Regional Algae Bloom: Natural Disaster Causes Economic Setback in Private Fishing Charter in Southwest Florida

Weixing Yu  
College of Art and Science Brandeis University, MA 02453, USA

ABSTRACT: In recent years, water eutrophication has become an environmental problem of general concern. In some drinking water sources, the proliferation of algae has a great impact on the operation of water plants and the quality of drinking water. At present, many scholars at home and abroad are studying the methods of algae monitoring and algae removal, and seek ways to solve the algae pollution, so as to improve the water quality of urban water supply and ensure the safety of water use for residents. In GB5749-2006, the national Ministry of health and the Standardization Administration stipulated that the index value of total microcystins was 0. Oolmg / L. Although this is an unconventional index, it reflects that the eutrophication of fresh water resources and the micro pollution of drinking water sources have become a global problem of great concern. Water eutrophication not only affects the basic life of human beings, but also has caused serious economic impact. Algal outbreaks and fish deaths caused by eutrophication in water bodies often result in economic losses to tourism, recreation, catch fisheries and aquaculture.

1. Introduction

In 2017, a major outbreak of the red tide struck Southwest Florida. The graph provided by Florida Wildlife Conservation Center indicates that in less than a year, the Karenia brevis cells, the red tide algae, skyrocketed in population and invaded the coastline in Southwest Florida (See figure 1). As a result, marine dwellers suffered a massacre in massive proportion, and this sudden outbreak also discouraged tourism in Florida, leading to an economic downfall.

Figure 1 Red tide status map in Southwest Florida in October 2017 and November 2018, indicating the concentration of Karenia brevis, by Florida Fishing and Wildlife Conservation Commission.

The Southwest Florida red tide epidemic was a regional algae bloom in areas including Sarasota Bay, Fort Myers Beach, and the coastline in Naples. The red tide occurs when an excessive accumulation of certain algae, Karenia brevis (or formally known as Gymnodinium breve) exists. When these marine dinoflagellates habit and proliferate at a microscopic level alongside the coast of Florida, the coastal waters turn to a maroon and crimson color due to the chlorophyll pigments...
produced by Karenia brevis (Hu et al., 2005). Unfortunately, red tide is extremely harmful to all living creatures under its exposure, thus commercial and game fish population rapidly decreased during and after the epidemic. When a substantial amount of Karenia brevis gather, the red tide releases Brevetoxin and occupied all usage of oxygen in the ocean. (Hu et al., 2005). The venomous toxic then devastates all vertebrates in the water.

In 2017, the worst red tide outbreak happened in Southwest Florida and caused a devastating marine species extinction. As a result, millions of commercial fishermen and fishing charter captains lost their jobs in a short span of time.

When local news reported this phenomenon, tourists were discouraged and immediately cancelled their fishing trips. As a result, fishing charter owners and captains were unemployed because of the lack of participation of tourists. Although some studies (Larkin & Adams, 2007) address the impact of red tide in regard to Florida’s overall economy, research indicating a direct relationship between red tide and private fishing charter industry in Florida from 2017 to 2019, which was the most recent and the devastating outbreak to fisheries business regarding of duration and range, does not exist. Moreover, society has limited resources for understanding the economic and emotional damage that charter captains received during the epidemic. Thus, the researcher conducted interviews with private fishing charter captains in Southwest Florida, conveying a message to the society, and address the effects of red tide. The purpose of this qualitative research is to reveal how red tide, from 2017-2019, affected the private fishing charter industry in Southwest Florida.

2. Literature Review

In this literature review, multiple perspectives of the Florida red tide are addressed, including historical trends, a scientific perspective of red tide, an introduction of the fishing charter industry in Southwest Florida, and the economic damage created by red tide. Because of the recency of this event, there are a lack of scholarly resource addressing this event, thus the researcher had interviewed selected professional saltwater fishermen and bait shop owners in the area to achieve necessary information.

2.1. What Is Red Tide

Historically, the red tide exists chronically in Southwest Florida and other adjacent states.

Scientists and other researchers believe that early detection of the incoming red tide following with human interference can significantly overturn the situation, eliminating any potential damage before the red tide becomes uncontrollable and devastating. When society first realized this harmful algae bloom, scientists started to utilize innovative methods to monitor the concentration of the Brev. In the past few decades, Dr. Carder and Dr. Steward, leading professors from the University of South Florida’s Marine Science department, have successfully established a new model to monitor and record the red tide by utilizing a special mathematical model that calculates the concentration of the Karenia Brevis on the coastline. A mathematical model that reflects spectral curves of remote-sensing reflectance of red tide dinoflagellate addresses the red-tide related issues and calculates the accumulation of it (Carder & Steward, 1985). This model has proven the ubiquitous existence of the red tide in Southwest Florida and successfully gathered data for the first time.

As time went on, this obsolete method was replaced by a more efficient and economically beneficial model: MODIS (Moderate Resolution Imaging Spectroradiometer), which provides live feedback satellite sensors that trace the movement of red tide (Hu et al.2003). Dr. Hu and Dr. Christopher Kelble (2003), PhDs at College of Marine Science at the University of South Florida, cooperated with their research team and applied MODIS to record the red tide in Florida. In their study, analyzing the data returned from a NASA satellite, the team discovered that red tide initially started in Charlotte Harbor and continued a southward trend in the following weeks (Hu et al., 2003).

Moreover, the team also revealed the advantages of using a MODIS FHL data rather than the traditional satellite data. Combining with the composite imagery from the spectral data and knowledge of local waters, the imagery from MODIS can identify unambiguously regardless of the geographical
factors. MODIS apprises the local residents and the government with its capability of early detection (Hu et al., 2003). With the addition of these technological advancements, residents of Southwest Florida will receive live data of the red tide situation.

However, researches and collection of data of recurring red tide prior to 2017 have shown that nothing previous existed is even close to the range and duration of this red tide, reinforcing and implying the devastation and damage brought by the red tide in 2017.

2.2 Health Impact on Respiratory System

Lorraine C. Backer, a Senior Environmental Epidemiologist at the National Center for Environmental Health, and her team explain that the red tide epidemics exist ubiquitously alongside the coastal region in Southwest Florida. Their research further indicates the harmfulness of the algae bloom and its fatal effect on humans and marine dwellers. Her team discovered that eleven percent of the human population report having upper or lower respiratory symptoms, such as nasal congestion or wheezing when they are moderately exposed to the red tide epidemic, and of twenty-eight percent of humans display similar symptoms while being constantly exposed by the Brevetoxin (Backer et al., 2003).

Similarly, a case study conducted by Dr. Ahmed M. Ibrahim (2007), a professor at Stockton University, implied that the algae bloom in Florida can be even be more deteriorated if the society remains ignorant. He compared and contrasted the algae bloom around the world and discovered that the algae bloom can eventually become fatal to humans: when humans consume contaminated seafood, the cumulative toxin stored inside this shellfish can be harmful enough to conduct a lethal effect on its consumers (Ibrahim, 2007). In one of the cases, four victims died after consuming toxic mussels from Prince Edward Island, Canada, where red tide just occurred. Dr. Sara E. Kuhar and her team also discovered the Floridians’ perception towards this event through surveys and interviews: residents, in which the majority were unable to receive an up-to-date information of the red tide, tend to be more cautious as they habit closer to the ocean: especially the fishermen and charter owners (Kumar et al., 2010). As these studies indicated, the fatal and major impacts of red tide regarding health is significant, and because of this concern, tourists were more reluctant and worrying about doing aquatic activities or even chartering near the infested area.

2.3 The Decline of Marine Dwellers

Unlike other natural disasters, red tide wipes out all living creatures, including game fish and bait fish, rather than certain species. In Southwest Florida, Brackish water (when salt water and fresh water mingle, normally occurs nearshore in Southwest Florida) fin fish, as opposed to the shellfish such as crab and oyster that were normally targeted on a charter fishing trip were drastically affected the red tide. Species such as snappers, red drum, and spotted seatrout, were suffocated and poisoned in the infested area. Moreover, bait fish such as mullet and ladyfish, went nearly extinct, and, because of this, predator fish like tarpon and common snook, which sports fishermen target, migrated out of waters in Southwest Florida. If the bait fish go extinct, the whole ecosystem in Southwest Florida will collapse.

According to Paul Murphey, a reporter for CNN, there were over 2,000 tons of dead marine life including the species mentioned above (Murphy, 2018). When tourists found out of the poor condition of fishing and chartering, cancellations of fishing trips were made.

Although technology has evolved throughout the years, people still fail to reduce the size and the frequency of the red tide, nor come up with an alternative solution to protect marine creatures by using technologies. In Florida, specifically, the game fish’s population is influenced significantly. Cooperating with the National Marine Fisheries Service, Cummings and his team concluded that red tide significantly affected the Great Amberjack population, a migrating species, the most abundant and predominant commercial and game fish in Florida. Utilizing Virtual Population Analysis (VPA) techniques, the team evaluated the condition of the amberjack population and collected sample data from individual amberjack. The result of the research provides an update for the Atlantic greater amberjack stock status. Calculating the CPH (catch per hour) with a mathematical model, the team concluded that in a span of ten years, the CPH of the Great Amberjack in the west coast of Florida
would decrease from 0.51 to 0.1, indicating the significant reduction, which is existed, of the amberjack population (Cummings et al., 1999).

Moreover, the overall population of marine dwellers in Southwest Florida continues to decrease according to Bohnsack, who works for the National Oceanic and Atmospheric Administration. In his study, researchers received their data from governmental organizations, such as Everglades National Park, Dry Tortuga National Park, and Biscayne National Park. The data revealed a major decline in population for multiple species such as groupers and mackerels (Bohnsack, McClellen, & Harper, 1994). With the existing decline in the population of marine creatures, the addition of the red tide can only deter the current situation and create more damage on an already vulnerable economy and ecosystem.

2.4. Economic Impact on Private Charter Fishing Industry

As a tropical peninsula, Florida has depended on its fishing industry for a significant and countable revenue for the economy. The history of fishing in Southwest Florida can be traced back to the 1920s when it was first inhabited, and fishing has accommodated generations of Floridians. Florida thrives on the fisheries and water. More specifically, the recreational fishing industry, especially the private charter fishing industry in Southwest Florida, is the backbone of this commercial system. By definition, a private fishing charter is a vessel carrying a passenger or passengers for hire that are engaged in recreational fishing, and this industry has occurred for over decades (Old Hat Deep Sea Fishing, n.d.). This small industry accounts for a major part of Florida’s recreational revenue. According to the official website of the Florida Fish and Wildlife Conservation Commission, recreational fishing in Florida was accountable for 3.2 billion dollars of income and supported approximately 80,000 jobs from 2018 to 2019 (Florida Fish and Wildlife Conservation Commission, 2019). However, this number downgraded due to the recent red tide epidemic.

Dr. Sherry L. Larkin, a Food and Resource Economist at the University of Florida, along with her colleague Dr. Charles M. Adams, created a separate time-series model to evaluate the reduction of tourism revenues in the localized study area. They concluded that the red tide is accounts for 2.8 million and 3.7 million per month, respectively, which represents a 29% to 35% decline in average monthly revenues during the span of the epidemic (Larkin & Adams, 2007). In addition to the established study conducted by Larkin and Adams, Dr. Ussif Rashid Sumaila, a marine and fisheries economics professor at the University of British Columbia, and his research team conducted a parallel study in regard to how natural disasters affect the economy in Florida and collected data from the local fishermen in South Florida, emphasizing the significant yet devastating effects of the red tide. In this case, the fishing industry seemed rather vulnerable under the impact of an oil spill. According to their conclusions, because the normal oil spill normally assembles near the water surface and onshore, which resembles the red tide, the onshore angling and nearshore fishing fail to remain appealing to tourists and are incapable of generating substantial revenue when such a crisis occurs. In addition, when unusual Deepwater Horizon well blowout, deeper parts of the Gulf of Mexico are also likely impacted, which indicates that an unexpected catastrophe can also impact the charter fisheries and offshore fish population. The data collected by the team indicates a major economic setback due to the marine contamination: Florida losses of total revenues, total profits, wages, and economic impact of $3.7, $1.9, $1.2, and $8.7 billion, respectively. Commercial and recreational fisheries suffered the most losses, with a respective estimated $1.6 and $1.9 billion of total revenue losses, $0.8 and $1.1 billion in total profit losses, and $4.9 and $3.5 billion of total economic losses (Sumaila et al., 2012).

Overall, Florida’s economy is not just suffering for the fisheries simultaneously, but it is a chronic issue that triggers a chain effect on the economy, which has the potential to wipe out the entire fishing industry. The red tide crisis in Southwest Florida remains as harmful yet unsolvable.
3. Method
This is a semi-structured interview study, a form of qualitative research that is customized with its collection of in-depth information, personal experience, and individuals’ emotional reflection. In order to discover how red tide, from 2017 to 2019, impacted the private fishing charter industry in Southwest Florida and achieve the most honest responses from the participants, a customized interview research, revealing emotional reflection and personal experience was chosen, as it was proven the most beneficial method. Unlike the survey research method, which collects diverse sample data but sacrifices in-depth information, the semi-structured interview methodology is best fit for this research: as it collects in-depth information and targets specific individuals’ responses, which eliminates redundant information. Using the semi-structured interview research method was most appropriate for my research due to the effort to collect in-depth information.

4. Participants
All participants were asked to read and sign consent forms. The participants in this study were selected individuals who own a private fishing charter for at least five years. These individuals were chosen because of their deep connection with the private charter fishing industry. All participant information and interview data is protected, stored electronically in the researcher’s recording devices and is only accessible to the researcher for academic purposes during the study period. All participants were given pseudonyms. All information was discarded after the study. These privacy terms were highlighted in the consent forms.

5. Procedures
Prior to the interview, all participants signed the consent forms, and the researcher handed a question sheet to the participants. The interview questions (displayed below) were asked chronologically during the interview. These questions were all open-ended questions and each interview took roughly thirty minutes. Because of the design of this study, a semi-structured interview, the participants expressed their ideas and emotions in the most natural way while having a conversation with the researcher. The researcher recorded the interview with a smartphone. After the interview, the researcher collected data from the recording devices and transcribed them. The researcher also analyzed the emotions of the participants and recorded them subjectively.

6. Interview Questions
1. Can you please give an introduction about yourself, your occupation, and your connection with the private fishing charter business?
2. Can you describe your daily business routine and the location of your business (which boat ramp? Which water)?
3. Have you heard of Karenia Brevis, K. Brevis, or Brevetoxin?
4. Can you describe your business before Oct. 2017?
5. Can you describe your business from Oct. 2017 to Feb. 2018?
6. Can you describe your business after Feb. 2018?
7. Was there any physical damage to your private fishing charter because of the red tide?
8. Is there an increase or decrease in out-of-state tourists’ participation during the red tide epidemics?
9. How do you feel about the red tide and its effect? Can you describe your feelings or emotions?
10. Have you received any help (financial, physical, or mental) from governmental organizations or individuals?
11. Can you describe your feelings or emotions?
12. Is there any alternative solution/business during this period? If there is, what is it?
13. Is there any message you want to convey via this opportunity?
7. Results and Discussion

7.1. Overview
I sent out fourteen invitations to qualified charter captains for this interview and received four responses. The average interview was approximately 25 minutes long and discussed all interview questions. All participants have an average working experiences of over 21 years in the charter fishing industry, and all, except one, have chartered full-time their entire life. The captains launch their charters from Wiggins Pass, Gordon’s Pass, Tin City, Lover’s keys, and Pine Island. These locations are adjacent to each other on the southwest coast of Florida.

7.2 Participant Information
Captain E. were born and raised in Ohio, when he was seventeen, he moved to Tampa and worked as a charter tour guide since then. Captain E. moved to Naples and continued to work as a full-time charter tour guide in his mid-thirties. He currently owns two charters with his partner and launches out of Tin City and Gordon’s pass.

Captain B. Is a local Floridian who has worked as a full-time charter tour guide his entire life. Captain B. majored in Marine Biology and studied professional knowledge about the ocean and marine creatures when he attended college. He currently works as a full-time charter tour guide and works for a nonprofit organization that dedicates to reduce local water contamination. He launches out of Wiggins Pass and Lover’s Keys.

Captain P. Is a local Floridian who has worked as a full-time tour guide his entire life, and he is also a professional sports fisherman. During the red tide epidemic, Captain P. sought an alternative solution, which he repaired and maintained marine vessels. He launches out of Gordon’s pass.

Captain M. Is a local Floridan who has worked as a full-time tour guide his entire life. He learned professional knowledge and skill from his father, who was a professional fisherman. Captain M. and his business were less influenced by the red tide since he launches his boat out of Pine Island and Saint James City.

In this qualitative study, the results of the interviews are presented and analyzed in detail while comparing to existing studies. The interviews unraveled participants’ experiences and connections with the red tide and revealed their responses to its harmful effects. Two main themes were identified: “Marine Population Reduction” and “Extinction and Revenue Loss and Unemployment.”

7.3 Marine Population Reduction and Extinction
Recalling from the time of October 2017 to February 2019, the most recent and harmful red tide epidemic in Southwest Florida, all Captains had unanimously depicted it as “devastating” when they were asked to describe this red tide outbreak in one word. In Southwest Florida, most of the captains charter and fish full-time, or, in other words, they live on and for the water. However, the recent red tide epidemic was the most destructive and devastating catastrophe they had ever witnessed and suffered. They believed the red tide and its after effects changed their entire lives and jobs completely.

Captain E., one of the most well known charter guides and knowledgeable fishermen in Southwest Florida because of his expertise in fishing and chartering, first described his encounter with the red tide back in 2017, “I have fished for almost sixty years and chartered for thirty, I have seen all natural disasters from hurricane to this, but I have never seen anything that is even close to this (red tide).” Captain M. conveyed an identical message, “It was horrible: I saw these fish dying in front of me. As a captain, it was our lives and income, but you can’t do a single thing about it.” Other two captains also delivered similar messages. In this short span of time, all four captains had realized that this red tide was historically the worst among the previous ones.

Moreover, despite of their experience and professional knowledge about fishing, they have all failed to trace down or discover any fish in this region since everything just went “disappeared.”
Captain E. said, “There was nothing in the water...it was so clear that it was almost black...in south of Gordon’s Pass, you can sometimes see a flock of dead snappers floating on the water and dying, even I would not want to fish in this water.” It was revealed that the accumulative algae alongside the coastline were responsible for the massacre of marine dwellers, for the Karenia brevis releases Brevetoxin and consumes all oxygen in the water.

According to Captain B, all fin fish’s populations had decreased dramatically, and some specific species such as common snook and spotted seatrout nearly extinct due to the red tide. Similarly, Captain E had witnessed an even more devastating situation as he “saw millions of vertebrates, every eel, and every fin fish died. Hardly everything survived when he dove down. “The dead game fish wasn’t even the worst nightmare for all the captains. Brevetoxin poisoned all the bait fish, and game fish such as tarpon and snook were forced to migrate to other uninfected waters. “It was forty miles out of Gordon’s pass, and there was nothing in the water...it was impossible to keep (the mullet) alive. No bait fish, no game fish.” Captain P. describes the red tide in March 2017 one of the worst times in his life because he didn’t see anything alive in the water. This natural disaster is no longer a bane to a specific marine creature but to everything in the water.

Expectedly, the decline of the marine population in massive proportion was presumed, however, the scale of such decline and the range of the epidemic were unexpected. Echoing with the data collected by Bohnsack and his colleagues (1994), the decline of fish population occurred ubiquitously in all areas of water and forced some game fish to migrate. When tourists asked for the fishing condition, they were informed that there were no fish in the area, then a cancelation of the fishing trip will be made. The disappearance and extinction of certain types of game fish and commercial fish possibly link to one of the explanations to the decreasing of fishing tourism in Florida, causing a major economic setback in Southwest Florida and to the local private fishing charter captains.

7.4 Revenue Loss and Unemployment

Florida thrives upon its natural resources and the abundant tourism revenue created because of the marine resources in particular. However, with the occurrence of the red tide, a major reduction of the tourists’ population and tourists’ participation in charter fishing have appeared, causing an economic downfall. According to the captains, the number of calls they had received during the red tide epidemic decreased sharply from hundreds to none.

Finding no alternative ways of living but fishing, private fishing charter captains were burdened with loans and struggled through the red tide epidemic from October 2017 to February 2019. All captains who participated in the interview showed that this natural phenomenon had driven them out of their business completely and made them lose massive revenue, and they had witnessed other captains quit because of it. Of my sample data, all captains except Captain P. had an alternative solution during this period to subsidize their loss of revenue. Even Captain P., who worked part time to maintenance yachts and boats, was barely breaking even without the revenue as charter captain. On the other hand, Captain E. had no alternative job during the red tide epidemic, and simply waiting for red tide to disappear had made him a loss of “an average 130,000 to 150,000 dollars annual income just for running charters before 2018”. Captain B, who eventually decided to continue his business at a less infested area in the Everglades to avoid the red tide in Southwest Florida, only ended up breaking even. Captain M. recalled that he normally receive over 500 calls per year for reserving his trips Despite the income revenue, the hidden revenue and expense were also created because of the red tide, causing an addition in the loss of revenue. According to Captain E, who launches out of Gordon’s Pass and Tin City, the red tide covered almost fifty miles of waters within the distance from the coastline, thus it forced him to conduct his business fifty miles offshore away from his usual working spot. This indicates that a normal half day fishing trip (four hours) was now a full day trip (eight hours) with four hours of chartering to escape from the red tide infested zone, wiping out a potential revenue of a half day trip.
Moreover, the hidden expenses such as gasoline and charter maintenance were doubled because of the red tide, as the farther a charter had to go offshore, the more gas was consumed. All captains had confronted a similar situation: tourists were hesitant to call and even ask for the fishing condition, even though the offshore fishing is comparatively less impacted. As a result, captains were forced to take on loans at an extremely high rate, at almost twice as much as usual, and survive without no aids or help from the local government. Out of four captains the researcher interviewed, three of them claimed that they have not received any form of help from local government or individual, and they all believed the government should be aware and give out financial assistance to captains. As the financial burdens were carried on, the majority of the captains were completely unemployed or heavily in debt.

8. Conclusion
These interviews and data collected show to be conclusive in regard to addressing the gap mentioned earlier within this area. However, some questions that originated from or linked to this one remained to be unanswered: the conclusion that whether the red tide is formed because of the excessive chemical effluence or because it is simply a natural and periodic phenomenon remains unaddressed.

Implications
Overall, this study has funded a solid base of information and data collection for similar studies or studies in different time periods. Specifically, the study reveals the economic loss and emotional damage of individual charter captains. Along with this, the attention of society and local government should be drawn on to this industry and each captain. Based on this finding, the local government should blueprint a financial aid program for these captains, in order to prevent similar events from recurring or deterring.

Along with this, local fishing charter owners should be prepared to seek alternative jobs and incomes during this potential red tide outbreak in the future, and local charity organization should take such catastrophe to its concern. By doing so, all captains will be mentally and financially prepared before they reencounter this natural disaster in the future.

9. Limitations
Due to the limited time constraints and lack of available interview participants, the research was not finished under prime condition. The sample data is localized to the city of Naples and Fort Myers, thus, cities such as Sarasota and Cape Coral may have yielded different results. In addition to the Covid-19 outbreak, some captains rejected my invitation, and the researcher was unable to finish his research since he decided to return back to China. Moreover, in order to collect in-depth and personal stories of each qualified charter captain, the research sacrificed the large sample size which caused the data to be less diverse and substantial. By only interviewing less than five charter captains, despite that they are all extremely qualified and have sufficient knowledge about this event, the data collected can not be assumed as a general or average response to the entire private fishing charter industry in Southwest Florida. The future research can utilize both interview and survey to the issues mentioned earlier, and the researcher should also manage their time carefully.

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