EFFECTS OF THE 2010 DEEPWATER HORIZON OIL SPILL ON FISHING IN THE GULF OF MEXICO

A THESIS SUBMITTED TO

THE GLOBAL ENVIRONMENTAL SCIENCE

UNDERGRADUATE DIVISION IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE

IN

GLOBAL ENVIRONMENTAL SCIENCE

DECEMBER 2016

By:

Jay S. Chitnis

Thesis Advisor

Margaret Edwards

I certify that I have read this thesis and that, in my opinion, it is satisfactory in scope and quality as a thesis for the degree of Bachelor of Science in Global Environmental Science.

THESIS ADVISOR

____

Margaret Edwards

Hawaii Institute of Geophysics & Planetology

For my parents and my brother Om. Thanks for all the guidance and support during this journey.

ACKNOWLEDGEMENTS

I'd like to give my thanks and appreciation to my mentor Margo Edwards for persevering and advising me through this project. I also want to acknowledge Michael Guidry for keeping me on track with his constant check-ins and update requests. Finally, I want to thank my Global Environmental Science ohana for enduring this journey with me. This project would not have been possible without the support of JAMSS America, Inc. and the Center for the Advancement of Science in Space (CASIS) who provided us with the necessary funding and who were great hosts during our trip to Houston.

ABSTRACT

On April 20, 2010 the wellhead of the Deepwater Horizon (DWH), an offshore oilrig operated by British Petroleum (BP) in the Gulf of Mexico (GoM), exploded causing 4.9 million barrels (roughly 780,000 cubic meters) of oil to leak into the surrounding waters before finally being sealed in September of the same year. The spill, centered at 28.7°N, 88.4°W, affected fisheries throughout the northern GoM. While there is no direct evidence of a decrease in commercial fish populations, several of the collected species showed injuries related to oil spills, such as lesions and rotting fins. I used Automatic Identification System (AIS) data from the exactEarth database to document fishing practices in the northern GoM during the first quarter of 2016. I used a geospatial approach to compare fishing vessel behaviors in the present with baseline data from before the DWH spill to see if there has been a noticeable change in the location of high volume fishing in the GoM. What I found is that for the blue crab and white shrimp fisheries there hasn’t been a noticeable long-term change, while the royal red shrimp, gulf menhaden, brown shrimp, and red snapper fisheries still seem to be feeling the effects of the oil spill.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

AIS	Automatic identification system
BP	British Petroleum
CASIS	Center for the Advancement of Science in Space
DWH	Deepwater Horizon
ERMA	Environmental Response Management Application
GMT	Generic Mapping Tool
GoM	Gulf of Mexico
ISS	International Space Station
JAI	JAMSS America, Inc.
OC	Ocean Conservancy

CHAPTER 1

INTRODUCTION

1.1 Background

The Deepwater Horizon (DWH) was an oil-rig owned by Transocean and leased to British Petroleum (BP) in the Gulf of Mexico (GoM), drilling in an area called Mississippi Canyon block 252, otherwise known as the Macondo well. It was designed for operation in water up to 8,000 feet deep and utilized a semi-submersible, which, instead of tethering cables, used a set of powerful thrusters to keep the rig carefully aligned (Transocean, 2010). It employed a crew of 130 people who lived and worked on the rig. In 2009, the DWH had set a record for deep-water drilling, with a completed well that extended almost six miles deep. On April 20, 2010, it celebrated being in operation for seven years without a single major accident. However, on that same day, an oil line exploded and leaked oil for 87 days before finally being capped in July 2010 (Freudenburg and Gramling, 2010).

In the past there have been similar incidences of devastating oil spills, most notable of which was the Exxon-Valdez spill in Prince William Sound, Alaska, on March 24, 1989, however, it is not a viable contender for this study due to Alaska's remoteness the amount of time that has passed since taking place (Skinner, 1989). The main reason for selecting the BP Oil Spill as the subject of this study is mainly because the GoM is a high traffic area, not only to fishers, but also to all types of vessels and because of the resources available during the years preceding the actual spill.

One major effect of the spill was on fisheries. The total discharge of oil has been estimated to be 4.9 million barrels or 210 million gallons (USCG, 2011). At its peak the spill covered 68,000 square miles (176,100 square kilometers) of sea surface, detrimentally affecting a massive amount of sea life in the GoM (Skytruth, 2010). This, combined with the three-month clean up process, which caused fishery closures across the Gulf, subsequently affected the livelihood of many fishermen throughout the region.

In June 2010, the U.S. Government closed 86,985 square miles of the GoM to fishing, this accounted for roughly 35% of federal waters in the GoM (NOAA, 2010). It has been found that over 20% of the annual American commercial catch in the GoM had been affected by the fisheries closures, accounting for a minimum loss of $247 million (McCrea-Strub, 2011). In addition to that, there were reports in 2012 by fishermen that they experienced a 75% reduction in amount of crabs caught and a 94% reduction in the amount of shrimp caught (Jamail, 2012). These reports give an idea of the economic impact to the fisheries, but they do not give any indication of the effect that the spill had on fishing itself.

How did the Deepwater Horizon Oil Spill effect fishing in the Gulf of Mexico? Using Automatic Identification System (AIS) data I can look at fishery locations from before the spill and compare them to fishery locations from after the spill to answer this question.

1.2 Study Area

The focus of this study is the northern GoM. Specifically the waters within, and immediately surrounding the full extent of the oil spill; see Fig. 1.

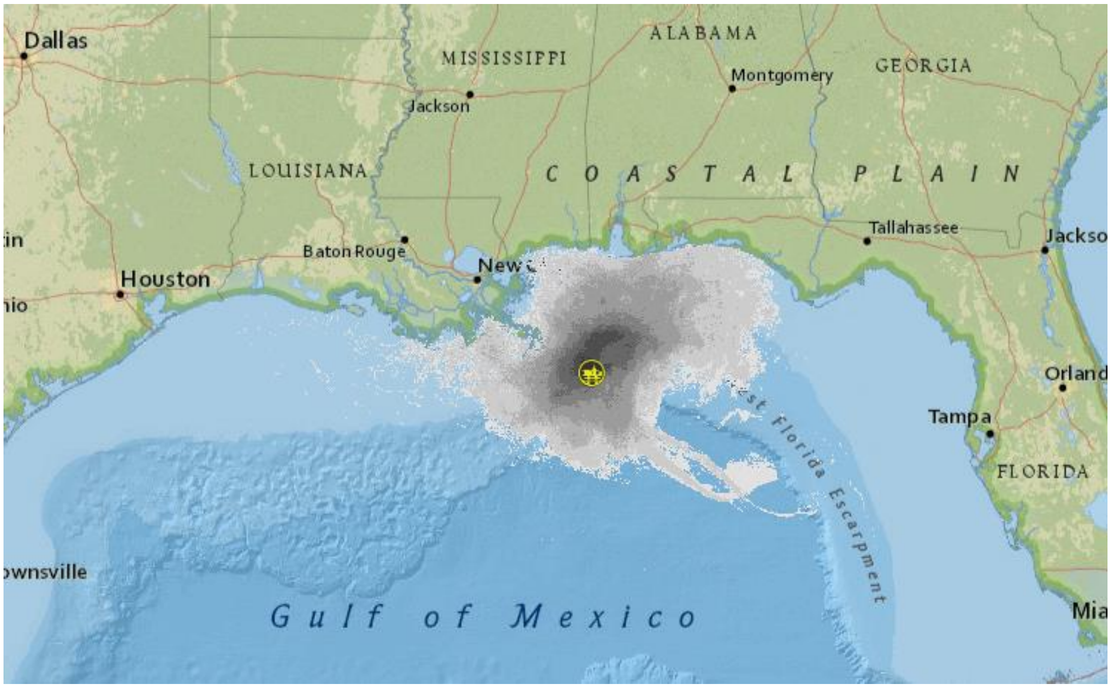

Figure 1. Maximum extent of cumulative observed surface oiling. Days of oiling range from 1 (white) to 60 (black). The yellow symbol is the surface location of the DWH wellhead. Obtained from noaa.gov.

CHAPTER 2

METHODS

2.1 Tracking System

Most of the world's commercial ships are outfitted with AIS transceivers in order to constantly broadcast their location. Traditionally, AIS is a land-based system, however, due to the curvature of the Earth, it is difficult to track ships in remote locations. Because of this, satellite-based AIS transceivers are becoming increasingly commonplace, making it easier to constantly monitor ship movement.

2.2 Pre-Spill Data Source

Because satellite AIS is an emerging technology, data from before the spill is nonexistent, therefore, maps depicting pre-spill fishing were obtained from *Ocean Conservancy's* (OC) Gulf of Mexico Ecosystem Atlas. The atlas is made up of over 50 maps representing GoM factors that are important for conservation and management application, however, for this study I only used seven—those for navigational networks, blue crab, brown shrimp, gulf menhaden, red snapper, royal red shrimp, and white shrimp (Love et al, 2011). The maps were compiled using various geospatial datasets along with analysis of spreadsheets, published literature, technical reports, and direct communication with researchers. Brown shrimp, white shrimp, and blue crab datasets were collected from 1987-2009, royal red shrimp data was collected from 2004-2011, gulf menhaden data was collected from 2006-2009, and red snapper data was collected from 1986-2006 (Love et al, 2011). The timespan of the collection of the data for these maps makes them perfect proxies for identifying pre-spill fishery locations in order to make a comparison between before and after the oil spill.

2.3 Post-Spill Data Source

All post-spill data came from AIS data. The primary source of the AIS data was going to be from JAMSS America, Inc. (JAI) and the Center for the Advancement of Science in Space (CASIS) who funded this project. The AIS antenna has been mounted on the International Space Station (ISS) since 2014, with the remote's expected arrival aboard the ISS to be in January 2016. However, due to launch failures the date of arrival was eventually pushed back to July 2016. Because of this we were forced to buy data from a private company called exactEarth.

2.4 Data Visualization

This study used AIS data to plot post-spill shipping locations, which were plotted using Generic Mapping Tool (GMT). Due to the cost of obtaining AIS data I was only able to obtain four month's worth of shipping data, from January-April 2016, from the exactEarth database. In order to easily perceive the plotted data I added an overlay of the oil spill, obtained from NOAA's Environmental Response Management Application (ERMA), on to the GMT map. Upon adding the oil spill map I got rid of all data points located outside the area of interest which was defined as the north central Gulf of Mexico in the region of the spill (86^{o}W to 94^{o}W and 26^{o}N to 30^{o}N; see Fig. 2). The main reason for doing this was to make plotting of data easier, as the program would not have to parse through all available data.

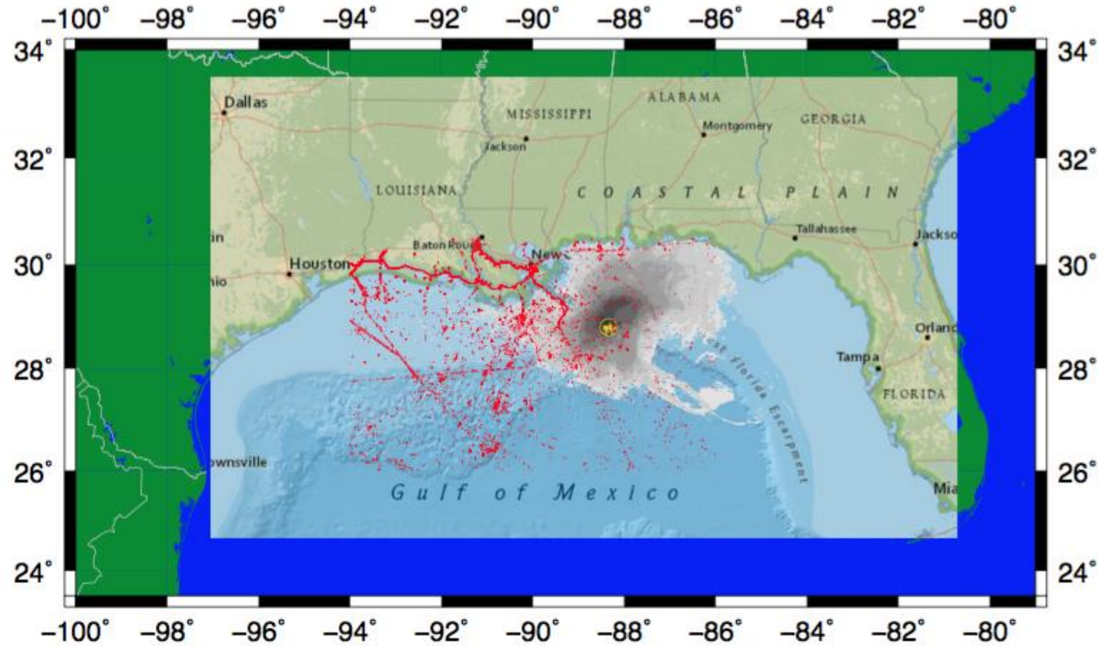

Figure 2. Sample GoM map of ships in area of interest.

2.5 Fishing Vessel Identification

The data from exactEarth had no indication of vessel type, so when the maps were created I identified potential fishing sites by comparing the GMT maps with the maps obtained from OC. The main map used for this identification was one mapping out the GoM’s navigation network; see Fig. 3. This allowed me narrow down my search for fishing vessels to two different characteristics: lines and clumps. I determined that all straight-line patterns are navigational networks while clumps are either oilrig support vessels or groups of fishing vessels. With potential fishing sites identified, I was able to compare my GMT maps with the OC maps of various GoM fish species.

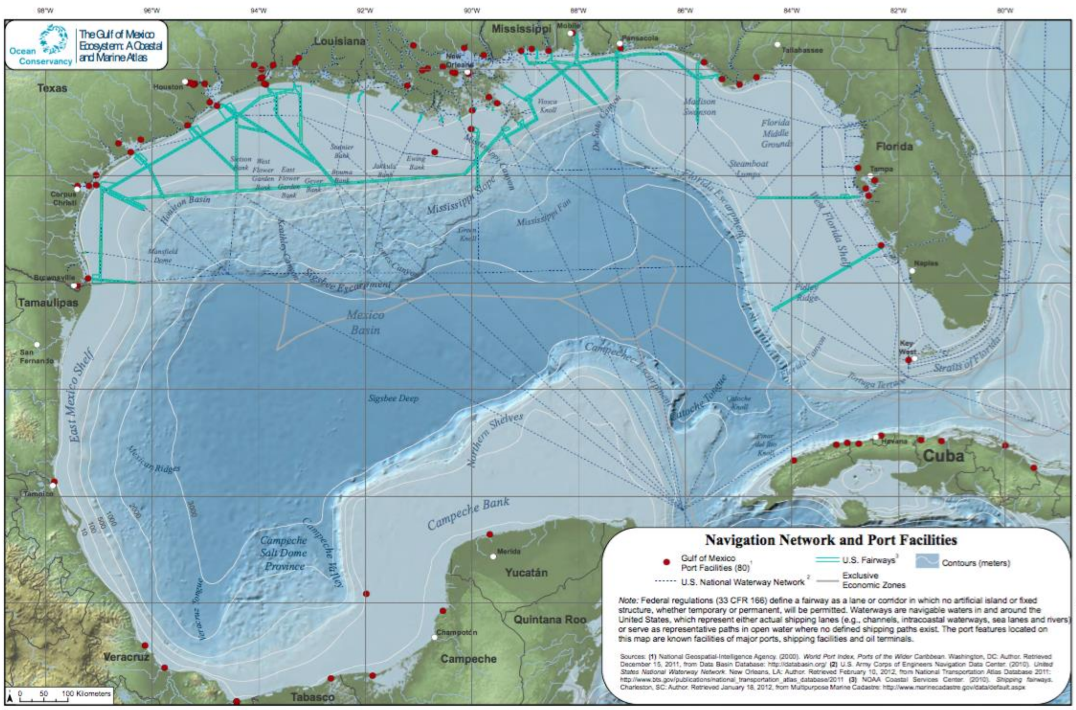

Figure 3. Navigation network of the Gulf of Mexico. Obtained from oceanconservancy.org.

CHAPTER 3

RESULTS

3.1 GMT Generated Maps

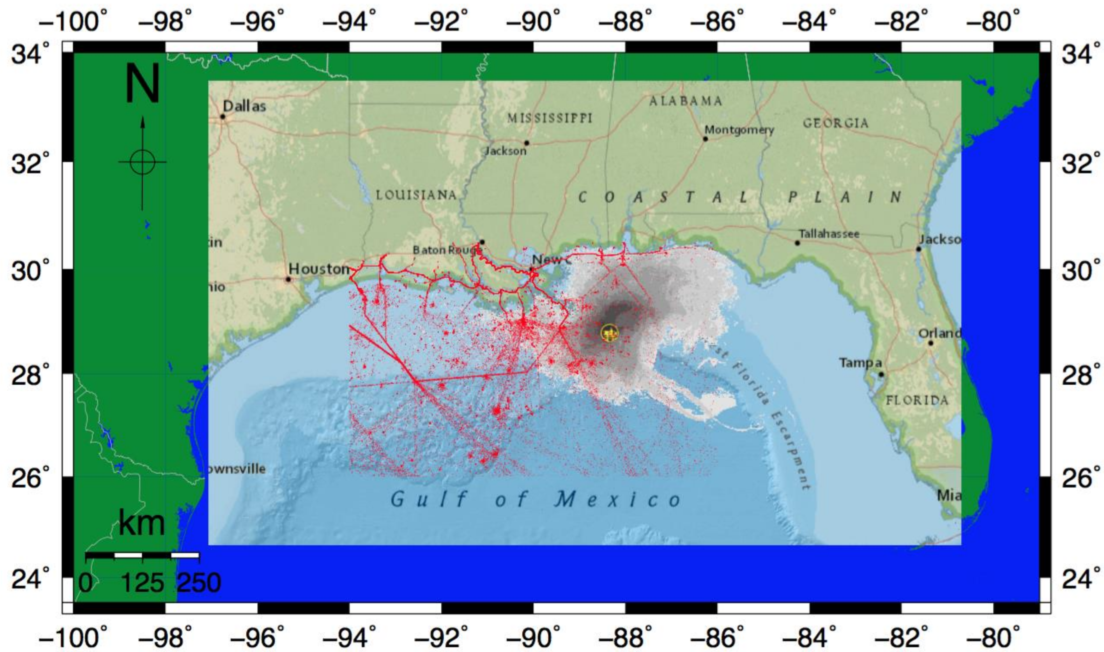

Figure 4. January 2016. Clusters represent groups of fishing vessels and lines represent navigation networks.

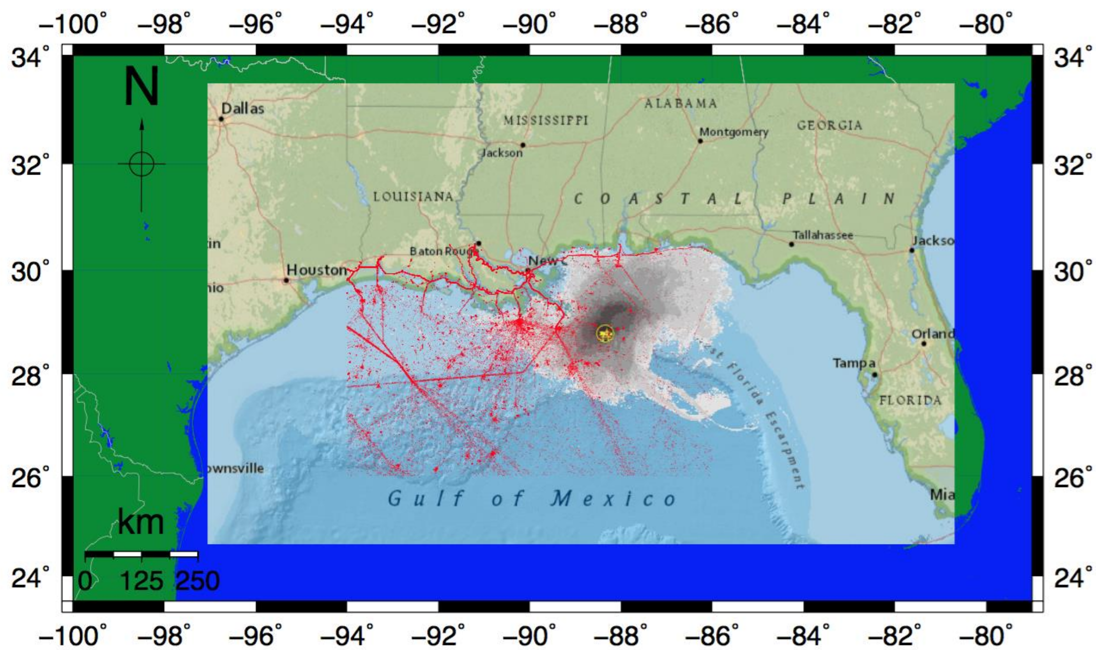

Figure 5. February 2016. Clusters represent groups of fishing vessels and lines represent navigation networks.

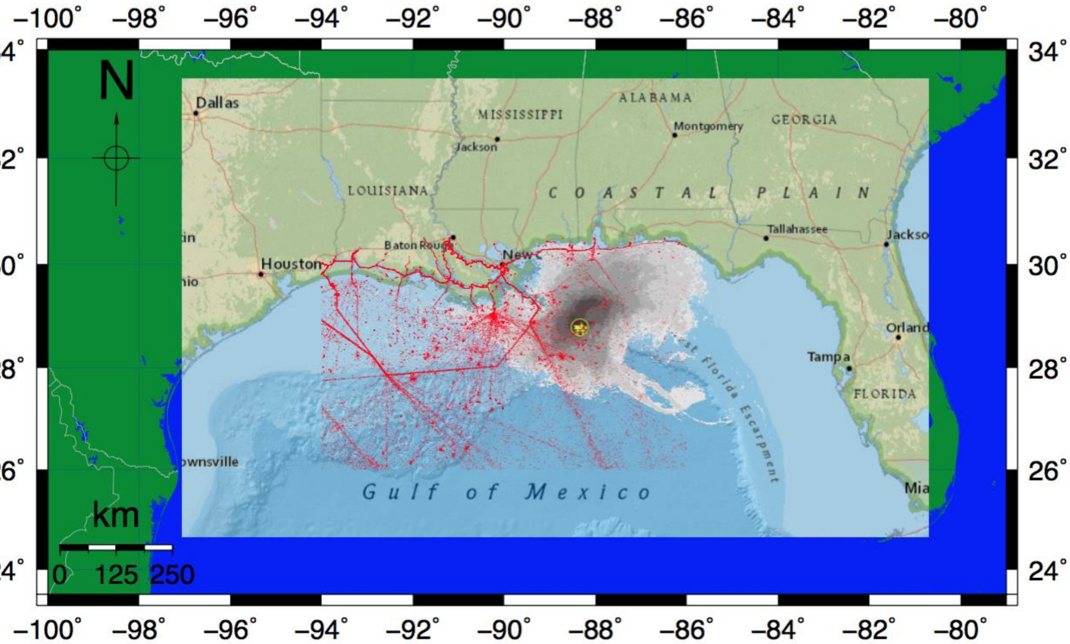

Figure 6. March 2016. Clusters represent groups of fishing vessels and lines represent navigation networks.

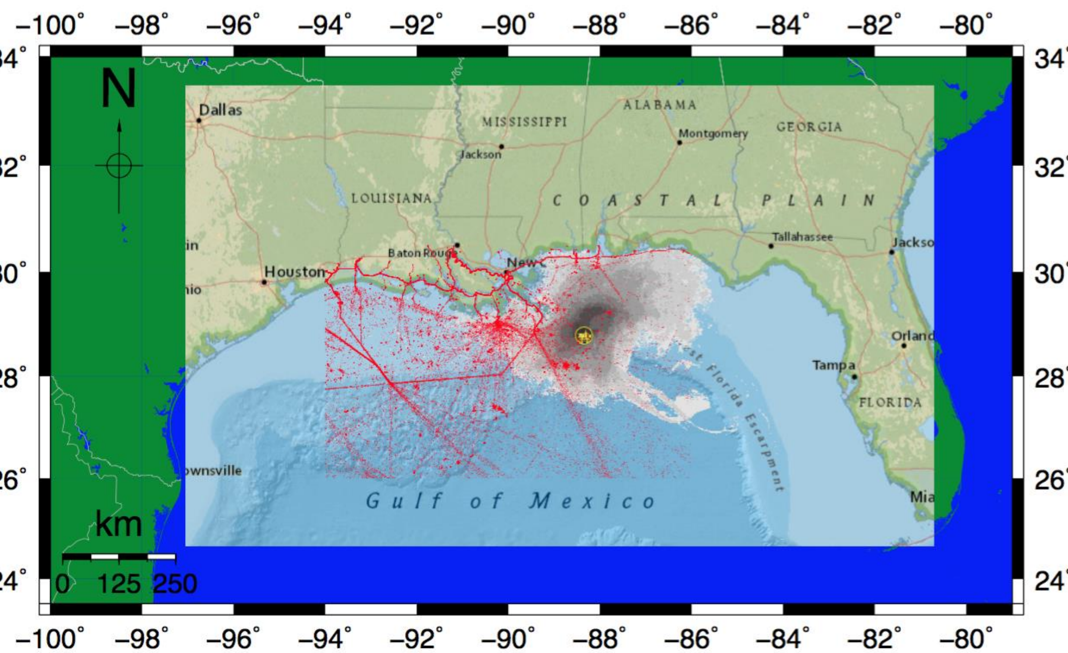

Figure 7. April 2016. Clusters represent groups of fishing vessels and lines represent navigation networks.

3.2 Ocean Conservancy Maps

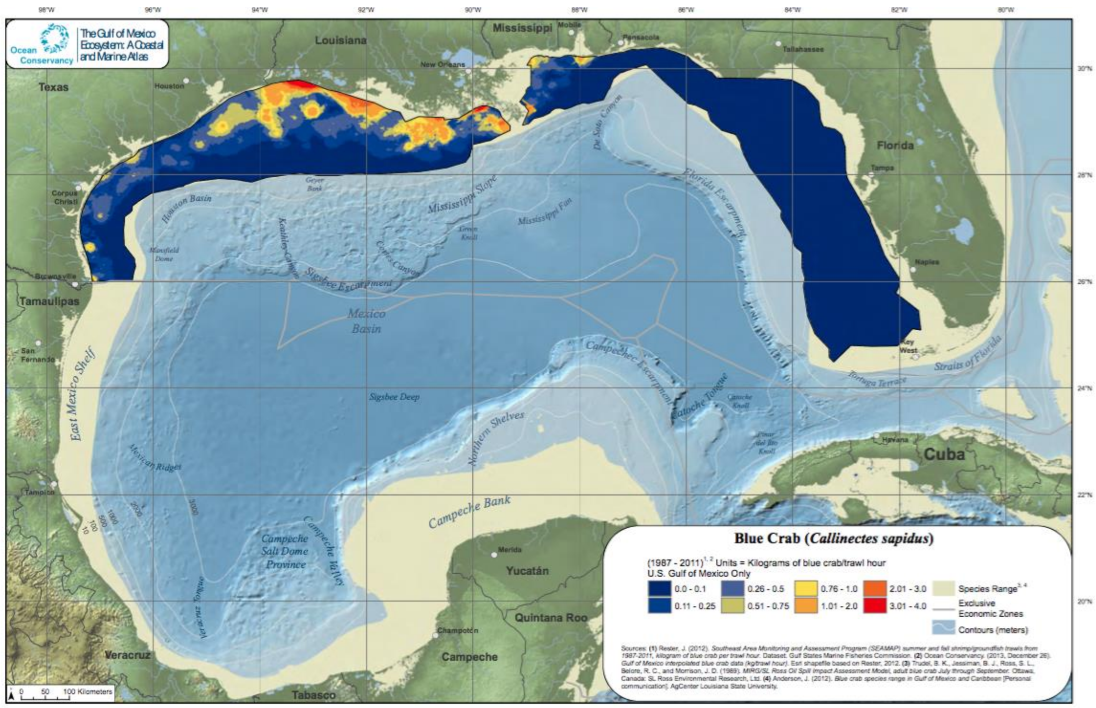

Figure 8. Distribution of blue crab catch per unit effort in the GoM. Obtained from oceanconservancy.org.

Blue crab occurs along the entire U.S. GoM coastline, with the highest concentrations along the Louisiana coast. The maps shows the abundance of blue crab, which was calculated by kilograms of crab caught per one-hour tow (Love et al, 2013).

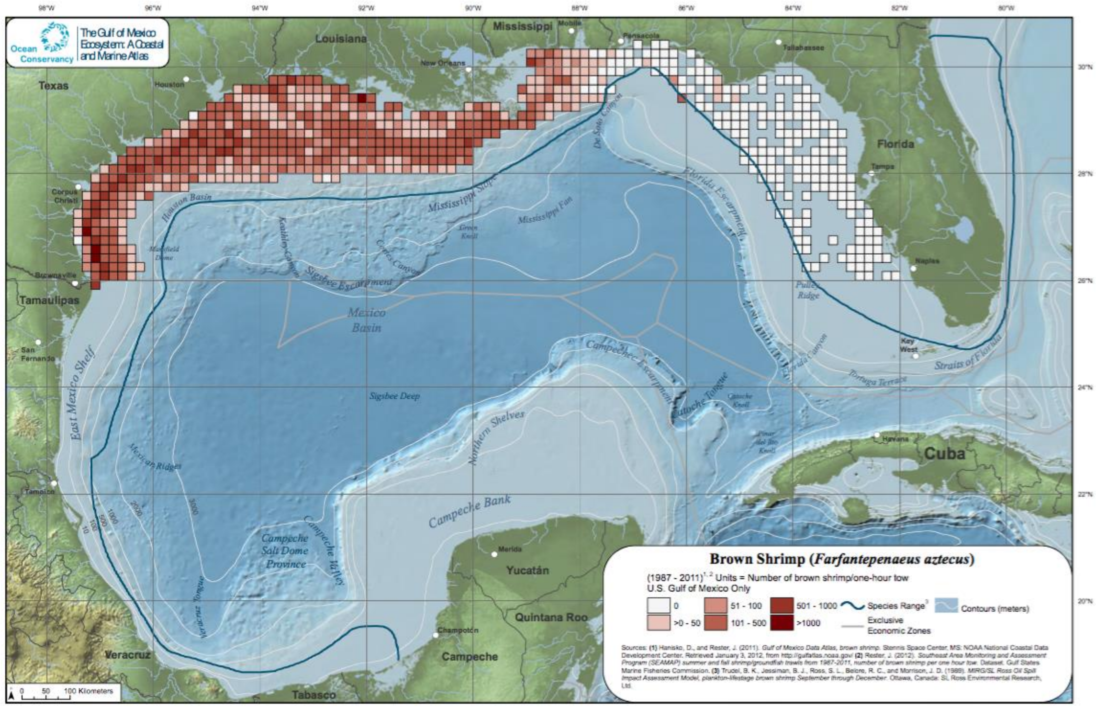

Figure 9. Distribution of brown shrimp in the GoM. Obtained from oceanconservancy.org.

Brown shrimp are present in both U.S. and Mexican coastal waters. In the U.S. they are the most abundant in the northern and northwestern GoM (off the coasts of Louisiana and Texas). Among the three shrimp species used in this study, brown shrimp are the most valuable. The map shows the abundance of brown shrimp, which was calculated by number of shrimp caught per one-hour tow (Love et al, 2011).

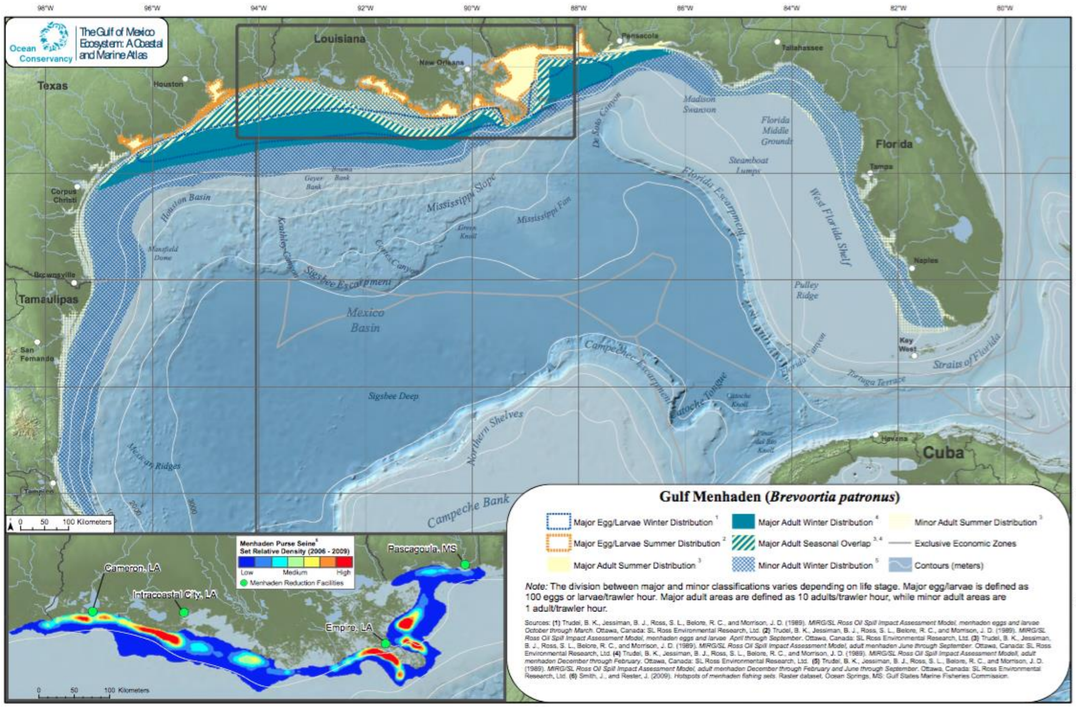

Figure 10. Distribution of gulf menhaden in the GoM. Obtained from oceanconservancy.org.

Gulf menhaden occur throughout the GoM, with the highest density being in the northern GoM from the mid-Texas coast all the way to Florida. The map shows the abundance of gulf menhaden, which was calculated by relative location density using a purse seine net; see Fig. 7, bottom left corner (Love et al, 2011).

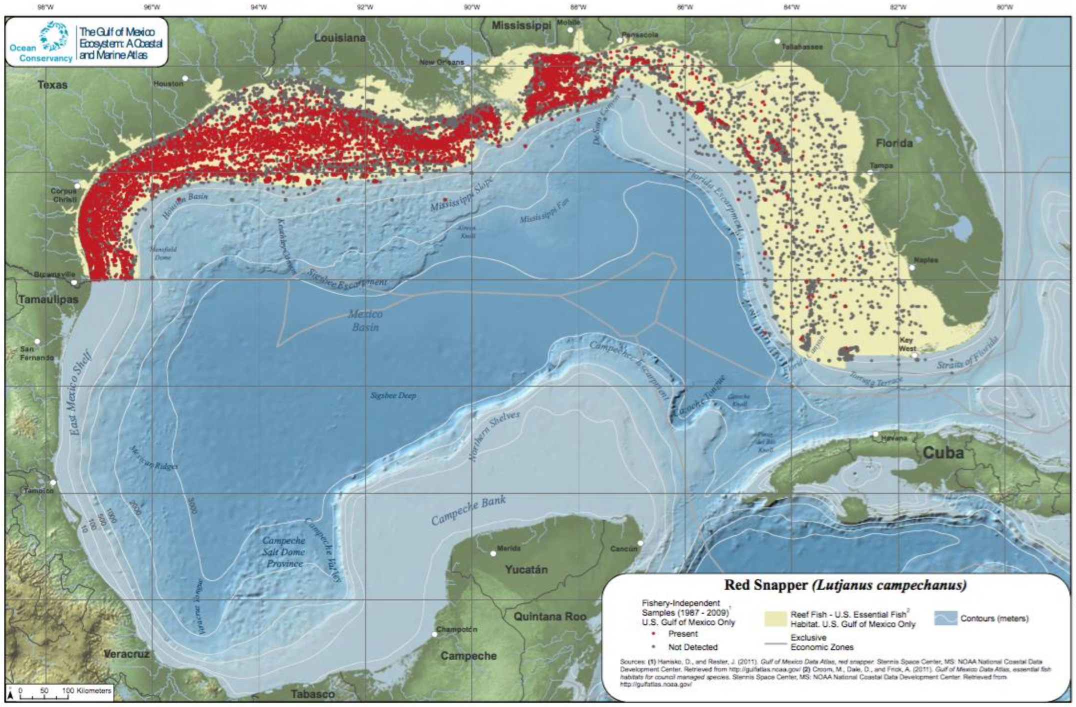

Figure 11. Distribution of red snapper in the GoM. Obtained from oceanconservancy.org.

Red snapper have been observed to occur throughout the GoM, however, they occur in highest abundance along the coasts of Alabama, Mississippi, Louisiana, and Texas. The map shows locations where red snapper has been sighted (red dots) and locations where it has not been sighted (gray dots) (Love et al, 2011).

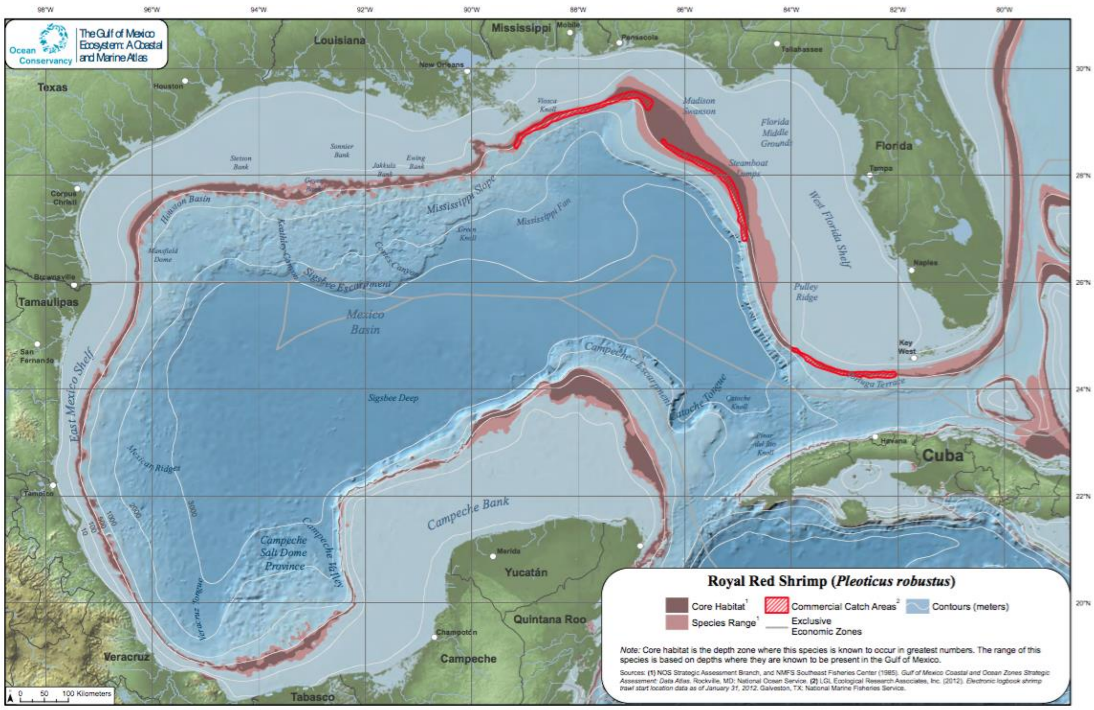

Figure 12. Distribution of royal red shrimp in the GoM. Obtained from oceanconservancy.org.

Royal red shrimp occur throughout the GoM, with high concentrations occurring off of the Dry Tortugas in the Florida Straits and off of the Mississippi River Delta. They are most commonly found in high abundance between 250-475m below sea level. The most important feature of this map is the commercial catch area in red. This was determined by looking at trawlers occurring at depths that were determined to be too deep for other GoM shrimp species (Love et al, 2011).

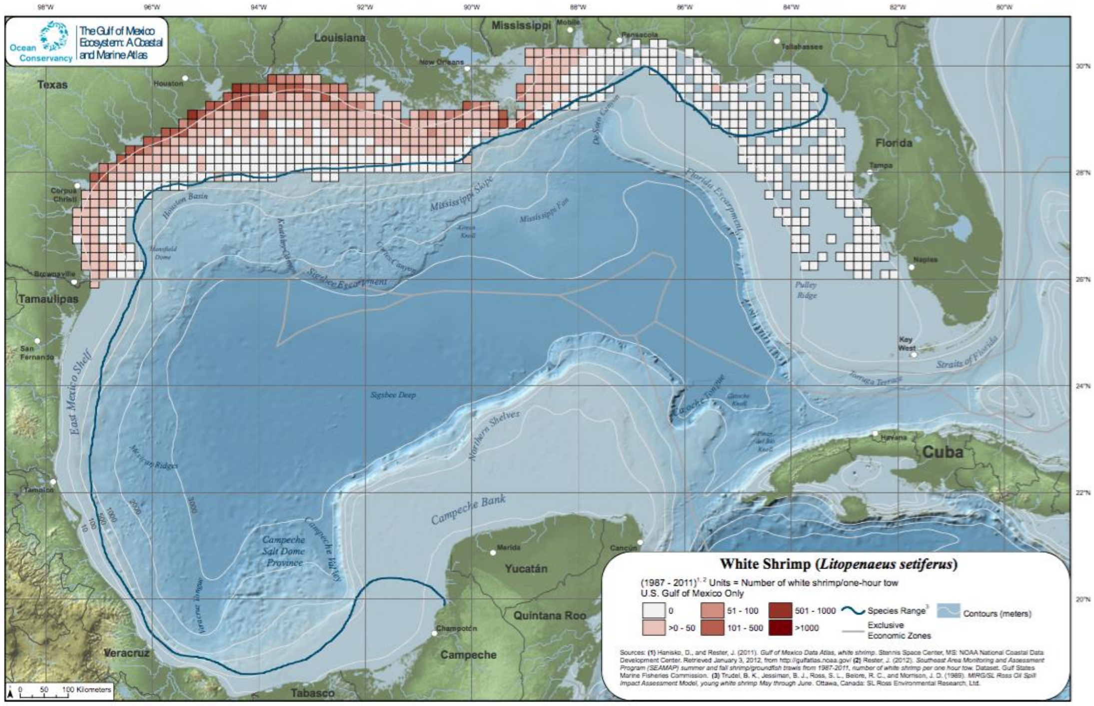

Figure 13. Distribution of white shrimp in the GoM. Obtained from oceanconservancy.org.

White shrimp are the most abundant in the northwestern GoM, primarily along the coast of Texas. The map shows white shrimp abundance, which was calculated as being the number of shrimp caught per one-hour tow (Love et al, 2011).

Upon looking at the maps of fish distribution it is apparent that for some of the species, specifically blue crab and white shrimp, their locations of highest population density are nowhere near the extent of the surface oil slick. This leads to the thinking that these fisheries were not heavily affected by the spill. There also appears to be fishing activity in these areas, which could be an indication that they have rebounded from the reduction in catch immediately following the oil spill.

CHAPTER 4

DISCUSSION

4.1 Effect on Fisheries

Royal red shrimp, red snapper, brown shrimp, and gulf menhaden were observed to have high population densities in the area along the coasts of eastern Louisiana, Mississippi, Alabama, and northwestern Florida. This overlaps with the area of total observed oil extent. The post-spill map clearly shows that there has been a reduction in the amount of activity seen in that area, with the only activity being that of ships traveling along a navigation network.

Royal red shrimp fisheries appear to have been the most heavily affected by the BP oil spill because one of the major commercial fishing areas was right at the epicenter of the spill. Looking at the post-spill map it is clear that very little vessels are staying in the areas that were previously home to the royal red shrimp fisheries.

Majority of the fish species found in the GoM are wide ranging (as evidenced by the OC maps), so this means that the BP oil spill acted to effectively shut down certain areas of the fisheries, but it did not serve to fully shutdown the fisheries as a whole.

4.2 Lessons Learned

From comparing the GMT maps with the OC maps it is clear that some fisheries did experience oiling, and as such, there are no observable ships in the area. But, due to the nature of this analysis it is difficult to form a concrete verdict due to the use of a proxy for the pre-spill data. It is also hard to evaluate level of catch from the AIS data alone.

If I had access to AIS data both from before and after the spill over a one-year timespan the results of this study would be much easier to confirm. However, with the materials at hand, one future study would be to use the parameters established by de Souza et al, 2016 for determining various fishing activities such as trawlers, longliners, and purse seiners. This would make it easier to determine what types of fish are being caught purely by looking at AIS maps and not having to rely on separate maps of fish locations.

Trawling is when nets are dragged behind a fishing vessel, either along the seafloor or somewhere in the water column. In the GoM, trawls are utilized in catching blue crab, royal red shrimp, white shrimp, and brown shrimp. The defining feature of a trawler is a ship travelling at a steady speed between 2.5 to 5.5 knots for 3 to 5 hours (de Souza et al, 2016). Using these parameters in conjunction with ocean depth of the ship's location, it might be possible to identify exactly what species is being caught.

Purse seines are nets deployed vertically that are suspended from floats at the water's surface. The method of catching using a purse seine is to fully surround a school of fish with the net, and then pull the bottom of the net shut. The defining feature of purse seiners is circular paths with high vessel speeds of about 10 knots; this is to ensure that as little fish escape from the net as possible. Once the net is closed the fish are hauled and transferred either on land or to a support vessel. Haul speeds are usually 2.5 knots or less (de Souza et al, 2016). Purse seines are utilized in the gulf menhaden industry.

While this study does not highlight the long-term economic effects that the BP oil spill had on fisheries, it does act as a way to better understand its geospatial effects. An understanding of the effects of the oil spill on fishing can give us a way to more effectively respond to future environmental disasters.

REFERENCES

"BP/Gulf Oil Spill – 68,000 Square Miles of Direct Impact". (July 2010). *SkyTruth.*

de Souza, E.N., Boerder, K., Matwin, S., Worm, B. (2016). "Improving Fishing Pattern Detection from Satellite AIS Using Data Mining and Machine Learning". *PLoS ONE* 11(7): e0158248. doi:10.1371/ journal.pone.0158248

"Fleet Specifications: Deepwater Horizon". 2010. Transocean.

Freudenburg, W. & Gramling, R. (2010). "Blowout in the Gulf : The BP Oil Spill Disaster and the Future of Energy in America". *MIT Press*.

Love, M.S., Baldera, A., Yeung, C., Robbins, C. (June 2013). "The Gulf of Mexico Ecosystem: A Coastal & Marine Atlas". *Ocean Conservancy.*

Skinner, Samuel K; Reilly, William K. The Exxon Valdez Oil Spill: A Report to the President. *National Response Team.* (May 1989).

United States Coast Guard. (September 2011). "On Scene Coordinator Report on Deepwater Horizon Oil Spill".