factors were held constant. This is a discussion that we as researchers do not answer in this study. However, this is important to consider when interpreting the results of this report.

With any impact model, data processing takes time, and national accounts tend to lag by several years. In this case, the most up-to-date data for the IMPLAN multipliers available for this project was 2012. Furthermore, the USNM is based on 2000 IMPLAN data and much of the cost data used to create the production functions, product flows and margins is from older data sources. Without a massive undertaking of time and money to collect and compile that data for the Gulf region's fisheries, the model must rely on these cost structures that are out of date. Many improvements have been made, as discussed above, but many more could be made. Unfortunately, those enhancements would entail expensive and time-consuming data collection. The impact of these older trade flows, margins, and cost structures is unknown. These relationships tend to change slowly and, therefore, the impact for the more recent data may be slight. Again, the only way to improve the model, to include more up-to-date data, would involve a large compilation of data across various sectors that was not feasible in this project.

This model does not examine the economic impact of any large shift in cost structures or trade flows induced by the oil spill. All the multipliers for the dealer, processing, market and restaurant sectors are from post-spill data. All of the multipliers for the harvesting and wholesale sectors were created using pre-spill data. Unlike a hurricane or other disaster that destroys physical plants or sinks boats, it is unlikely that this spill caused large shifts in technology. For instance, processing underwent significant technological and cost structure change after Hurricanes Katrina and Rita. Those types of technology shifts did not occur in response to the spill.

However, some harvesters may have had to switch target species or travel farther to reach unclosed water. This no doubt had an impact on their production functions, but it is unknown how this may have impacted the multipliers. If they are substituting one input, say increased diesel, for another, perhaps less ice, it is unclear how that would change the multipliers. An examination of these changes was beyond the scope of this project and certainly beyond the data available.

As with any model, this model is an abstraction. A certain level of aggregation is necessary, but that aggregation comes at the cost of granularity. The harvesting sectors used in this model are based on representative cost and earnings data for the most important species in the Gulf region. However, for the catch-all categories, the multipliers represent average technologies and average cost structures across a range of gear types.

There is also uncertainty in the product flow estimates. They are not specific to each state, making the state-level estimates less certain than the Gulf region totals. Many improvements have been made over the USNM to represent the seafood supply chain as it exists in the Gulf. However, the available data has been exhausted and all previously documented caveats and concerns in the USNM remain beyond those improvements.

Additionally, even though this model adds additional links in the seafood supply chain over the USNM, and allows those linkages to be complex, with products from each stage potentially jumping links in that chain, better product flow information would likely increase the impact estimates. Seafood product flow is complicated, and this model makes a number of simplifying assumptions that may skip multiple processing steps or market pathways that may exist. If this model is underestimating the number of links in this supply chain, then total impacts are being underestimated. Again, improving the trade flow data would require extensive surveys of the industry that are broader in scope and better subscribed than the Commission Reports.

Because of the objectives and scope of this project, the review of I/O models shows that modifying IMPLAN and/or relying on base IMPLAN data and multipliers is the most flexible, most adaptable way to proceed. Within those approaches, adding new sectors to the base IMPLAN data is the best method, retaining all the IMPLAN functionality, but is cost-prohibitive and requires data that simply does not exist in the Gulf. Instead, spreadsheet models require less data and can be constructed more quickly. Though built external to IMPLAN, they are constructed using IMPLAN data and retain the ability to examine the impacts in the supply chain across the entities of concern to this project. However, they do not allow the disaggregation of those impacts to the ancillary industries.

BOEM already uses spreadsheet-type impact models like the USNM. MAG-PLAN is a large, multi-region model that calculates the economic impact of oil and gas exploration and drilling operations in the Gulf. Its construction is very similar to the USNM. One benefit of these types of models is their scalability. New sectors can be added easily. As product flow data improves or changes, the model can be quickly modified to take advantage of the new or better information.

CGE models, though not discussed in depth here, may be the ultimate phase for this impact modeling effort. They allow the examination of welfare effects and relax price, input, and demand substitution restrictions inherent with I/O analysis. However, due to data and budget limitations, CGE models are beyond the scope of this effort. It may be advisable for BOEM to pursue the construction of these types of models in future developments.

6.4 General Uses

Economic impact models produce positive, rather than normative, measures of the change in economic activity that results from a perturbation of the demand or production of a good or group of goods. A positive model cannot comment on whether these changes are better for society or worse for society. Instead, it gives simply a measure of the change in economic activity that resulted from changes in revenue from the spill. In much the same way, a thermometer measures temperature changes through the course of a storm, but does not itself tell the observer if that change in temperature is good or bad.

The focus here should not be on the ultimate numbers produced. This study could have estimated impact across a near-infinite number of potential revenue change scenarios. There are any numbers of justifications for examining changes using different base periods or looking at the present value of a stream of future reductions. The aim was to develop an upper and lower bound based on a fairly narrow impact window that included only the damage period. This does not mean that these results represent the definitive answer to the question of what was the loss in activity stemming from the oil spill. These scenarios were chosen strictly because they used the same periods used in the settlement agreement. Instead, it may be helpful to think of the results detailed here as measurements of economic “temperatures” as the result of “storm” that was the oil spill. The point is that the usefulness of this study is not about the absolute impact measurement or which estimate is right or wrong, but rather a demonstration that this work represents the creation of a flexible, adaptable model of the seafood supply chain that BOEM and others can use to analyze further scenarios related to any oil exploration, development, or disaster that BOEM feels might impact the seafood supply chain.

Going forward, BOEM can use this model to quickly examine any activity under their purview that may have an impact on the seafood supply chain in the Gulf. Exploration and drilling activities may have impacts on the seafood supply chain and those impacts can now be estimated quickly and easily for use in future management of offshore mineral resources. In the event of another spill or in examining the risk of future spills, this model can make assessments quickly and easily. In the face of a future spill, using similar revenue change scenarios, losses in activity could be estimated in near real-time based on closure information. Future extensions would include estimating demand and supply relationships to forecast impacts at the early onset of a spill. That forecast model could be linked to this impact model to provide impact estimates quickly. If BOEM chooses to go further down this path, we recommend using the model developed to create a CGE model that would allow price dynamism and the calculation of welfare impacts.

References

Alexander-Bloch B, Anderson B. 2011 Apr 18. Gulf seafood industry sputters back to life, a year after oil spill. The Times-Picayune. [cited 2015 Aug 6]. Available from: http://www.nola.com/news/gulf-oil-spill/index.ssf/2011/04/gulf_seafood_industry_sputters.html

Austin D, Marks B, Prakash P, Rogers B, McGuire T, et al. 2014. Offshore oil and the *Deepwater Horizon*: social effects on Gulf coast communities, Volumes I and II. U.S. Dept. of the Interior, BOEM, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-617 and BOEM 2014-618. 265 pp and 207 pp.

Baird D, Ulanowicz RE. 1989. The seasonal dynamics of the Chesapeake Bay ecosystem. Ecological Monographs. 59: 329-364.

Bauer, Gary. 2014. Owner of Pontchartrain Blue Crab, Inc. Personal Communication.

Beck MW, Brumbaugh RD, Airoldi L, Carranza A, Coen L.D, et al. 2011. Oyster reefs at risk and recommendations for conservation, restoration, and management. BioScience 61(2): 107-116.

Björk M, Gilek M. 1996. Uptake and elimination of ^{14}C-Phenanthrene by the blue mussel *Mytilus edulis* L. at different algal concentrations. Bulletin of Environmental Contamination and Toxicology 56: 151–158.

BP Website. 2013 Dec 17. BP files suit over plaintiffs’ lawyer fraud in seafood compensation program alleging that funding for program was inappropriately inflated due to fraud. [cited 2015 Aug 6]. Available from: http://www.bp.com/en/global/corporate/press/press-releases/bp-files-suit-plaintiff-lawyer-fraud.html

Brodersen CC, Rice SD, Short JW, Mecklenburg TA, Karinen JF. 1977. Sensitivity of larval and adult Alaskan shrimp and crabs to acute exposures of the water-soluble fraction of Cook Inlet crude oil. International Oil Spill Conference Proceedings; 1977 (1): 575-578.

Bue BG, Sharr S, Seeb JE. 1998. Evidence of damage to pink salmon populations inhabiting Prince William Sound, Alaska, two generations after the *Exxon Valdez* oil spill. Transactions of the American Fisheries Society 127(1): 35–43.

Burdeau C, Reeves J. 2012 May 24. Gulf oil spill: fishermen reel from seafood troubles. Huffington Post. [cited 2015 Aug 6]. Available from: http://www.huffingtonpost.com/2012/05/24/gulf-oil-spill-fishermen-_n_1542032.html

Buskey, Nikki. 2010 Jul 24. Unleashing river to fight oil causes massive oyster kills. Houma Courier [cited 2015 Aug 6]. Available from: http://www.houmatoday.com/article/20100724/articles/100729582?p=all&tc=pgall

Camilli R, Reddy CM, Yoerger DR, Van Mooy BAS, Jakuba MV, et al. 2010. Tracking hydrocarbon plume transport and biodegradation at *Deepwater Horizon*. Science. 330: 201-204.

Carls M, Marty GD, Meyers TR, Thomas RE, Rice SD. 1998. Expression of viral hemorrhagic septicemia virus in pre-spawning Pacific herring (*Clupea pallasi*) exposed to weathered crude oil. Canadian Journal of Fisheries and Aquatic Sciences. 55: 2300-2309.

Carter C, Radtke H. 1986. Coastal community impacts of the recreational/commercial allocation of salmon in the ocean fisheries. Salem (OR): Oregon Department of Fish and Wildlife Staff Report.

Chamberlain G. 2013 Dec 10. Early mortality syndrome in shrimp: managing 'the perfect killer'. Global Aquaculture Alliance. [cited 2015 Aug 6]. Available from: https://cc.readytalk.com/cc/s/meetingArchive?eventId=23ira4zne20c

Chandra, S. 2010 July 30. Recession in U.S. was even worse than estimated, revisions show. Bloomberg. [cited 2015 Aug 6]. Available from: http://www.bloomberg.com/news/print/2010-07-30/recession-in-america-was-even-worse-than-estimated-revisions-to-data-show.html

Chapman PM, Wang F. 2001. Assessing sediment contamination in estuaries. Environmental Toxicology and Chemistry. 20: 3-22.

Corn ML, Copeland C. 2010. The *Deepwater Horizon* oil spill: coastal wetland and wildlife impacts and response. Congressional Research Service Report, Washington, DC, USA.

Cruz-Rodríguez LA, Chu FLE. 2002. Heat-shock protein (HSP70) response in the eastern oyster, *Crassostrea virginica*, exposed to PAHs sorbed to suspended artificial clay particles and to suspended field contaminated sediments. Aquatic Toxicology 60: 157-168.

Culbertson JB, Valiela I, Peacock EE, Reddy CM, Carter A, et al. 2007. Long-term biological effects of petroleum residues on fiddler crabs in salt marshes. Marine Pollution Bulletin 54(7): 955–962.

Culbertson JB, Valiela I, Olsen YS, Reddy CM. 2008. Effect of field exposure to 38-year-old residual petroleum hydrocarbons on growth, condition index, and filtration rate of the ribbed mussel, *Geukensia demissa*. Environmental Pollution 154(2): 312–319.

Dame RF, Dankers N. 1988. Uptake and release of materials by a Wadden Sea mussel bed. Journal of Experimental Marine Biology and Ecology 118: 207–216.

Daybrook. 2014. New Orleans (LA): Daybrook Fisheries. [cited 2015 Aug 6]. Available from: http://www.daybrook.com/operations/

Decker K. 2012 October 9-11. The Groundfish forum. Berlin (Germany): Grand Hyatt.

Deepwater Horizon Settlements. 2015. Public statistics for the economic and property damages settlement. [cited 2015 January 21] Available from: http://www.deepwaterhorizoneconomicsettlement.com/docs/statistics.pdf

Deepwater Horizon Unified Command. 2010. U.S. scientific teams refine estimates of oil flow from BP's well prior to capping. Gulf of Mexico Oil Spill Response. [cited 2015 Aug 6]. Available from: www.deepwaterhorizonresponse.com/go/doc/2931/840475/

DeLaune RD, Smith CJ, Patrick WH Jr, Fleeger JW, Tolley M.D. 1984. Effect of oil on salt marsh biota: methods for restoration. Environmental Pollution 36: 207–227.

DNR (Department of Natural Resources). 2012. Oyster lease damage evaluation board. Louisiana Department of Natural Resources.

Dubansky B, Whitehead A, Miller JT, Rice CD, and Galvez F. 2013. Multitissue molecular genomic and developmental effects of the *Deepwater Horizon* oil spill on resident Gulf killifish (*Fundulus grandis*). Environmental Science and Technology 47: 5074-5082.

FDA (Food and Drug Administration). 2012. Recall expanded for frozen oysters imported from Korea. [cited 2015 Aug 6]. Available from: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Outbreaks/ucm279170.htm

FEUS (Fisheries Economics of the United States). 2011. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-118, 175p. [cited 2015 Aug 6]. Available from: https://www.st.nmfs.noaa.gov/economics/publications/feus/fisheries_economics_2011

FEUS (Fisheries Economics of the United States). 2012: Economic and sociocultural status and trends series. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Office of Science and Technology. Division of Economics and Social Analysis. P.166. [cited 2015 Aug 6]. Available from: https://www.st.nmfs.noaa.gov/Assets/economics/documents/feus/2012/FEUS2012.pdf

Fisher WS, Oliver LM, Winstead JT, Long ER. 2000. A survey of oysters *Crassostrea virginica* from Tampa Bay, Florida: associations of internal defense measurements with contaminant burdens. Aquatic Toxicology 51: 115-138.

Fish Watch. National Oceanic and Atmospheric Administration. [cited 2015 Aug 6]. Available from: http://www.fishwatch.gov/seafood_profiles/index.htm

Fodrie FJ, Heck KL Jr. 2011. Response of coastal fishes to the Gulf of Mexico oil disaster. PLoS ONE 6(7): e21609. doi:10.1371/journal.pone.0021609.

Freeman M, Gidiere S, Samuels M. 2010. The oil spill's impact on Gulf coast oysters. News and Analysis Environmental Law Reporter: 1-3.

Friedrick J. 2011 May 5. For business owners, planning for the worst is better than hoping for the best. Seafood Business.

Fowler T. 2012 April 12. Toll on shellfish takes a while to become clear. Wall Street Journal. [cited 2015 Aug 6]. Available from: http://www.wsj.com/articles/SB10001424052702303624004577340051283828264

Getter CD, Scott GI, Michel J. 1981. "The effects of oil spills on mangrove forests: a comparison of five oil spill sites in the Gulf of Mexico and the Caribbean Sea." Proceedings of the International Oil Spill Conference; 1981 (1): 535-540.

Gill DA, et al. 2011. The *Exxon Valdez* and BP oil spills: a comparison of initial social and psychological impacts. American Behavioral Scientist, Volume 56 (1): 3-23.

Goldenberg S. 2010 Sept 6. BP spill: white house says oil has gone, but Gulf's fishermen are not so sure. The Guardian. [cited 2015 Aug 6]. Available from: http://www.theguardian.com/environment/2010/sep/06/bp-oil-spill-fishing-fears

GOM FMC (Gulf of Mexico Fisheries Management Council). 2011 Aug. Final Amendment 10 to the fishery management plan for spiny lobster in the Gulf of Mexico and South Atlantic. [cited 2015 Aug 6]. Available from: http://www.gulfcouncil.org/docs/amendments/Final%20Final_Spiny_Lobster_Amendment_10_August_11.pdf

Grabowski JH, Peterson CH. 2007. "Restoring oyster reefs to recover ecosystem services." *In*: Cuddington K, Byers JE, Wilson WG, Hastings A. (eds). Ecosystem engineers: concepts, theory, and applications. Elsevier-Academic Press, Amsterdam, 281-298.

Graham S. 2003 Dec 19. Environmental effects of *Exxon Valdez* spill still being felt. News report. Scientific American. [cited 2015 Aug 6]. Available from: http://www.scientificamerican.com/article.cfm?id=environmental-effects-of

Greater New Orleans, Inc. 2010. A study of the economic impact of the *Deepwater Horizon* oil spill. Prepared by IEM. [cited 2015 Aug 6]. Available from: http://gnoinc.org/wp-content/uploads/GNO_Inc_EIS_FINAL_FINAL_Publication.pdf

Grizzle RE, Greene JK, Luckenbach MW, Coen LD. 2006. A new in situ method for measuring seston uptake by suspension-feeding bivalve molluscs. Journal of Shellfish Research 25: 643-649.

Hartman J. 2002. Economic impact analysis of the seafood industry in southeast Alaska: importance, person income, and employment in 1994. Division of Commercial Fisheries, Alaska Department of Fish and Game. October.

Henderson J, O'Neil LJ. 2003. Economic values associated with construction of oyster reefs by the Corps of Engineers. EMRRP Technical Notes Collection. Vicksburg, MS. U.S. Army Engineer Research and Development Center.

Hjermann, DØ, Melsom A, Dingsør GE, Durant JM, Eikeset AM, et al. 2007. Fish and oil in the Lofoten-Barents Sea system: synoptic review of the effect of oil spills on fish populations." Marine Ecology Progress Series 339: 283-299.

International Fishmeal and Fish Oil Organization. 2009. 50 year history booklet. [cited 2015 Aug 6]. Available from: http://www.iffo.net/system/files/50-year-history-booklet.pdf

Incardona JP, Gardner LD, Linbo TL, Brown TL, Esbaugh AJ, et al. 2014 April 15. *Deepwater Horizon* crude oil impacts the developing hearts of large predatory pelagic fish. Proceedings of the National Academy of Sciences of the United States of America. 111(15): E1510. [cited 2015 Aug 6]. Available from: http://www.tunaresearch.org/reprints/PNAS-2014-Incardona-1320950111.pdf

ITC (U.S. International Trade Commission). 2000 Aug. Crabmeat from swimming crabs determination and views of the commission. Investigation No. TA-201-71.

ITC (U.S. International Trade Commission). 2011 Mar. frozen warmwater shrimp from Brazil, China, India, Thailand, and Vietnam. Investigation Nos. 731-TA-1063, 1064, 1066-1068 (Review).

Jackson JBC, Cubit JD, Keller BD, Batista V, Burns K, et al. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243(4887): 37-44.

Jamall D. 2012 Apr 19. Gulf fisheries in decline after oil disaster. Al-Jazeera. [cited 2015 Aug 6]. Available from: http://www.aljazeera.com/indepth/features/2012/03/20123571723894800.html

Johnson A, Calkins L, Fisk MC. 2012 Feb 23. BP spill victims face economic fallout two years later. Bloomberg Business. [cited 2015 Aug 6]. Available from: http://www.bloomberg.com/news/articles/2012-02-23/bp-oil-spill-haunts-gulf-business-owners-almost-two-years-after-disaster

Kaufman L. 2011 Sept 26. Oil spill affected Gulf fish's cell function, study finds. The New York Times. [cited 2015 Aug 6]. Available from: http://green.blogs.nytimes.com/2011/09/26/oil-spill-affected-gulf-fishs-biology-study-finds/?_r=0

Keithly W, Diop H, Kazmierczak RF Jr, and Travis MD. 2005. An economic analysis of the southeast U.S. shrimp processing industry responses to an increasing import base. Coastal Fisheries Institute, Louisiana State University. Proceedings of the Gulf and Caribbean Fisheries Institute 56: 133-149.

Kilgen RH, Dugas RJ. 1989. "The ecology of oyster reefs of the northern Gulf of Mexico: an open file report." NWRC-open file rep. 89-02.

Kirkham C. 2010 Aug 8. Convincing the public the Gulf seafood is safe will take time. The Times-Picayune. [cited 2015 Aug 6]. Available from: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/08/convincing_public_that_gulf_of.html

Kirkley J. 2011. A user's guide to the national and coastal state I/O model. [cited 2015 Aug 6]. Available from: http://www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf

Kocan, RM, Hose JE, Brown ED, and Baker TT. 1996 Mar 11. Pacific herring (*Clupea pallasi*) embryo sensitivity to Prudhoe Bay petroleum hydrocarbons: laboratory evaluation and in situ exposure at oiled and unoiled sites in Prince William Sound. Canadian Journal of Fisheries and Aquatic Sciences, 53(10): 2366-2375, 10.1139/f96-173.

Kowalski, A. 2011 Jul 29. Recession took bigger bite than estimated. Bloomberg. [cited 2015 Aug 6]. Available from: http://www.bloomberg.com/news/print/2011-07-29/recession-took-bigger-bite-out-of-u-s-economy-than-previously-estimated.html

Kraybill. 1994. A primer on regional computable general equilibrium analysis. Annual meeting of the American Agricultural Economics Association, San Diego, California, Aug 7-10, 1994.

Krebs, D. 2014. President of Ariel Seafoods. Personal Communication.

Kyriakoudes, Dr. Louis M. 2010-2012. Voices from the Fisheries. The Center for Oral History and Cultural Heritage. University of Southern Mississippi. [cited 2015 Aug 6]. Available from: https://www.st.nmfs.noaa.gov/apex/f?p=213:6:0::NO:RP::

La Monica, PR. 2011. Biggest winner in BP claim game is…, CNN Money, The Buzz. [cited 2015 Aug 6]. Available from: http://money.cnn.com/2011/04/21/smallbusiness/thebuzz/

Landrum PF, Gossiaux DC, Fisher SW, Bruner KA. 1991. The role of zebra mussels in contaminant cycling in the Great Lakes. Journal of Shellfish Research 10: 252–253.

Lee RF, Dornseif B, Gonsoulin F, Tenore K, Hanson R. 1981. Fate and effects of a heavy fuel oil spill on a Georgia salt marsh. Marine Environmental Research 5: 125–143.

Leeworthy V, Wiley P. 2000. A socioeconomic overview of the Santa Barbara and Ventura Counties as it relates to marine related industries and activities (draft). National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Levy JK, Gopalakrishnan C. 2010. Promoting ecological sustainability and community resilience in the U.S. Gulf Coast after the 2010 *Deepwater Horizon* oil spill. Journal of Natural Resources Policy Research 2(3): 297–315.

Louisiana Seafood News. 2011 Nov 2. Scientists Attest to Gulf Seafood Safety at National Summit. [cited 2014 November 4]. Available from: http://www.louisianaseafoodnews.com/2011/11/02/scientists-attest-to-gulf-seafood-safety-at-national-summit/

Love M, Baldera A, Yeung C, Robbins C. 2013. The Gulf of Mexico ecosystem: a coastal and marine atlas. New Orleans, LA: Ocean Conservancy, Gulf Restoration Center. [cited 2015 Aug 6]. Available from: http://www.oceanconservancy.org/places/gulf-of-mexico/gulf-atlas.html

Lynch T. 2000. Analyzing the economic impact of transportation projects using RIMS II, IMPLAN, and REMI. Office of Research and Special Programs, U.S. Department of Transportation. October.

Malan DE. 1990. Predicted effects of a hypothetical oil spill on the saltmarsh crab *Sesarma catenata*. Oil and Chemical Pollution 6: 137-159.

McCrea-Strub A, Kleisner K, Sumaila UR, Swartz W, Watson R, Zeller D, Pauly D. 2011. Potential impact of the *Deepwater Horizon* oil spill on commercial fisheries in the Gulf of Mexico. Fisheries 36(7): 332-336.

McKendree MGS, Ortega DL, Widmar NO, and Wang HH. 2013 Aug. Consumer perceptions of seafood industries in the wake of the *Deepwater Horizon* oil spill and the Fukushima Daiichi nuclear disaster. Staff Paper 2013-03. Department of Agriculture, Food and Resource Economics, Michigan State University, Lansing, Michigan.

Mendelssohn IA, Andersen GL, Baltz DM, Caffey RH, Carman KR, et al. 2012. Oil impacts on coastal wetlands: implications for the Mississippi river delta ecosystem after the *Deepwater Horizon* oil spill. BioScience 62(6): 562-574.

Meyer DL, Tornmsend EC, Thayer GW. 1997. Stabilization and erosion control value of oyster clutch for intertidal marsh. Restoration Ecology 5: 93-99.

MIG, Inc. 2013. IMPLAN professional 2.0 social accounting & impact analysis software: user's guide, analysis guide, data guide.

Miller A, Isaacs J, Bharadwaj L. 2014a. An economic baseline and characterization of U.S. Gulf of Mexico seafood processors. Gulf States Marine Fisheries Commission Publication, Publication Number 225. Ocean Springs, Mississippi.

Miller A, Ogunyinka E, and Isaacs J. 2014b. An economic baseline and characterization of U.S. Gulf of Mexico dockside seafood dealers. Gulf States Marine Fisheries Commission Publication, Publication Number 226. Ocean Springs, Mississippi.

Miller RE, Blair P. 1985. Input-output analysis: foundations and extensions. Englewood Cliffs, NJ, Prentice Hall, Inc.

Mohan J. 2013 May 2. Study: Gulf oil spill is sickening fish vital to seafood industry. The Los Angeles Times. Science section. [cited 2015 Aug 6]. Available from: http://articles.latimes.com/2013/may/02/science/la-sci-sn-gulf-oil-spill-fish-20130502

Moles AD, Rice SD, Okihiro MS. 1993. Herring parasite and tissue alterations following the *Exxon Valdez* oil spill. Proceedings of the 1993 Oil Spill Conference. American Petroleum Institute, Washington, D.C. pp. 325–328.

Monterey Bay Aquarium Seafood Watch. 2015. [cited 2015 Aug 6]. Available from: http://www.seafoodwatch.org/seafood-recommendations/seafood-a-z

Moody RM, Cebrian J, Heck KL Jr. 2013. Interannual recruitment dynamics for resident and transient marsh species: evidence for a lack of impact by the Macondo oil spill. PLoS ONE 8(3): e58376. doi:10.1371/journal.pone.0058376

Murdock S, Leistritz F, Albrecht S. 2002. An examination of selected recent MMS socioeconomic studies and assessments in the Gulf of Mexico. OCS Study MMS 2002-057. U.S. Dept. of the Interior, Minerals Management Service, Environmental Studies Program, Herndon, VA. 2002. 63

National Research Council of the National Academies. 2005. Oil in the sea III, inputs, fates, and effects. Washington D.C., The National Academies Press.

Nelson C. 2014. Vice President of Bon Secour Fisheries Inc. Personal Communication.

Newell RIE. 1988. Ecological changes in Chesapeake Bay: Are they the result of overharvesting the American oyster, *Crassostrea virginica*. Understanding the Estuary: advances in Chesapeake Bay Research, (Lynch, M.P., Krome, E.C. (eds). Baltimore, MD, Chesapeake Research Consortium.

Newell RIE. 2004. Ecosystem influences of natural and cultivated populations of suspension-feeding bivalve molluscs: a review. Journal of Shellfish Research 23(1):51-62.

NOAA (National Oceanic and Atmospheric Administration). 2010 April. Shorelines and coastal habitats in the Gulf of Mexico Fact Sheet.

NOAA (National Oceanic and Atmospheric Administration) Fisheries. 2013. Annual commercial landing statistics. [cited 2015 Aug 6]. Available from: http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

NOAA (National Oceanic and Atmospheric Administration) Fish Watch. 2014. Brown shrimp biology and white shrimp biology. [cited 2015 Aug 6]. Available from: http://www.fishwatch.gov/seafood_profiles/species/shrimp/group_pages/

NMFS (National Marine Fisheries Service). 2011. Imports and exports of fishery products annual summary, 2011. Commercial fisheries statistics. [cited 2015 Aug 6]. Available from: http://www.st.nmfs.noaa.gov/st1/publications.html

NMFS (National Marine Fisheries Service). 2014. NMFS trade query: Products by U.S. customs district. [cited 2015 Aug 6]. Available from: http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/applications/annual-trade-through-specific-us-customs-districts

Obana H, Hori S, Kashimoto T, Kunita N. 1981. Determination of PAH in marine samples by HPLC. Bulletin of Environmental Contamination and Toxicology 26: 613–620.

Omega Protein. 2011. 2011 Annual Report. Omega Protein Corporation. [cited 2015 Aug 6]. Available from: http://files.shareholder.com/downloads/AMDA-HWM23/3877310699x0x565377/40E422C3-B72B-4FDE-AAB1-ADB3C26D1E6E/2011

Pacific Fishery Management Council. 2004. Amendment 16-3 to the Pacific coast groundfish fishery management plan: rebuilding plans for boccacio, cowcod, widow rockfish, and yelloweye rockfish. Draft environmental impact statement including regulatory impact review and initial regulatory flexibility analysis.

Peterson CH, Rice SD, Short JW, Esler D, Bodkin JL, et al. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302: 2082-2806.

Pittman C. 2013 April 13. Gulf oil spill’s effects still has seafood industry nervous. Tampa Bay Times. [cited 2015 Aug 6]. Available from: http://www.tampabay.com/news/environment/wildlife/seafood-industry-still-holding-its-breath-as-scientists-explore-impact-of/2115038

Posadas BC, Posadas BKA Jr. 2013 May. Estimation of the baseline for assessment of economic impacts of the Gulf of Mexico oil spill on Mississippi’s commercial fishing sector. Mississippi State University. [cited 2015 Aug 6]. Available from: http://msucares.com/pubs/bulletins/b1204.pdf

Poudel P. 2008. An analysis of the world shrimp market and the impact of an increasing import base on the Gulf of Mexico dockside price. The Department of Agricultural Economics & Agribusiness. Louisiana State University and Agricultural and Mechanical College.

Research Group, The. 2000. Local economic impacts from alternative hydrosystem actions being considered for the lower Snake River dams. Report prepared for the National Marine Fisheries Service, Northwest Fisheries Science Center. Seattle, Washington.

Rey S. 2000. Integrated regional econometric+input-output modeling: issues and opportunities. Papers in Regional Science: 79: 271–92.

Rice SD, Thomas RE, Carls MG, Heintz RA, Wertheimer AC, et al. 2001. Impacts to pink salmon following the *Exxon Valdez* oil spill: persistence, toxicity, sensitivity, and controversy. Reviews in Fisheries Science 9(3): 165–211.

Robbins L. 2010 May 1. Seafood Industry Fights Public Perception. The New York Times. [cited 2015 Aug 6]. Available from: http://www.nytimes.com/2010/05/02/us/02fishing.html

Rooker JR, Kitchens LL, Dance MA, Wells RJD, Falterman B, Cornic M. 2013. Spatial, temporal, and habitat-related variation in abundance of pelagic fishes in the Gulf of Mexico: potential implications of the Deepwater Horizon oil spill. PloS One 8.10:e76080.

Rozas LP, Minello TJ, Henry CB. 2000. An assessment of potential oil spill damage to salt marsh habitats and fisheries resources in Galveston Bay, Texas. Marine Pollution Bulletin 40: 1148-1160.

Sanders HL, Grassle JF, Hampson GR, Morse LS, Garner-Price S, et al. 1980. Anatomy of an oil spill: Long-term effects from the grounding of the barge *Florida* off West Falmouth, Massachusetts. Journal of Marine Research 38: 265–380.

SEDAR (Southeast Data, Assessment, and Review). 2009. Stock assessment report of SEDAR 7: Gulf of Mexico red snapper. Charleston, SC.

Settlement Agreement. 2012 May 3. Deepwater Horizon Economic and Property Damages as amended on May 3, 2012. Civil Action No. 12-970 Section J. Exhibit 4: Compensation Framework for Business Economic Loss Claims. Exhibit 10: Seafood Compensation Program. [cited 2015 Aug 6]. Available from: http://www.deepwaterhorizonsettlements.com/Economic/SettlementAgreement.aspx

Seung CK, Waters EC. 2006. A review of regional economic models for fisheries management in the U.S. Marine Resource Economics. 21: 101-124.

Smith M. 2013 Apr 29. “Empty nets in Louisiana three years after the spill”. CNN. [cited 2015 Aug 6]. Available from: http://www.cnn.com/2013/04/27/us/gulf-disaster-fishing-industry/

Spiny Lobster Review Panel. 2015 Feb 9. Spiny lobster review panel summary, Key West (FL): Marriot Beachside Resort. Gulf of Mexico Fishery Management Council. [cited 2015 Aug 6]. Available from:

http://gulfcouncil.org/council_meetings/Briefing%20Materials/BB-03-2015/K-4%20%20Final%20Spiny%20Lobster%20Review%20Panel%20Summary_Feb%2026_2015.pdf

Steinback S. 1999. Regional economic impact assessments of recreational fisheries: an application of the IMPLAN modeling system to marine party and charter boat fishing in Maine. North American Journal of Fishery Management 19: 725–36.

Steinback SR. 2004. Using ready-made regional input-output models to estimate backward-linkage effects of exogenous output shocks. The Review of Regional Studies 34:1. Pp 57-71.

Sturgis S, Kromm C. Troubled waters: two years after the BP oil disaster, a struggling Gulf coast calls for national leadership for recovery. The Institute for Southern Studies. [cited 2015 Aug 6]. Available from: http://www.southernstudies.org/sites/default/files/BPTroubledWatersWeb.pdf

Suchanek TH. 1993. Oil impacts on marine invertebrate populations and communities. American Zoologist 33(6): 510-523.

Suedel BC, Boraczek JA, Peddicord RK, Clifford PA, Dillon TM. 1994. Trophic transfer and biomagnification potential of contaminants in aquatic ecosystems. Reviews of Environmental Contamination and Toxicology. Springer New York, pp. 21-89.

Sumaila UR, Cisneros-Montemayor AM, Dyck A, Huang L, Cheung W, et al. 2012. Impact of the *Deepwater Horizon* well blowout on the economics of U.S. Gulf fisheries. Canadian Journal of Fisheries and Aquatic Sciences 69: 499-510.

Tabarestani M. 2013. The effects of U.S. shrimp imports on the Gulf of Mexico dockside price: a source differentiated mixed demand model. Agricultural Economics & Agribusiness Department. Louisiana State University and Agricultural and Mechanical College.

TechLaw, Inc. 2001. The economic contribution of the sport fishing, commercial fishing, and seafood industries to New York state. New York SeaGrant. Report No.: NYSGI-T-01-001. [cited 2015 Aug 6]. Available from: http://www.seagrant.sunysb.edu/seafood/pdfs/EcOfSeafood-Full.pdf

Telesca J. 2012 April 9. Consumers grow more comfortable with Gulf seafood." Supermarket News. [cited 2015 Aug 6]. Available from: http://supermarketnews.com/seafood/consumers-grow-more-comfortable-gulf-seafood

Thorne RE, Thomas GL. 2008. Herring and the *Exxon Valdez* oil spill: an investigation into historical data conflicts. ICES Journal of Marine Science 65(1): 44–50.

Tunnell J. 2011. An expert opinion of when the Gulf of Mexico will return to pre-spill harvest status following the BP *Deepwater Horizon* MC 252 oil spill. Harte Research Institute for

Gulf of Mexico Studies. Texas A&M University-Corpus Christi. [cited 2015 Aug 6]. Available from: http://media.nola.com/2010_gulf_oil_spill/other/Tunnell-GCCF-Final-Report.pdf

Tuvikene A. 1995 Nov. Responses of fish to polycyclic aromatic hydrocarbons (PAHs). Ann. Zool. Fennici 32, 295-309. [cited 2015 Aug 6]. Available from: http://www.annzool.net/PDF/anzf32/anz32-295-309.pdf

UL (University of Louisiana) 2010 Mar 29. Crawfish markets and marketing. [cited 2015 Aug 6]. Available from: http://www.thefishsite.com/articles/840/crawfish-markets-and-marketing

Upton HF. 2011. The *Deepwater Horizon* oil spill and the Gulf of Mexico fishing industry. Congressional Research Service. 7-5700 R41640

Urriza MSG, Duran R. 2010. The Gulf oil spill: we have been here before. Can we learn from the past? Journal of Cosmology 8: 2026–2028.

U.S. Small Business Administration. 2013. Small business impacts associated with the 2010 oil spill and drilling moratorium in the Gulf of Mexico. Small Business Administration Office of Advocacy. SBAHQ-11-M-0210. [cited 2015 Aug 6]. Available from: https://www.sba.gov/sites/default/files/rs417tot.pdf

Vondruska J. 2010 Aug. Spiny lobster: Florida's commercial fishery, markets, and global landings and trade. National Marine Fisheries Service. Southeast Regional Office Fisheries Social Sciences Branch St. Petersburg, Florida. SERO-FSSB-2010-04 [cited 2015 Aug 6]. Available from: http://sero.nmfs.noaa.gov/sustainable_fisheries/social/documents/pdfs/publications/2013/fssb_2010-04_lobster_trade.pdf

West G. 1995. Comparison of input-output, input-output + econometric and computable general equilibrium impact models at the regional level. Economic Systems Research 7: (2):209–27.

White HK, Hsing PY, Cho W, Shank TM, Cordes EE, et al. 2011. Impact of the *Deepwater Horizon* oil spill on a deep-water coral community in the Gulf of Mexico. Proceedings of the National Academy of Sciences 109(50): 20303-20308.

Woods Hole Oceanographic Institution (WHOI). 2000. Development of an input-output model for social economic assessment of fisheries regulations in New England. Marine Policy Center. MARFIN Project Final Report to the National Marine Fisheries Service, Grant Number: NA87FF0548. Woods Hole, MA.

Wright J. 2010 May 1. The top 25 North American seafood suppliers post nearly $12 billion in sales during a difficult 2009. Seafood Business. [cited 2015 Aug 6]. Available from: http://www.seafoodbusiness.com/articledetail.aspx?id=4294994446

Wittenberg M. 2011 May 25. Gulf spill fix part 2: consumer confidence. Huffington Post. Food section. [cited 2015 Aug 6]. Available from: http://www.huffingtonpost.com/malcolm-wittenberg/gulf-spill-fix-part-2-con_b_783028.html

Zacharias MA, Gregr EJ 2005. Sensitivity and vulnerability in marine environments: an approach to identifying vulnerable marine areas. Conservation Biology 19(1): 86-97.

Appendix I. Tables of Supply Chain Multipliers by Species and State, Inclusive of Trade Flows and Margins

Alabama

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Shrimp	Harvester	Employment	0.0000339	0.0000014	0.0000032	0.0000384
		Sales	0.9666627	0.2240365	0.3517429	1.5424421
		Value Added	0.4789330	0.0641320	0.1700030	0.7130680
		Income	0.4064782	0.0617001	0.1072458	0.5754241
Blue crab	Harvester	Employment	0.0000125	0.0000014	0.0000062	0.0000201
		Sales	0.6143070	0.2762882	0.8392597	1.7298549
		Value Added	0.3576188	0.0798753	0.2598881	0.6973823
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Menhaden	Harvester	Employment	0.0000162	0.0000016	0.0000059	0.0000237
		Sales	0.6054416	0.3497251	0.8050697	1.7602364
		Value Added	0.3276854	0.0936000	0.2493102	0.6705955
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Reef fish	Harvester	Employment	0.0000113	0.0000015	0.0000059	0.0000187
		Sales	0.5984202	0.3251572	0.8009360	1.7245134
		Value Added	0.3260211	0.0895149	0.2479695	0.6635056
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Pelagic finfish	Harvester	Employment	0.0000132	0.0000017	0.0000058	0.0000206
		Sales	0.5960249	0.3358495	0.7873444	1.7192188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.3164522	0.0946016	0.2437235	0.6547773
Bait	Harvester	Employment	0.0000097	0.0000019	0.0000050	0.0000166
		Sales	0.6289379	0.3942922	0.6866940	1.7099241
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2626752	0.1097102	0.2123601	0.5847455
Other shellfish	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Misc finfish	Harvester	Employment	0.0000101	0.0000017	0.0000055	0.0000173
		Sales	0.6164447	0.3584126	0.7440150	1.7188723
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2954643	0.0993158	0.2302367	0.6250168
All species	Dealer	Employment	0.0000014	0.0000004	0.0000003	0.0000021
		Sales	0.4772400	0.0291207	0.0317971	0.5381578

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
All species		Value Added	0.0424844	0.0148942	0.0196862	0.0770647
		Income	0.0405339	0.0084529	0.0103475	0.0593343
	Processor	Employment	0.0000019	0.0000011	0.0000005	0.0000035
		Sales	0.6543987	0.0883883	0.0521222	0.7949092
		Value Added	0.0582552	0.0456319	0.0322697	0.1361568
		Income	0.0555807	0.0247853	0.0169640	0.0973300
	Distributor	Employment	0.0000050	0.0000005	0.0000024	0.0000079
		Sales	0.4740927	0.0620967	0.2686132	0.8048026
		Value Added	0.1989961	0.1366047	0.1447595	0.4803603
		Income	0.2962584	0.0186946	0.0822784	0.3972314
	Market	Employment	0.0000078	0.0000008	0.0000013	0.0000099
		Sales	0.4264513	0.0893160	0.1459585	0.6617258
		Value Added	0.2982729	0.0551730	0.0930116	0.4464575
		Income	0.2109233	0.0300102	0.0483967	0.2893302
	Restaurant	Employment	0.0000070	0.0000007	0.0000013	0.0000090
		Sales	0.3860405	0.0864955	0.1424235	0.6149595
		Value Added	0.2083048	0.0552825	0.0681732	0.3317605
		Income	0.1909360	0.0290225	0.0463534	0.2663120

Florida (West Coast)

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Shrimp	Harvester	Employment	0.0000221	0.0000018	0.0000036	0.0000276
		Sales	0.9781490	0.3107369	0.4135884	1.7024743
		Value Added	0.5122210	0.1042110	0.2525540	0.8689860
		Income	0.4088788	0.0823676	0.1363208	0.6275672
Blue crab	Harvester	Employment	0.0000125	0.0000014	0.0000062	0.0000201
		Sales	0.6143070	0.2762882	0.8392597	1.7298549
		Value Added	0.3576188	0.0798753	0.2598881	0.6973823
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Oysters	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Menhaden	Harvester	Employment	0.0000162	0.0000016	0.0000059	0.0000237
		Sales	0.6054416	0.3497251	0.8050697	1.7602364
		Value Added	0.3276854	0.0936000	0.2493102	0.6705955

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Reef fish	Harvester	Employment	0.0000113	0.0000015	0.0000059	0.0000187
		Sales	0.5984202	0.3251572	0.8009360	1.7245134
		Value Added	0.3260211	0.0895149	0.2479695	0.6635056
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Pelagic finfish	Harvester	Employment	0.0000132	0.0000017	0.0000058	0.0000206
		Sales	0.5960249	0.3358495	0.7873444	1.7192188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.3164522	0.0946016	0.2437235	0.6547773
Bait	Harvester	Employment	0.0000097	0.0000019	0.0000050	0.0000166
		Sales	0.6289379	0.3942922	0.6866940	1.7099241
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2626752	0.1097102	0.2123601	0.5847455
Other crustaceans	Harvester	Employment	0.0000094	0.0000019	0.0000049	0.0000162
		Sales	0.6355971	0.4062471	0.6650747	1.7069188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2511355	0.1132601	0.2056249	0.5700205
Other shellfish	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Misc. finfish	Harvester	Employment	0.0000101	0.0000017	0.0000055	0.0000173
		Sales	0.6164447	0.3584126	0.7440150	1.7188723
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2954643	0.0993158	0.2302367	0.6250168
All species	Dealer	Employment	0.0000031	0.0000006	0.0000000	0.0000037
		Sales	0.4772400	0.0559721	0.0298227	0.5630349
		Value Added	0.0243240	0.0327387	0.0188643	0.0759270
		Income	0.0133136	0.0203209	0.0104640	0.0440984
	Processor	Employment	0.0000039	0.0000012	0.0000005	0.0000056
		Sales	0.6543987	0.1373256	0.0572802	0.8490044
		Value Added	0.0333534	0.0770770	0.0362308	0.1466612
		Income	0.0182558	0.0460500	0.0200913	0.0843971
	Distributor	Employment	0.0000051	0.0000006	0.0000027	0.0000084
		Sales	0.4740927	0.0773138	0.3081427	0.8595491
		Value Added	0.1989961	0.1366047	0.1447595	0.4803603

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
All species		Income	0.2988335	0.0259444	0.1016869	0.4264648
	Market	Employment	0.0000074	0.0000010	0.0000020	0.0000104
		Sales	0.4264513	0.1325479	0.2445101	0.8035094
		Value Added	0.3040125	0.0862579	0.1546999	0.5449703
		Income	0.2256021	0.0473655	0.0857449	0.3587125
	Restaurant	Employment	0.0000063	0.0000009	0.0000015	0.0000087
		Sales	0.3860405	0.1350146	0.1796864	0.7007415
		Value Added	0.2280392	0.0799150	0.1136874	0.4216416
		Income	0.1566927	0.0438299	0.0630115	0.2635340

Louisiana

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Shrimp	Harvester	Employment	0.0000251	0.0000014	0.0000034	0.0000299
		Sales	0.9754093	0.2315655	0.3613721	1.5683469
		Value Added	0.4538010	0.1960040	0.1994690	0.8492740
		Income	0.4089262	0.0597568	0.1126051	0.5812881
Blue crab	Harvester	Employment	0.0000125	0.0000014	0.0000062	0.0000201
		Sales	0.6143070	0.2762882	0.8392597	1.7298549
		Value Added	0.3576188	0.0798753	0.2598881	0.6973823
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Oysters	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Menhaden	Harvester	Employment	0.0000162	0.0000016	0.0000059	0.0000237
		Sales	0.6054416	0.3497251	0.8050697	1.7602364
		Value Added	0.3276854	0.0936000	0.2493102	0.6705955
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Reef fish	Harvester	Employment	0.0000113	0.0000015	0.0000059	0.0000187
		Sales	0.5984202	0.3251572	0.8009360	1.7245134
		Value Added	0.3260211	0.0895149	0.2479695	0.6635056
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Pelagic finfish	Harvester	Employment	0.0000132	0.0000017	0.0000058	0.0000206
		Sales	0.5960249	0.3358495	0.7873444	1.7192188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.3164522	0.0946016	0.2437235	0.6547773

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Bait	Harvester	Employment	0.0000097	0.0000019	0.0000050	0.0000166
		Sales	0.6289379	0.3942922	0.6866940	1.7099241
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2626752	0.1097102	0.2123601	0.5847455
Other crustaceans	Harvester	Employment	0.0000094	0.0000019	0.0000049	0.0000162
		Sales	0.6355971	0.4062471	0.6650747	1.7069188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2511355	0.1132601	0.2056249	0.5700205
Other shellfish	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Misc. finfish	Harvester	Employment	0.0000101	0.0000017	0.0000055	0.0000173
		Sales	0.6164447	0.3584126	0.7440150	1.7188723
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2954643	0.0993158	0.2302367	0.6250168
All species	Dealer	Employment	0.0000031	0.0000006	0.0000005	0.0000042
		Sales	0.4772400	0.0367914	0.0595080	0.5735394
		Value Added	0.0906131	0.0177691	0.0367556	0.1451378
		Income	0.0737364	0.0118327	0.0199434	0.1055125
	Processor	Employment	0.0000039	0.0000008	0.0000008	0.0000056
		Sales	0.6543987	0.0738103	0.0849750	0.8131839
		Value Added	0.1242533	0.0384040	0.0524782	0.2151355
		Income	0.1011079	0.0210003	0.0284729	0.1505811
	Distributor	Employment	0.0000050	0.0000005	0.0000026	0.0000082
		Sales	0.4606349	0.0532855	0.2673772	0.7812975
		Value Added	0.1989961	0.1366047	0.1447595	0.4803603
		Income	0.2981619	0.0164221	0.0877405	0.4023245
	Market	Employment	0.0000077	0.0000007	0.0000014	0.0000097
		Sales	0.4264513	0.0871893	0.1534841	0.6671247
		Value Added	0.2998678	0.0538113	0.0973435	0.4510226
		Income	0.2108930	0.0286554	0.0524019	0.2919503
	Restaurant	Employment	0.0000069	0.0000007	0.0000011	0.0000087
		Sales	0.3860405	0.1117695	0.1276439	0.6254540
		Value Added	0.2143150	0.0608199	0.0789005	0.3540355
		Income	0.1505782	0.0332589	0.0428042	0.2266413

Mississippi

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Shrimp	Harvester	Employment	0.0000201	0.0000013	0.0000032	0.0000246
		Sales	0.5608192	0.9679633	0.2166960	1.7454785
		Value Added	0.5251030	0.0628320	0.1841100	0.7720450
		Income	0.4088737	0.0512355	0.1007100	0.5608192
Blue crab	Harvester	Employment	0.0000125	0.0000014	0.0000062	0.0000201
		Sales	0.6143070	0.2762882	0.8392597	1.7298549
		Value Added	0.3576188	0.0798753	0.2598881	0.6973823
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Oysters	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Menhaden	Harvester	Employment	0.0000162	0.0000016	0.0000059	0.0000237
		Sales	0.6054416	0.3497251	0.8050697	1.7602364
		Value Added	0.3276854	0.0936000	0.2493102	0.6705955
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Bait	Harvester	Employment	0.0000097	0.0000019	0.0000050	0.0000166
		Sales	0.6289379	0.3942922	0.6866940	1.7099241
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2626752	0.1097102	0.2123601	0.5847455
Other shellfish	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Misc. finfish	Harvester	Employment	0.0000101	0.0000017	0.0000055	0.0000173
		Sales	0.6164447	0.3584126	0.7440150	1.7188723
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2954643	0.0993158	0.2302367	0.6250168
All species	Dealer	Employment	0.0000031	0.0000005	0.0000003	0.0000039
		Sales	0.4772400	0.0354551	0.0355448	0.5482399
		Value Added	0.0495179	0.0180440	0.0217039	0.0892658
		Income	0.0459367	0.0098569	0.0111545	0.0669482
	Processor	Employment	0.0000039	0.0000014	0.0000005	0.0000059
		Sales	0.6543987	0.1146356	0.0582866	0.8273209
		Value Added	0.0678997	0.0585602	0.0355901	0.1620500
		Income	0.0629891	0.0284618	0.0182911	0.1097420

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
All species	Distributor	Employment	0.0000051	0.0000005	0.0000025	0.0000080
		Sales	0.4740927	0.0601765	0.2670535	0.8013227
		Value Added	0.1989961	0.1366047	0.1447595	0.4803603
		Income	0.2996701	0.0163901	0.0795283	0.3955885
	Market	Employment	0.0000074	0.0000006	0.0000013	0.0000093
		Sales	0.4264513	0.0744414	0.1379916	0.6388843
		Value Added	0.3039767	0.0449305	0.0867172	0.4356243
		Income	0.2115826	0.0220505	0.0440503	0.2776834
	Restaurant	Employment	0.0000073	0.0000007	0.0000009	0.0000090
		Sales	0.3860405	0.1013874	0.1060341	0.5934620
		Value Added	0.2040120	0.0526922	0.0648247	0.3215289
		Income	0.1388345	0.0281370	0.0333149	0.2002863

Texas

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Shrimp	Harvester	Employment	0.0000150	0.0000017	0.0000036	0.0000203
		Sales	0.9794106	0.4185381	0.4567722	1.8547210
		Value Added	0.5122210	0.1042110	0.2525540	0.8689860
		Income	0.4022475	0.1142126	0.1384403	0.6549005
Blue crab	Harvester	Employment	0.0000125	0.0000014	0.0000062	0.0000201
		Sales	0.6143070	0.2762882	0.8392597	1.7298549
		Value Added	0.3576188	0.0798753	0.2598881	0.6973823
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Oysters	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Reef fish	Harvester	Employment	0.0000113	0.0000015	0.0000059	0.0000187
		Sales	0.5984202	0.3251572	0.8009360	1.7245134
		Value Added	0.3260211	0.0895149	0.2479695	0.6635056
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Pelagic finfish	Harvester	Employment	0.0000132	0.0000017	0.0000058	0.0000206
		Sales	0.5960249	0.3358495	0.7873444	1.7192188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.3164522	0.0946016	0.2437235	0.6547773
Bait	Harvester	Employment	0.0000097	0.0000019	0.0000050	0.0000166
		Sales	0.6289379	0.3942922	0.6866940	1.7099241

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2626752	0.1097102	0.2123601	0.5847455
Other crustaceans	Harvester	Employment	0.0000094	0.0000019	0.0000049	0.0000162
		Sales	0.6355971	0.4062471	0.6650747	1.7069188
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2511355	0.1132601	0.2056249	0.5700205
Other shellfish	Harvester	Employment	0.0000120	0.0000014	0.0000060	0.0000194
		Sales	0.6075021	0.2913910	0.8156346	1.7145277
		Value Added	0.3413325	0.0817599	0.2525825	0.6756749
		Income	0.3391104	0.1350218	0.1864866	0.6606188
Misc. finfish	Harvester	Employment	0.0000101	0.0000017	0.0000055	0.0000173
		Sales	0.6164447	0.3584126	0.7440150	1.7188723
		Value Added	0.3391104	0.1350218	0.1864866	0.6606188
		Income	0.2954643	0.0993158	0.2302367	0.6250168
All species	Dealer	Employment	0.0000029	0.0000001	0.0000004	0.0000033
		Sales	0.4772400	0.0171234	0.0468211	0.5411844
		Value Added	0.0555732	0.0101452	0.0292119	0.0949302
		Income	0.0498935	0.0058925	0.0161751	0.0719611
	Processor	Employment	0.0000039	0.0000006	0.0000006	0.0000051
		Sales	0.6543987	0.0796658	0.0804217	0.8144862
		Value Added	0.0762028	0.0472064	0.0501754	0.1735845
		Income	0.0684148	0.0274206	0.0277831	0.1236185
	Distributor	Employment	0.0000050	0.0000006	0.0000025	0.0000081
		Sales	0.4740927	0.0893119	0.3183330	0.8817376
		Value Added	0.1989961	0.1366047	0.1447595	0.4803603
		Income	0.2962891	0.0277689	0.0965431	0.4206011
	Market	Employment	0.0000072	0.0000009	0.0000017	0.0000097
		Sales	0.4264513	0.1243029	0.2259736	0.7767278
		Value Added	0.3081145	0.0809780	0.1409605	0.5300530
		Income	0.2246064	0.0448013	0.0769148	0.3463224
	Restaurant	Employment	0.0000065	0.0000009	0.0000012	0.0000086
		Sales	0.3860405	0.1484021	0.1619733	0.6964160
		Value Added	0.2241347	0.0808110	0.1010380	0.4059838
		Income	0.1470309	0.0459859	0.0559485	0.2489653

Total Gulf

Species	Sector	Economic Activity	Direct	Indirect	Induced	Total
Shrimp	Harvester	Employment	0.0000143	0.0000028	0.0000073	0.0000243
		Sales	0.9255327	0.5746010	0.9941932	2.4943269
		Value Added	0.4968370	0.1978230	0.2732250	0.9678850
		Income	0.3716233	0.1609359	0.3075290	0.8400882
Blue crab	Harvester	Employment	0.0000183	0.0000021	0.0000090	0.0000294
		Sales	0.9000327	0.4047951	1.2296150	2.5344428
		Value Added	0.5239540	0.1170268	0.3807670	1.0217478
		Income	0.4968370	0.1978230	0.2732250	0.9678850
Oysters	Harvester	Employment	0.0000176	0.0000021	0.0000088	0.0000285
		Sales	0.8900627	0.4269224	1.1950015	2.5119866
		Value Added	0.5000926	0.1197880	0.3700633	0.9899439
		Income	0.4968370	0.1978230	0.2732250	0.9678850
Menhaden	Harvester	Employment	0.0000237	0.0000024	0.0000087	0.0000348
		Sales	0.8870438	0.5123888	1.1795227	2.5789553
		Value Added	0.4800979	0.1371351	0.3652690	0.9825020
		Income	0.4968370	0.1978230	0.2732250	0.9678850
Reef fish	Harvester	Employment	0.0000165	0.0000023	0.0000086	0.0000274
		Sales	0.8767566	0.4763939	1.1734664	2.5266168
		Value Added	0.4776597	0.1311500	0.3633048	0.9721144
		Income	0.4968370	0.1978230	0.2732250	0.9678850
Pelagic finfish	Harvester	Employment	0.0000193	0.0000024	0.0000085	0.0000302
		Sales	0.8732472	0.4920594	1.1535530	2.5188595
		Value Added	0.4968370	0.1978230	0.2732250	0.9678850
		Income	0.4636400	0.1386026	0.3570838	0.9593264
Bait	Harvester	Employment	0.0000142	0.0000027	0.0000074	0.0000243
		Sales	0.9214687	0.5776849	1.0060881	2.5052418
		Value Added	0.4968370	0.1978230	0.2732250	0.9678850
		Income	0.3848504	0.1607384	0.3111327	0.8567215
Other crustaceans	Harvester	Employment	0.0000137	0.0000028	0.0000071	0.0000237
		Sales	0.9312252	0.5952001	0.9744133	2.5008387
		Value Added	0.4968370	0.1978230	0.2732250	0.9678850
		Income	0.3679433	0.1659395	0.3012648	0.8351477
Other shellfish	Harvester	Employment	0.0000176	0.0000021	0.0000088	0.0000285
		Sales	0.8900627	0.4269224	1.1950015	2.5119866
		Value Added	0.5000926	0.1197880	0.3700633	0.9899439
		Income	0.4968370	0.1978230	0.2732250	0.9678850

Misc. finfish	Harvester	Employment	0.0000149	0.0000025	0.0000080	0.0000253
		Sales	0.9031646	0.5251170	1.0900702	2.5183519
		Value Added	0.4968370	0.1978230	0.2732250	0.9678850
		Income	0.4328902	0.1455095	0.3373241	0.9157238
All species	Dealer	Employment	0.0000029	0.0000004	0.0000005	0.0000037
		Sales	0.4772400	0.0334579	0.0609421	0.5716400
		Value Added	0.0640227	0.0175925	0.0374123	0.1190275
		Income	0.0559488	0.0109885	0.0205218	0.0874590
	Processor	Employment	0.0000039	0.0000010	0.0000008	0.0000057
		Sales	0.6543987	0.0988443	0.0984811	0.8517241
		Value Added	0.0877889	0.0534493	0.0604566	0.2016948
		Income	0.0767178	0.0314511	0.0331636	0.1413324
	Distributor	Employment	0.0000051	0.0000010	0.0000049	0.0000109
		Sales	0.4740927	0.1642962	0.6649981	1.3033870
		Value Added	0.2996763	0.0503103	0.2059001	0.5558867
		Income	0.1989961	0.1366047	0.1447595	0.4803603
	Market	Employment	0.0000073	0.0000008	0.0000017	0.0000099
		Sales	0.4264513	0.1154587	0.2135199	0.7554300
		Value Added	0.3051878	0.0739305	0.1358482	0.5149664
		Income	0.2226375	0.0395427	0.0736264	0.3358066
	Restaurant	Employment	0.0000066	0.0000009	0.0000014	0.0000088
		Sales	0.3860405	0.1523119	0.2213294	0.7596818
		Value Added	0.2228759	0.0828987	0.1094722	0.4152468
		Income	0.1498258	0.0460693	0.0600420	0.2559372

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Bureau of Ocean Energy Management

As a bureau of the Department of the Interior, the Bureau of Ocean Energy (BOEM) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.

The BOEM Environmental Studies Program

The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments.