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Turning the Tides - An Examination of the Red Tide Epidemic in Florida

Dahlia Lilleslåtten
dlilleslatten@rollins.edu


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DAHLIA ARADO
LILLESLATTEN
AN EXAMINATION OF THE RED TIDE EPIDEMIC IN FLORIDA

TURNING THE TIDES:

ECOLOGICAL RESTORATION AND SOCIAL BUSINESSES IN SOUTHWEST FLORIDA

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DAHLIA ARADO LILLESLATTEN

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Prologue

Growing up on Sanibel Island is nothing short of a magical, transformational experience for a young child. I was constantly immersed in nature, consumed by Florida in all of her sunlit, humid splendor. In the morning, I would dart across our sandy backyard, building fairy dens in the gnarly roots of my grandfather's grapefruit tree. The days were a blur of running to catch the school bus, classes, baseball practice, and homework. The Sanibel School had entire classes devoted to the study of mollusks, native bird species, and - almost ironically - an entire course called "boat safety" tailored for middle-schoolers. To this day, I can still recall intricate facts about the juvenile night heron, recite the anatomical structure of the fighting conch (see: Strombus pugilis), and I am well-versed on the lives of the Calusa native indians that inhabited Southwest Florida long before our time.

Once my homework was completed for the evening, I would kayak with my family across a clam-filled bayou to the beach just as the sun dipped under the horizon. While I have yet to see the fabled 'green flash,' the real magic of the ocean lies in the blanket of darkness. Under the dim glare of the moon, we would chase pale ghost crabs into the surf, giggling as they tickled our toes and frantically scurried into the frothy seafoam. Sea-turtle nests dotted the beach, enclosed by protective stakes and enshrouded with an air of mystery and possibility. When would they hatch? Would we be the lucky ones who saw loggerhead hatchlings crawl into the ocean, guided by the flickering light of the moon? The boat ride back to our dock was nothing short of a spectacular light show as bioluminescent algae transformed the bayou water into vivid flashes of blue-green light.

Though cited as being a chemical reaction between oxygen and the complex molecule luciferin, I still attribute the bioluminescent glow of the water to magic and nature's sorcery.

It is my innate attachment to the ocean that has inspired me to pursue the topic of red tide, environmental conservation, and harnessing the power of social business as core foci for my thesis. My unwavering passion for my island has inspired me to research the protection of coastal ecosystems and the responsibility we have as informed citizens to mitigate the effects of climate change before we inflict irreparable damage. Our natural ecosystems are vulnerable, exploited by the crippling hand of industrialization and lack of government accountability. Only by reversing this top-to-bottom trajectory can we inflict real positive change. The hope for our future lies in the hands of individuals; social entrepreneurs and empowered changemakers that create 'blue ocean solutions' to target gaping inefficiencies in the market. The future lies with us, and the entire world is watching.

Dahlia Arado Lilleslatten

Abstract

Southwest Florida's red tides are characterized by patches of maroon-colored water, respiratory irritants, and elevated levels of marine mortalities. While a natural phenomenon, red tide has a devastating impact on aquatic ecosystems that become overwhelmed with dense aggregations of unicellular organisms and the subsequent brevetoxins that are released into the air. This paper reviews recent research on the Gulf Coast's red tide epidemic in an attempt to fully understand the cause of the heightened intensity, frequency, and duration of algal blooms. It goes on to highlight the Sanibel and Captiva Islands' rich history in conservation, and how this foundation of sustainability and corporate responsibility has promoted the rise of grassroots organizations and a strong culture of island preservation. Lastly, this review includes interviews with prominent community members who are diligently working to improve Florida's water quality, and has profound implications for future studies of red tide blooms and their impact on local business. The underlying intent of this thesis is to influence legislation to minimize fertilizer consumption in Florida and to increase awareness regarding our role as consumers and advocates on behalf of our natural resources.

Keywords: *Florida red tide, red tide, Karenia brevis, harmful algal blooms, marine toxins, social entrepreneurship, corporate social responsibility, local business, fertilizer byproducts.*

Introduction

After showcasing data on red tide to explore the severity of this issue, I will discuss the history of this issue, the factors that have led to its proliferation, and the numerous impacts of red tide. These include losses to marine biodiversity, the retardation of the local economy, and harmful health effects that are reported in both humans and other mammals. Next, I will examine the role of social entrepreneurship as an intervening force, analyzing three different strategies to address the issue. Finally, I will present three interviews from prominent experts in the field that support my conclusions to systematically mitigate harmful algal blooms.

My thesis closely correlates with the United Nations Sustainable Development Goal no. 14, which explores “Life Below Water” and how marine ecosystems make the Earth habitable for all of humankind. The Sustainable Development Goals (SDGs) are a framework developed by the United Nations to universally work towards an end to poverty, climate change, and systemic inequality by the year 2030 ("Sustainable Development Goals | UNDP"). Goal 14 dictates that the health of our oceans is mutually related to our subsistence as a species. While the chemistry, temperature, and currents of our seas drive our global systems, our actions also play a large role in keeping oceans free of waste and at a stable temperature necessary for the preservation of life. The interdependent relationship between humans and their natural environment will be an implicit theme throughout my thesis as I seek to explain how our actions have a direct impact on the health of our ecosystems.

Statement of the Problem

The specific problem I am targeting is water quality concerns in Florida. More explicitly, I am examining natural chemical stressors in South Florida's coastal ecosystems and the detrimental impact of large concentrations of Karenia brevis, a marine algae. The issue of red tide has persisted for several years and has already claimed the lives of thousands of marine animals while posing a severe health hazard to human inhabitants living along the Southwest coast of Florida. Karenia brevis produces neurotoxins called 'brevetoxins' (PBTX) which interfere with neurotransmission and severely impact human and marine health. Air-borne toxins bind to voltage-gated sodium channels, resulting in the depolarization of nerve cells (Pierce, R. H., & Henry, M. S., 2008). Massive fish kills, shellfish contamination, the inhalation of air-borne toxins, and marine mammal mortalities are just a few of the frightening results of a red tide bloom.

Causes & Environmental Stressors

Throughout this essay, the term ‘Karenia brevis’ will frequently be used in reference to harmful algal blooms (HABs) and the red tide epidemic. Karenia brevis is a naturally-occurring marine organism that is classified in the phylum Dinoflagellate and super group Alveolates ("Harmful Algal Blooms & the Environment,” 2017). These organisms are flagellated, unicellular, photosynthetic, and use their flagella for locomotion throughout bodies of water ("Harmful Algal Blooms & the Environment,” 2017). Karenia brevis, often referred to as simply ‘K. brevis,’ play a harmful role in the

creation of algal blooms because they are heavily condensed in warm coastal waters. The more abundant and plentiful the bloom, the more of an issue this poses to the health of marine life because when K. brevis multiplies and expands, they consume all of the available resources needed for their own survival. The competition for space, oxygen, and sunlight results in the subsequent death of these unicellular organisms and the emission of potent neurotoxins called brevetoxins that these cells create. As will be discussed in greater depth throughout the course of this thesis, these neurotoxins cause a plethora of adverse effects for marine life and humans that coexist in coastal ecosystems.

The phenomenon of toxic red tide blooms can be traced to the 1840s, when Florida experienced early episodes of harmful algal blooms characterized by massive fish kills and crimson-colored waves (B. Kirkpatrick et al, 2004*)*. HABs, while a natural ecological occurrence, appear to be increasing in incidence, duration and geographic spread (B. Kirkpatrick et al, 2004*)*. Red tide is predominantly concentrated in the Gulf of Mexico, with blooms spreading along the coasts of Mexico, Florida, North Carolina, Texas, Alabama, and Mississippi.

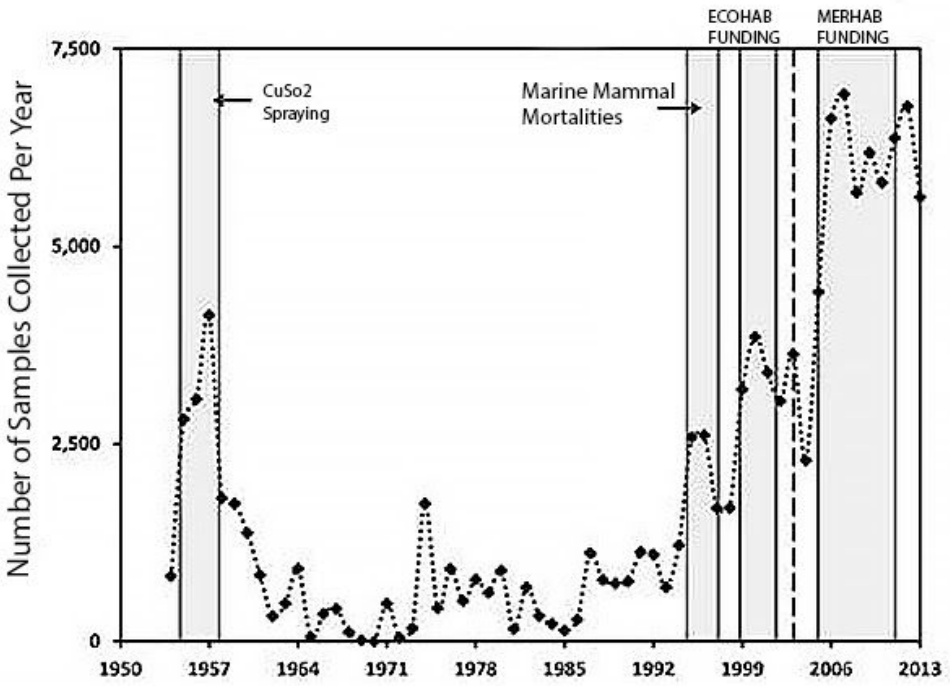
There is much speculation as to the causes and anthropogenic influences that contribute to increased bloom frequency. Despite the fact that the source of their increased severity and duration are currently presumed to be unknown, Van Dolah cites climate change and alterations in nutrient dynamics possibly playing a role (2000). Furthermore, agricultural development and the widespread industrialization of coastal

communities are potential enablers for fertilizer byproducts contaminating waterways. Lake Okeechobee, the “liquid heart of Florida”, is severely polluted from development in Central and South Florida and fertilizer run-off produced by agriculture. During rainy seasons, large amounts of toxic water bleeds into the Caloosahatchee River, filtering into the Gulf and helping to drive the catastrophic red tide algal blooms that kill Florida’s coastal wildlife. Multiple conservation groups have filed a collective lawsuit to demand higher accountability from federal agencies that have “ignored the impacts of the algal blooms and failed to consider how the ongoing damage would harm populations of manatees, sea turtles, smalltooth sawfish and coral for the next seven years” (“Red Tide Lawsuit Launched After Feds Ignore Wildlife Harms of Lake Okeechobee Discharges”, 2018). By approving the continual release of Lake Okeechobee waters, we will continue to see high-volume discharges that devastate coastal ecosystems.

Jack Davis, professor of environmental history at the University of Florida, has analyzed the human impact component of red tide. He is the author of the seminal text “*The Gulf: The Making of an American Sea,*” which examines the Gulf of Mexico’s important contributions to both our economy and U.S. history as a whole. The Gulf is described as being “one of the richest estuarine environments in the world, with five major states directly benefiting from its resources.” Davis also notes that approximately two-thirds of all rivers in the United States drain into the Gulf of Mexico, and they bring runoff from both urban and agricultural areas. This huge nutrient dump of nitrogen and phosphorus creates massive dead zones devoid of life, and in Florida “much [of the runoff] comes from the agriculture around Lake Okeechobee” (Davis). While there is

ongoing speculation as to the extent of human influence on algal blooms, Davis highlights the undisputed fact that algae blooms in recent years have significantly increased in both propensity and severity in both fresh and saltwater environments.

Figure 1: Over 100 Years of Red Tide Off Florida's West Coast



Source: Florida Fish and Wildlife Conservation Commission.

Figure 1 depicts water sampling efforts between the years 1954 and 2013, with the dotted line illustrating trends in sampling efforts and the points denoting the number of samples collected each year. While the findings suggest an increased detection of harmful blooms, it is important to consider potential fallacies present in the data. The

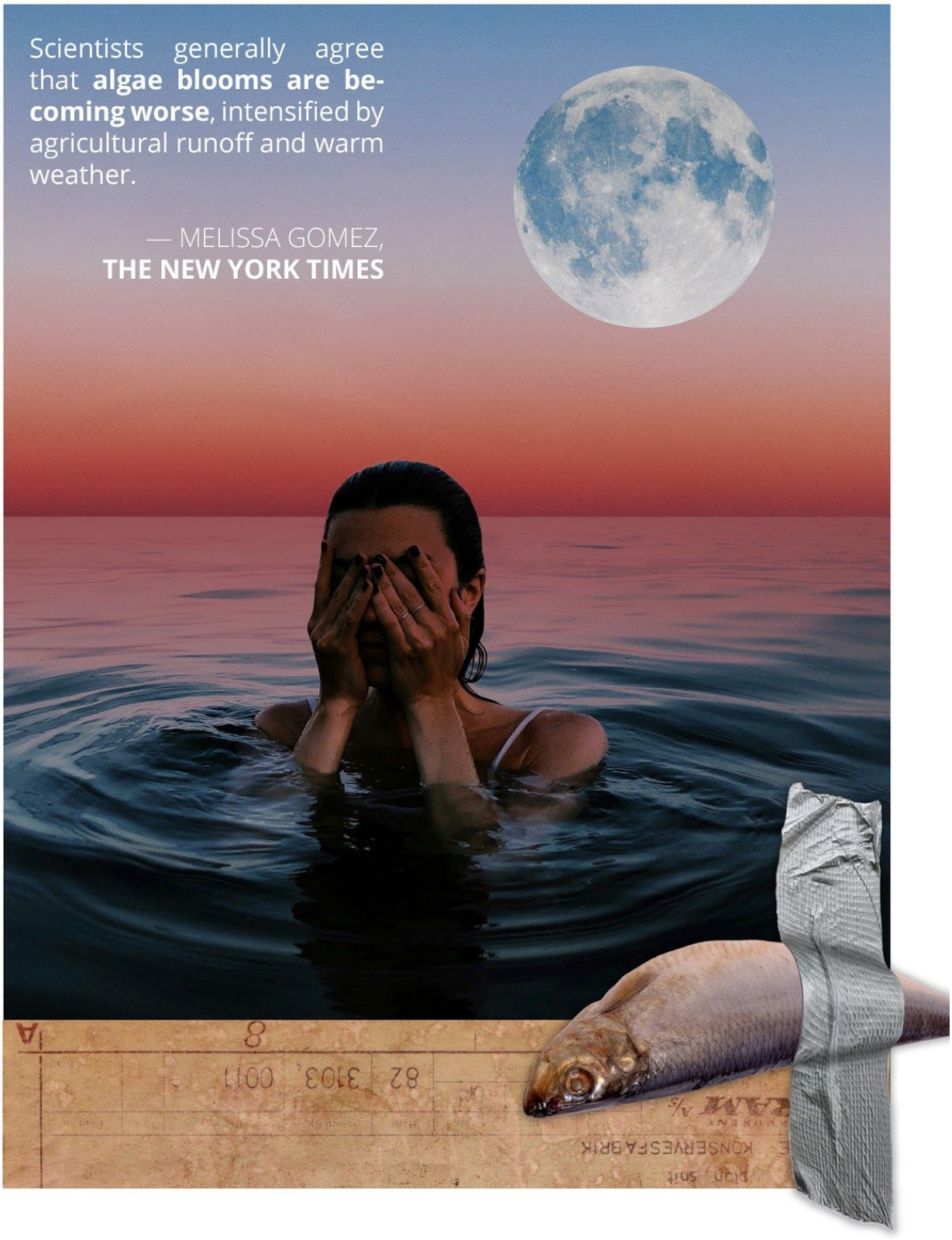
peaks and dips of the graph reflect the number of samples collected and are largely dependent on funding. Thus, throughout the 1990s and beyond we see a sharp increase in sampling efforts which correlate with the detection of more blooms. Unfortunately, the changes in sampling efforts over time coupled with the variability in event response efforts prevents scientists from determining if red tides have increased in duration, severity, and frequency over the past 60 years. Nevertheless, throughout the next portion of my analysis I will examine changing ocean temperatures and how currents and weather patterns associated with global warming might prompt the next devastating bloom.

Linking Climate Change to Red Tide

The human race is faced with the formidable and increasingly urgent task of maintaining climate change below 1.5° Celsius by the year 2030. As natural disasters increase in their frequency, intensity, and devastation, we have become reluctant witnesses to the collapse of entire ecosystems and the elimination of vulnerable marine life. Furthermore, as carbon accumulates in the atmosphere, ocean surface temperatures are becoming warmer, leading to rising sea levels, increased wind speeds in tropical storms, and the exposure of coastal ecosystems to the erosive force of waves and currents.

Researchers at the University of North Carolina and the University of Florida have proposed that there is a direct link between increased ocean temperatures and the severity of blooms, stating that “climate change will severely affect our ability to control blooms, and in some cases could make it near impossible” (Fritz, 2018). Moreover, the

increased propensity of tropical storms might trigger the onset of some HABs, which are frequently reported in the aftermath of natural phenomena due to unusually high water temperatures, sluggish water circulation, and resulting weather events like flooding or droughts (US Department of Commerce & National Oceanic and Atmospheric Administration, 2014). Summer months in particular are increasingly susceptible periods for toxic algae blooms, primarily due to low salinity, calm seas, intermittent rain showers, and high nutrient content found in the water.


Scientists generally agree that **algae blooms are becoming worse**, intensified by agricultural runoff and warm weather.
— MELISSA GOMEZ,
THE NEW YORK TIMES

Fertilizer Runoff and Nutrient Overfeeding

It comes as no surprise that fertilizer runoff is a commonly-referenced culprit for nutrient build-up. HABs may be linked to 'overfeeding,' an occurrence in which fertilizer byproducts such as phosphorus and nitrogen trickle from freshwater sources to the ocean. The lakes and springs of Florida are being slowly contaminated by the fertilizers used to maintain lawns, theme park landscaping, and agriculture. These chemical contaminants trickle downriver to the sea, building up at rates that 'overfeed' the preexisting algae that inhabit the aquatic environment. Cheryl Lyn Dybas, a marine science journalist, affirms the threat this poses to marine life, writing: “In the presence of excessive concentrations of nitrogen and phosphorus, phytoplankton proliferate, reaching massive blooms. When the plankton die, they fall to the seafloor and are digested by microorganisms. The process removes oxygen from the bottom water and creates low-oxygen zones” (Dybas, 2005). The aforementioned “dead zones” are commonly found in the coastal waters of the Gulf of Mexico and are regions void of marine life.

A recent report released by the United Nations, titled the *Millennium Ecosystem Assessment Synthesis Report* (2005), compiled findings and research from 1300 scientists in 95 countries. Throughout the report, it is revealed that more land has been converted to agriculture since 1945 than in the 18th and 19th centuries combined. Furthermore, it highlights our society’s crippling dependence on harsh fertilizers and notes that “[h]umans now produce more reactive (biologically available) nitrogen than is produced by all natural pathways combined, and some projections suggest that this

may increase by roughly a further two thirds by 2050” (Finlayson et. al, 2005). This projection could have a devastating impact on Florida’s coasts in years to come because society’s inefficient overuse of fertilizers is radically changing entire ecosystems. We must reconsider the staggering amount of power allocated to the agricultural industry and how legislation can help influence the enforcement of a fertilizer tax to curtail nitrogen and phosphorous consumption in Florida.

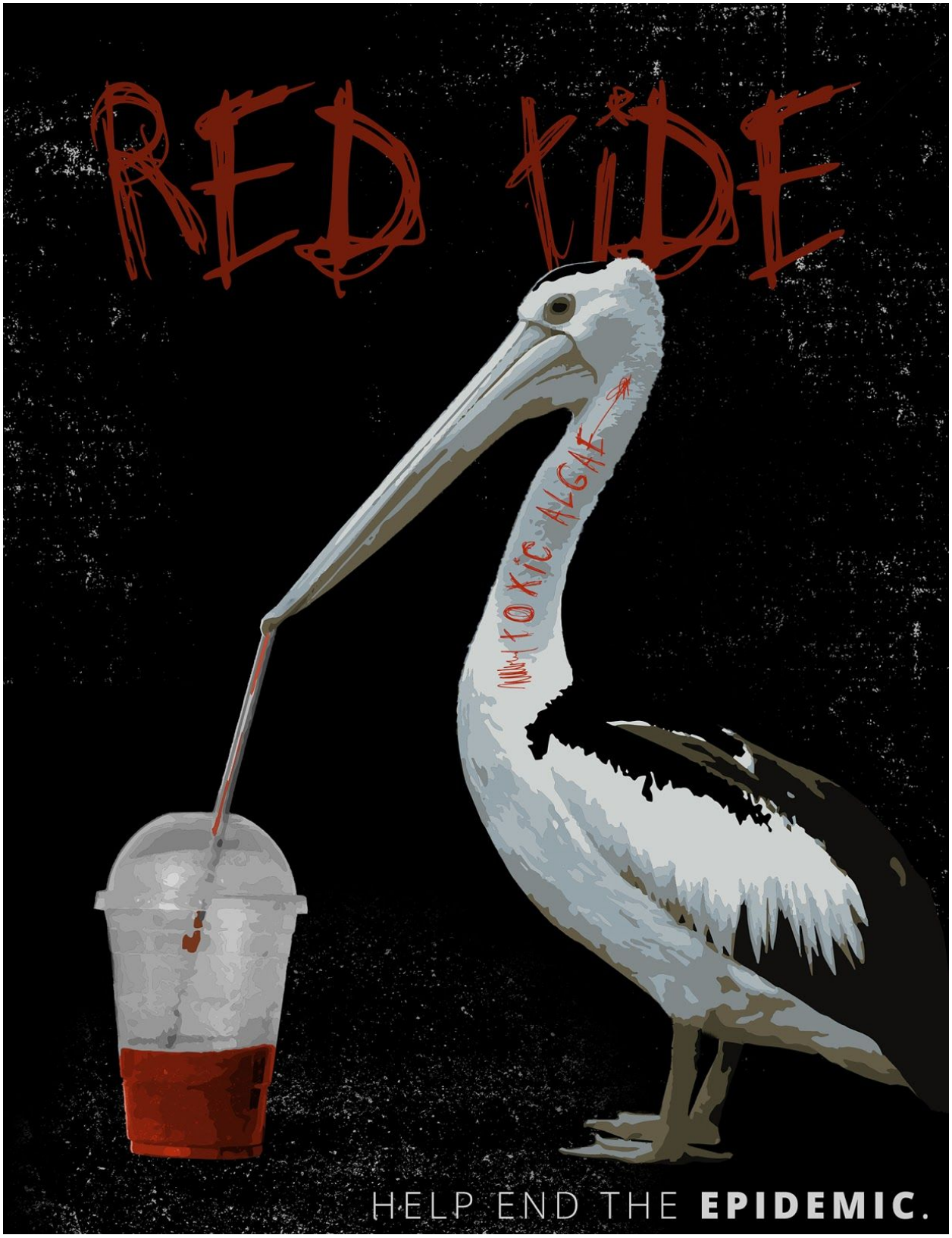
Health Hazards

Karenia brevis, the unicellular dinoflagellate responsible for red tide blooms, produces neurotoxins commonly referred to as 'brevetoxins.' These neurotoxins pose a plethora of concerning health hazards to marine life and the human inhabitants that occupy coastal regions. From a biological context, brevetoxins interfere with neurotransmission because the air-borne toxins bind to voltage-gated sodium channels (Kirkpatrick et. al, 2004). This results in the depolarization of nerve cells, causing shellfish contamination, massive fish kills, marine mammal mortalities, and the inhalation of air-borne toxins (Kirkpatrick et. al, 2004). Sanibel residents have become unwilling witnesses to the devastating massacre of marine life, which includes large dolphin kills and more recently, the carcass of a 21-foot whale shark washing ashore.

Fish are some of the first organisms to experience the neurotoxic effects of red tide, with an estimated 100 tons of fish [killed] per day during an active red tide (Kirkpatrick et. al, 2004). Brevetoxins trigger convulsions, paralysis, muscle spasms, and respiratory failure in fish, whereas birds die acutely with hematologic and neurologic

effects and mammals (such as mice and guinea pig) report respiratory failure in less than 30 minutes after being exposed intravenously to PBTX (Kirkpatrick et. al, 20015).

While humans are predominantly exposed to brevetoxins through contaminated fish and shellfish, another major route of exposure is through aerosols that infiltrate the respiratory tract. Particularly for those with underlying lung afflictions (such as asthma and bronchitis), this could produce acute respiratory symptoms that last anywhere from several days up to multiple months (Kirkpatrick et al., 2004; Fleming et al., 2005, 2007, 2009). An analysis of emergency room patients during severe Florida red tide blooms suggest a heightened occurrence of gastrointestinal and respiratory disease associated with exposure to brevetoxins (Kirkpatrick et al., 2006, 2009). Additional studies conducted on canine tracheal smooth muscle indicate that the primary toxin found in red tide, *Ptychodiscus brevis,* has an asthma-triggering mechanism and stimulates the cough receptor reflex (Asai et. al, 1982).


RED TIDE
TOXIC ALGAE
HELP END THE EPIDEMIC.

Tourism and Impact on Local Business and Commerce

The debilitating effects of red tide extend beyond healthcare to encompass losses in tourism, local business, and detriments to the commercial fishery sector. Often underestimated in importance, the cumulative impact of red tide on Florida's coastal economy demonstrates how vulnerable and interdependent littoral communities are on the health of Florida's waterways and oceans. A comprehensive glimpse into the wide-ranging economic ramifications of harmful algal blooms is seen in reports that trace financial losses throughout time.

The authors of a report produced in 1974, Habas and Gilbert, estimate that roughly $20 million was lost in commercial and recreational fishing activities in the wake of the 1971 Florida red tide. The impacts of this HAB extend to revenues that were lost from other recreational beach activities as well, and were felt particularly hard by private citizens who incurred personal costs cleaning up dead fish and debris. Habas and Gilbert estimated that, "without [an] economic cushion, a future red tide of equal severity could cause up to 40% more economic damage and one of greater severity could easily triple the damage" (1974).

Larkin and Adams (2008) reveal how residents of Southwest Florida respond to red tide outbreaks and attempts to gauge public awareness and knowledge of red tide events among Southwest Florida residents to better develop programs to assist governmental agencies during HABs. While all residents interviewed were familiar with red tide blooms, roughly eighty percent were well-versed in the risks associated with

shellfish consumption and thus resolved to avoid eating shellfish entirely (SOURCE: https://www.joe.org/joe/2008april/a8.php).

While contaminated shellfish is a veritable health threat, one must note that these consumers are likely to falsely believe that *all* seafood is unsafe to eat during an algal bloom. This fails to consider the seafood served in local restaurants, which is primarily harvested from uncontaminated waters. Unfounded conjectures result in the cancellation of beach-related activities and thus disadvantage coastal businesses which rely on these sources of income. Table 1 (*below*) is taken from the aforementioned study conducted by Larkins and Adams (2008) and highlights the importance of increasing the public's awareness through scientifically-driven findings of red tide events

Table 1: Incidence of Incorrect Responses (%) Regarding Three Key Human Health Consequences During a Red Tide Event by Respondent Demographics

Characteristic	Safe to Eat Finfish	Safe to Eat Shrimp/Crab	Safe to Swim
Average:	72.0	78.0	73.0
Annual Residency			
Less than 7 months	62.2	66.9	69.8
Full time (12 months)	74.7	80.8	74.0
Duration of Residency			

Less than 5 years	70.1	75.8	76.4
5-10 years	71.8	74.6	73.2
At least 10 years	72.9	79.9	71.9
Age			
18-24 years	80.0	88.0	96.0
25-44 years	81.2	82.6	76.5
45 years or older	69.3	76.8	71.8
Education Level			
Did not complete high school	72.1	76.7	76.7
Completed some college	74.9	81.1	74.9
College graduate or higher	69.0	74.3	71.1
Race			
African American	95.2	95.2	95.2
Caucasian	71.1	77.6	72.1
Other	79.0	73.7	89.5
Gross Annual Income			
Less than $75,000	74.0	79.0	74.8

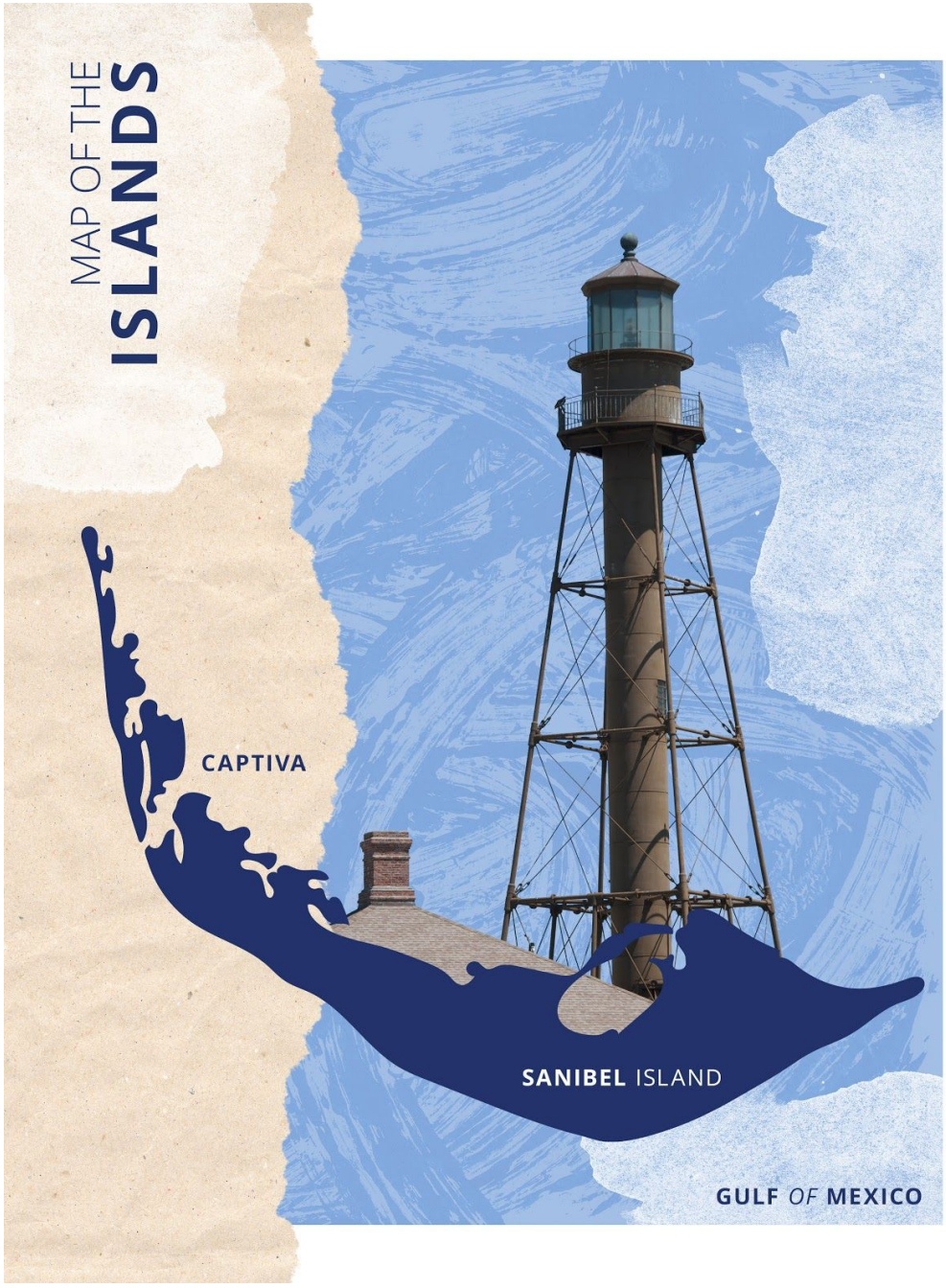
At least $75,000	67.6	74.8	66.9

(SOURCE: https://www.joe.org/joe/2008april/a8.php)

To conceptualize the full impact of red tide on our modern economy, a recent report released by the National Oceanographic and Atmospheric Administration estimates annual losses at a staggering $75 million per year (Bauer, 2006). Even more shocking, this research was conducted several years prior to 2017, when Southwest Florida had one of its worst red tides to date — a bloom of magnified severity that lasted for onwards of 16 months and was projected to cause $90 million dollars in damages (Fears, 2018).

Background of the Study: The Sanibel and Captiva Islands

The Sanibel and Captiva Islands are the focus of my examination into the chronic red tide epidemic. Ecological gems that have withstood the overdevelopment and commodification that have befallen many of Florida's barrier islands, Sanibel and Captiva are characterized by a "powerful conservation ethic that is present and a sense of place that has been vibrantly viable for well over one hundred years" (Anholt & LeBuff, 2018). To truly understand why these islands have upheld their core values of environmental conservation and preservation, it is first valuable to paint a comprehensive picture of their history. What truly distinguishes Sanibel and Captiva are the pioneering forces that fought to pursue conservation, even while other Floridians were commodifying the very allure of Florida's natural resources.



An integral part of Sanibel and Captiva's history can be traced to their unique geographic situation. Located several miles off the Florida mainland in the Gulf of Mexico, they are among a chain of sporadically-positioned barrier islands that hug the

coast. The Charlotte Harbor Estuary, located at the northernmost end of the eighteen-mile-long Pine Island Sound, and the Caloosahatchee Estuary, situated near the southern tip of Sanibel Island, play important roles in providing the islands with a productive, biologically rich marine ecosystem. Unlike most barrier islands, Sanibel has a highly atypical east-west alignment.

Sanibel Island – An Early History

Sanibel's early history is characterized by intermittent periods of European conquest. It is important to note, however, that the islands were originally inhabited by the Calusa Indians who subsisted as hunter-gatherers and left countless invaluable artifacts behind in the form of towering shell mounds. Charles LeBuff and Betty Anholt, authors of the seminal historical text "Protecting Sanibel and Captiva Islands: The Conservation Story," describe the unique characteristics that made the islands inhabitable for native populations:

> "*Once sea levels stabilized some five thousand years ago, longshore currents gradually shaped barrier islands like Cayo Costa, Captiva and Sanibel, and their slow emergence and growth from sandbar to island allowed the formation of shallow estuary waters between them and the mainland. The mix of salt water with the fresh water from creeks and rivers and rainfall produced a less saline environment that encouraged nurseries for marine creatures from fish to plants and attracted birds and mammals to patrol there for their meals.*"

The Calusa had several terse interactions with Spanish explorers – one of the first documented cases being Ponce de Leon's brief exploration of the Sanibel and Captiva Islands. As he utilized the shallow waters of the Gulf to scrape the wooden hulls of his fleet, Ponce de Leon was met with a staged welcome from the native Calusa indians. Shortly after the feigned welcome, however, Indian war canoes overwhelmed the Spanish ships in an attempt to ward off the European intruders and send out a clear message: they were not welcome, and would be met with force. This would not be the last interaction between the native populations and Spanish explorers/settlers, and in 1513, Florida was entirely controlled by Spain.

Spain was perpetually at war with other nations, and consequently the broad-reaching territory that fell under their jurisdiction, encompassing Florida, was ultimately acquiesced during the French and Indian War. The Treaty of Paris in 1763 allowed Spain to trade the territory of Florida with English-controlled Havana, and thus we witness a brief period of British settlement of the region. This colonization was ultimately short-lived, and the Spanish regained control of Florida in 1783 as a result of the second Treaty of Paris. It was not long before Florida was besieged again, this time in raids coordinated by American generals, and Anholt and LeBuff note that the "Adams-Onis Treaty . . . resulted in the United States acquiring the territory of Florida from Spain in forgiveness of [their] debts" (2018).

Early Development

The 1800s are the start of a new era for Florida. We witness the first development tycoons staking out Key West and surrounding regions – many filled with avid naturalists and birders. This obsession with wildlife led them to the island of 'Sanybel,' which was regarded as a promising site for development due to its protected harbor and biologically-rich waters. Subsequently, Sanibel was planned as a town with roughly fifty lots sectioning off the island.

To this day, one of the most prominent landmarks on the island is the lighthouse, which was the first major development project. Countless individuals sent petitions and pleas to Congress and the US Lighthouse Board calling for the installation of a light station, however most went overlooked or unheeded for a substantial period of time. An increase in commercial vessel traffic, however, justified the erection of a lighthouse near Port Punta Rassa, and Sanibel's visibility made it the logical site to be selected for the construction. Incidentally, the families that tended to the lighthouse became the first permanent residents of Sanibel Island.

Homesteading on the islands officially began in 1888, not long after the U.S. Homestead Act of 1862 offered 160 acres of land to those who would live on properties for 5 years and make consistent improvements to the land. Many families soon flocked to Sanibel, and increases in the overall population of Southwest Florida prompted the unfortunate start to the exploitation of valuable natural resources. LeBuff and Anholt affirm this, writing that "In 1907, the Charlotte Harbor and Northern Railway opened between Boca Grande at Charlotte Harbor and Arcadia and a phosphate dock was built.

Pebble phosphate was being mined from the bed of the Peace River and shipped internationally. The businesses of farming, fishing, tourism, logging and other commerce increased" (2018). Other settlers were drawn to the islands after writers and explorers portrayed a vivid and appealing image of life in Florida.

The stock market crash of October 1929 was a shot that resounded across the entire nation. In spite of the fact that no banks existed on Sanibel, effects of the depression drastically shifted the local way of life. Countless cities and towns across Florida defaulted as a result of the inflated price of bonds, and property values plummeted. One might ask – how did this translate to life on the islands? Tourism was the prevailing industry on Sanibel and Captiva, and sport fishing and travel were all but eliminated entirely during the Great Depression.

Life for those who remained was dismal, and there was an innate interdepence on the elements that characterized island life; rainwater was meticulously collected, gardening provided crops for survival, and commercial fishing became a prominent source of income and commerce. Other, more innovative ways to earn money were significantly 'less' legal than the aforementioned fishing operations. Home brewing was not uncommon, and large quantities of liquor were smuggled from Cuba and the Bahamas. While life on the islands could easily be regarded as primitive, the introduction of electricity in neighboring Fort Myers indicated that big change was on the horizon. A new wave of tourism arrived and with it came substantial changes in local mindsets regarding the environment, responsible development projects, and progressive conservation initiatives.

The Rise of Conservation Movement on Sanibel Island

Sanibel Island as we know it was not the product of chance. In fact, much of the precautionary development procedures still intact today were cultivated through intentional acts of conservation in the 1900s. Anticipating the mass-commercialization of Florida's beaches, visionary residents detailed a Comprehensive Land Use Plan in 1976, shortly after Sanibel's incorporation as a city ("The Environmental Reference Handbook for Sanibel," 2009). The public played a noteworthy role in working to maintain the integrity of the original mandates, recognizing the value in preserving wildlife, native vegetation, and the distinct way of life that has captivated the imagination of those who live here.

The Environmental Reference Handbook for Sanibel outlines the underlying premise of the city ordinances, stating that "future development on Sanibel could and should minimize human impact and occur in an orderly and planned way to preserve the unique and natural characteristics of the Island" ("The Environmental Reference Handbook for Sanibel," 2009). Furthermore, the City Charter's Vision Statement highlights the sheer significance of environmental values in the community, reinforcing the integral role human inhabitants play in preserving natural ecosystems. While the city ordinances were cumbersome, these regulations maintain the unique qualities of Sanibel for future generations.

What significant events prompted islanders to act with such integrity and virtue on behalf of nature's best interest? And how do the City standards continue to promote

the on-going stewardship of this island sanctuary? Understanding these acts of higher purpose is a crucial step to maintaining the high quality of life that humans and wildlife enjoy in coastal Florida, even as events like red tide threaten the very core upon which Sanibel was founded.

The innate desire to protect the interests of wildlife is often traced to severe fashion trends originating in New York and Paris in the late nineteenth century. 'En vogue' hats were plastered with bird feather plumage, the majority of which was sourced from South Florida and the Everglades. An analysis into the wading bird population during this period states that "In 1892, a single agent reported the shipment of 130,000 birds for millinery purposes, followed by 192,000 a decade later from Florida alone" (Frohring et. al). These devastating reports of mass destruction prompted the passage of the Federal Lacey Act in 1900, which outlawed plume hunting in all forms. The Florida Audubon Society and National Committee of the Audubon Society undertook several protective measures to ensure this doctrine was strictly enforced; namely, they employed local residents - many of whom were priorly-employed in the plume trade - to take on the perilous role of acting as wardens to safeguard major rookeries. One notable example is Jack C. Watson, a warden who served with the National Audubon Society before later becoming manager of the National Key Deer Refuge (Anholt & LeBuff, 2018). This job came with numerous hazards and responsibilities, and it was not uncommon for wardens to be murdered when trying to protect their designated rookery.

This tension was similarly felt on Sanibel, and in spite of the Federal Lacey Act, there was an overall lack of enforcement with wildlife killings continuing. The extending ramifications of Depression meant that economically deprived islanders relied on migratory waterfowl as a source of food, which “bothered seasonal residents and the financially better-off homesteaders” (Anholt & LeBuff, 2018). Changes in attitude, however, became more widespread by the year 1930, and there was a general consensus amongst the public to halt the illegal taking of wildlife. At the request of Sanibel and Captiva Island residents, the Florida legislature passed an act in 1939 that established Sanibel and Captiva Islands as a fish and game refuge. In particular, the progressive acts of resident Jay Norwood (“Ding”) Darling ensured that the seeds of conservation firmly took root between the years 1935 and 1945.

“A political cartoonist with an eye toward conservation,” J.N. “Ding” Darling was an influential resident who helped prevent the sale of environmentally valuable land to developers on Sanibel Island. In 1945, Darling had a direct role in influencing President Harry S. Truman to issue an executive order creating the Sanibel National Wildlife Refuge. The J.N. "Ding" Darling National Wildlife Refuge now encompasses nearly 90 million acres and is one of over 460 refuges in the National Wildlife Refuge System. The U.S. Fish and Wildlife Service administers the Refuge System through an agency of the Department of the Interior.

The J.N. “Ding” Darling Refuge conducts a wide range of wildlife management techniques in the community to counteract the expansion of human development. These include water management practices, the preservation of habitat diversity, wildlife

research, law enforcement measures, and the dissemination of public information. In terms of water management practices, the refuge instituted a dike in the 1960s to control the mosquito population, which had the positive side-effect of providing migratory waterfowl with a place to roost. To protect native plant species and habitats, the refuge acknowledges the need to eliminate exotic plants used for the beautification of yards and landscaping. Ornamental plant species pose a serious concern because they overwhelm wild habitats, crowding out native species that provide numerous benefits and uses to wildlife. The Environmental Reference Handbook for Sanibel reaffirms the important role of native plant species, stating that: “native plants are important to Sanibel because most: are adapted to local weather conditions, including drought, occasional salt water flooding, and heavy summer rains; can exist well without fertilizers or pesticides . . . [and] provide a food source and habitat for wildlife . . .” (6).

Ecologists at the refuge study native species and monitor wildlife populations to ensure the survival of threatened species. The Ding Darling Refuge also acknowledges the important role law enforcement plays in administering and upholding regulations. The Environmental Reference Handbook supports the prioritization of interdisciplinary relations, stating that: “Long-standing and successful cooperative partnerships with outside groups such as Sanibel-Captiva Conservation Foundation and the City of Sanibel assist the Refuge to achieve its goals while supporting natural resource protection on lands adjoining the Refuge” (47). Finally, the Ding Darling Refuge prioritizes transparency and communication in order to ensure that the public is informed and proactively.

Yet another prominent conservation organization on the island is the highly-esteemed Sanibel and Captiva Conservation Foundation (SCCF), founded in 1967. SCCF is registered as a 501(c)3 non-profit organization and is dedicated to "the conservation of coastal habitats and aquatic resources on Sanibel and Captiva and in the surrounding watershed" ("About Us," The Sanibel-Captiva Conservation Foundation). SCCF has an impressive history of land acquisition on Sanibel, and is currently the single largest private landowner on the island. In addition to managing over 1,200 acres on Sanibel, SCCF manages approximately 600 acres on surrounding islands - most notably, Captiva. Programs in the surrounding community conducted by SCCF encompass a broad scope of topics, including: Sea Turtle Research and Monitoring, the prominent Marine Research Laboratory, Wildlife & Habitat Management, Environmental Education, Native Landscapes & Garden Center, and the Natural Resource Policy.

The overarching success of this influential organization can be attributed to several factors. Namely, the altruistic support of public sector partners and conservationist donors (including the aforementioned J.N. "Ding" Darling National Wildlife Refuge) which have helped solidify SCCF as an environmental success story with a venerable reputation in research for the past 43 years. This is affirmed by the reliance of numerous governmental agencies and universities on SCCF for its forward-thinking leadership and scientific specialization (particularly in the marine laboratory sector).

Dr. Eric Milbrandt is the director of the Marine Laboratory at SCCF and a distinguished researcher in the field of marine biology. His article entitled “Brief History of the Sanibel–Captiva Conservation Foundation (SCCF)'s Marine Laboratory, Sanibel, Florida: Not to be Confused with Doc Ford's Sanibel Biological Supply Company” reinforces SCCF’s role as a conservation leader in southwest Florida, noting several significant community initiatives conducted by the organization: “(1) preserving habitat through land acquisition; (2) removing exotic species; and (3) addressing problems related to freshwater releases by the U.S. Army Corps of Engineers (USACOE) and the South Florida Water Management District (SFWMD)” (1).

The presence of eminent conservation organizations on the islands of Sanibel and Captiva document the efforts to preserve the island’s unique allure, and underscores the role my prospective business will play in unifying the population around red tide reduction policies. Sanibel is an oasis; a niche market that can embrace environmental preservation and the rise of social enterprises.

Social Entrepreneurship and the Role of Grassroots Movements

How does one go about addressing chronic ecological occurrences like HABs? One prospective solution is social entrepreneurship, a rapidly-expanding field of business that is gaining traction as organizations across the planet are developing novel approaches to solving some of the world’s most pressing concerns. Social enterprises transcend the boundaries of entrepreneurship, the economic development sector,

academia, and nonprofits, using business as a force for good to alleviate poverty and other social problems (MacMillan & Thompson, 2013). MacMillan and Thompson chronicle the shifting trajectory of modern businesses, writing: “[t]hese organizations—be they nonprofits (increasingly under financial strain), for-profits (looking to combine corporate social responsibility with growth possibilities in bottom-of-the-pyramid environments), or public-private partnerships—have begun launching revenue-generating enterprises to carry out their social missions” (2013). Thus, the convergence of numerous disciplines and the piqued interest of business schools, the business press, foreign aid and economic development agencies, and philanthropic organizations. Social entrepreneurship is described as the combination of the passion of a social mission with the discipline of business and innovation. Social entrepreneurship harnesses the growing power of the individual, placing millennials at the forefront of the accountable business revolution. Businesses are filling a widening leadership vacuum as distrust of political institutions mounts and technological change creates massive opportunities to achieve sustainable, inclusive growth.

Perhaps the most fitting descriptor of social enterprises is the concept of a ‘hybrid business.’ A powerful differentiation between social enterprises and traditional non-profits (which similarly occupy the social sector) is the abilities social enterprises possess to self-sustain through the generation of net profits. One of the fundamental purposes for creating a social enterprise (versus a non-profit) is to address social problems whilst simultaneously generating revenues. Social enterprises “[streamline their] operations and supply chain to maximize social impact and minimize the use of

resources, and [additionally use] a sustainable, replicable, and potentially scalable business model" (Chahine, pp.2). Furthermore, whereas many traditional corporations enter heavily saturated markets and attempt to claim a share of overall profit, social entrepreneurs are hailed for their ingenuity, creating markets where none yet exist. They work in highly uncertain and largely uncharted environments, targeting intractable social problems and entering volatile markets that are conducive for the development of idiosyncratic innovations. This concept is known as the "blue ocean strategy."

Red oceans constitute all industries in existence today, and the known market space. In essence, corporate entities work to outperform their rivals in an attempt to claim a larger share of the marketplace. Within red oceans, industry boundaries are pre-determined and generally accepted with the competitive rules of the game already established and understood (MacMillan, 2013). However, as the market becomes more saturated, the prospect for profit and growth becomes significantly reduced. Blue oceans, on the other hand, represent all the industries not in existence today. They are the unknown variable in market space that has not yet been influenced by competition. In blue oceans, demand is created rather than fought over. Thus, there is a lot of opportunity for rapid growth and profit. Blue oceans will remain the engine of growth in future years because prospects in most established market spaces are rapidly shrinking. Technological advances have substantially improved industrial productivity and thus suppliers are able to produce an unprecedented array of products and services (MacMillan, 2013). Furthermore, as our world becomes more globalized, trade

barriers between nations are shrinking and products/prices become instantly and globally available (MacMillan, 2013).

Table 2 (*below*), presents some of the defining characteristics of social entrepreneurship in a simplified format. It observes the skills required to be a successful social entrepreneur, along with the replicable and scalable qualities social businesses possess.

Table 2: The Defining Characteristics of Social Entrepreneurship and Corresponding Interdisciplinary Skills

Social entrepreneurship is…	*Skills required…*
Disruptive Ambitious, scalable Financially viable	The Entrepreneurship Component: Innovation and Business Skills
Evidence based Accessible to target population Effective in addressing root causes of the problem	The Social Component: Social Service Skills

(SOURCE: Chahine, Teresa. Introduction to Social Entrepreneurship (Page 2). CRC Press.)

Furthermore, it is valuable to define corporate social responsibility (CSR), whereby companies make informed and intentional decisions to positively contribute to the betterment of society. Businesses that operate in accordance to the principle of CSR often make commitments influenced by ethical values, complying with legal

requirements that respect both their communities and the environment (Dahlsrud, 2006). Instead of solely being motivated by the quest for profit, these enterprises integrate the concept of the triple bottom line – the interdependent coexistence of people, planet, and profit – to inflict tangible, positive change in the world.

There are several distinct approaches used in social entrepreneurship to solve wicked environmental problems — i.e., ecological issues with no clear solution characterized by changing conditions and chronic policy failure. One-on-one interactions with individuals afflicted by environmental concerns allow social entrepreneurs to form connections with the people they are serving to better understand the challenges they face. Instead of approaching the social/environmental concern with a 'savior mentality,' this approach provides changemakers with the opportunity to immerse themselves fully in the lives of their beneficiaries to comprehensively understand their needs and aspirations. Another useful approach is a top-down lobbying effort in which social entrepreneurs attempt to "influence policy decisions at a local or federal level" ("Existing Approaches to Social Entrepreneurship"). The success of this approach is dependent on collaborations with government agencies, legal entities, and foundations. Various strategies within this approach that can be applied to the issue of red tide include multidisciplinary and coordinated partnerships, raising public awareness, and supporting environmental advocacy efforts to strengthen grassroots community-based efforts.

The interrelated topic of “grassroots movements” demonstrates the dynamic nature of the citizen sector and how it can be characterized as a market economy of social ideas. The term ‘grassroots’ refers to a type of movement, frequently political in nature, that seeks to mobilize and empower individuals to take action. These campaigns are tailored specifically to influence a desired outcome, and can be condensed into two general types: “(1) efforts to mobilize individuals either to turn out to vote or to vote a certain way in an upcoming election and (2) efforts to mobilize individuals to contact a policymaker or other individual with influence to take a particular action” (Bergan, 2016).

My thesis is predominantly concerned with the distinguishing features of the latter; I am interested in examining the ways in which informed and engaged social entrepreneurs can use their businesses to drive change all the way up to the governmental level in order to influence key Florida legislators. Government policies dictate the allocation of monetary resources and funding for conservation initiatives, so political activism is essential. Several distinguishing features of grassroots movements include their capacity to mobilize masses to participate in politics, and the outlets of communication they employ to disseminate their messaging — narrow communications such as face-to-face visits, emails, mail, and phone calls (Bergan, 2016).The quest for greater accountability in international institutions reflects the pressure society is imposing on transnational conglomerates largely preoccupied with fulfilling their own agendas. Unregulated business practices have been a cardinal sin since the

progressive era and serve as a catalyst for civil society to demand more accountability and the justification of actions.

A local example of a grassroots movement based in Southwest Florida is *Captains For Clean Water*, a 501(c)3 nonprofit organization that advocates for the "elimination of harmful, large-scale Lake Okeechobee discharges into the Caloosahatchee and St. Lucie River Estuaries by restoring the natural flow of Lake Okeechobee water south into the Everglades and Florida Bay" (https://captainsforcleanwater.org). While technically classified as a non-profit, Captains for Clean Water more closely resembles a hybrid business because they sell promotional apparel and memberships on their website. This ensures that they always have a consistent stream of income to support their community impact initiatives whilst simultaneously disseminating their core mission through the free advertising provided by apparel.

Captains For Clean Water originated in Fort Myers, FL, the neighboring city to Sanibel Island that is located across the causeway. A group of impassioned fishing guides were deeply frustrated with Florida's poor water management practices and the systemic decline of estuaries, paired with an inexplicable lack of progress being made towards resolving this enormous problem. They chose to vocally express their dissent for poor water management practices, government mismanagement, and the agricultural industry's legislative power, accordingly creating a widely influential grassroots movement. As will be discussed in the following section entitled "Strategies,"

Captains for Clean Water integrated the use of scientific reasoning and evidence-driven findings to develop potential solutions to the degradation of coastal ecosystems.

While enacting water quality regulations can be an effective way to prevent the exploitation of valuable resources, this approach depends on a high level of enforcement and can be impeded by opposing market forces such as the agricultural industry. Examples of other revenue-generating SE models in the U.S. that have successfully aligned the profit motive with the conservation of coastal ecosystems include catch shares, mitigation banking, water quality markets, and payments for ecosystem services. Catch shares are a fishery management strategy that have “helped fisheries meet their conservation goals while increasing profits” (Fujita, 2013). This process entails securing privileges to individual fishermen or cooperatives to harvest a portion of a fishery's total catch, thus allowing the fish population to replenish itself through natural processes. Mitigation banking is a system of credits and debits used to compensate for anticipated ecological losses. When agricultural producers destroy land through the processes of dredging, drainage, and ditching, nearby wetlands or habitats can be restored to offset these adverse impacts. Fujita notes that mitigation banking has been successfully used to ”restore mangrove forests, salt marshes, and oyster reefs” (2013).

Water quality markets, yet another “eco-market” tool, are cap and trade programs that help farmers reduce polluted runoff. This solution improves water quality in a way that maximizes economic efficiency and maintains environmental standards. Trading is

a progressive solution that upholds environmental integrity and allows “sources with higher pollution control costs to purchase pollution reductions from sources with lower costs. Those with higher costs can save money, while those with lower costs can earn new revenue” (“*Water Quality Trading,”* 2015). Finally, payments for ecosystem services (PES) is a pioneering nature conservation strategy that rewards those whose lands provide essential ecological services with subsidies or market payments. This has resulted in improvements in coastal watershed and the empowerment of stewards who create new ocean-driven economies.

Specific examples of social startups that target nature conservation initiatives and have successfully harnessed the power of entrepreneurial strategies include *Oxyn*, *Green Charcoal Uganda*, and *4Ocean*. Oxyn is a blockchain infrastructure and cryptocurrency driven by environmental incentives that manages payments between businesses, conscious consumers, and environmental organizations (“Oxyn: A Cryptocurrency Designed to Reduce Plastic Pollution”). This enterprise is particularly effective because it utilizes a new industry force — blockchain. This powerful record-keeping technology promotes transparency and can be used to “address environmental governance challenges by offering a secure and verifiable record of who exchanges what with whom and who has what at a given time” (Le Sève, Mason, & Nassiry, 2018).

Another innovative solution is Green Charcoal Uganda, an enterprise that solves the problem of fuel scarcity for local populations in Eastern Africa by extracting briquette

from discarded palm kernels, an otherwise wasted resource. This enterprise has important implications for Uganda's circular economy which is heavily reliant on renewable energy with an estimated 90% of energy derived from biomass ("Green Charcoal Uganda," 2019). Finally, 4Ocean is a purpose-driven organization that seeks to clean the ocean and coastlines while systematically working to halt the influx of plastic by changing consumption habits. 4Ocean was created by two surfing enthusiasts hailing from Florida who developed a unique business model to target the ocean plastic crisis; for every product purchased, 4Ocean pulls one pound of trash from the ocean and coastlines ("4Ocean: Our Mission".

Strategies and Recommendations

Several actions are proven to diminish the impact of toxic algae blooms. First and foremost, Captains for Clean Water proposes that the state of Florida acquire the land south of Lake Okeechobee to treat and store water before it continues south to estuaries. This can have the positive outcome of diminishing the severity and length of blooms. There have been significant delays, however, in actually instituting this policy. *Why*, some may wonder, *do legislators postpone such a relatively straight-forward solution*? Self-serving influences motivate political actions, and for many decades state lawmakers have reaped the benefits of public disengagement and hefty campaign contributions from agricultural conglomerates.

Another veritable solution is increased funding for research projects. Michael Crosby, president and CEO of Mote Marine Laboratory, stresses that funding increases

will “significantly bolster the scientific community’s research to detect, respond to, and develop innovative technologies to lessen the impacts from some of the country’s most challenging harmful algal blooms – red tide – on our environment, marine life, and human health” (Rutger, 2017). The Mote Marine Laboratory, a 64-year-old independent nonprofit marine research organization based in Sarasota, announced an unprecedented competitive grant opportunity geared towards scientists fighting the red tide epidemic. This initiative harnesses the power of partnerships between the Florida Fish and Wildlife Conservation Commission’s (FWC’s) Fish and Wildlife Research Institute and Mote to foster a “coordinated effort among public and private research entities to develop prevention, control and mitigation technologies and approaches that will decrease Florida red tide impacts on the environment, economy and quality of life in Florida” (Rutger, 2017).

This grant opportunity can stimulate the Floridian economy through the development of new technologies that foster interdisciplinary collaboration. Moreover, this initiative will create novel detection systems that have the potential to forecast future outbreaks and can protect the health of the public through reports disseminated in easily-accessible smartphone apps. The aforementioned example highlights the powerful capacity social enterprises and technological innovations possess for radically redesigning the social landscape and addressing prominent community problems such as environmental degradation. A research initiative conducted in 2007 found that “city support makes a difference in both the quantity and quality of social entrepreneurs' activities, and that supportive city governments were more likely to improve settings for

business” (Sullivan). Thus, governments can primarily foster the development of social enterprise strategies in two ways: integrating social enterprises into a sustainable tourism system through the institution of policies that promote organizational development and operation, and by promoting institutional conditions to legitimize and encourage social entrepreneurship formation.

One of the principal legislative activities that can reduce the occurence of future HABs is the “Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2017” (S.1057). Congress has allowed the national algal bloom research and prevention program to expire, and in order for the aforementioned act to go into effect, the House must pass legislation that extends the reauthorization of the program until 2022 (H. Rept. 116-202 - SOUTH FLORIDA CLEAN COASTAL WATERS ACT OF 2019). This act will fund the Florida Healthy Beaches Program to test recreational beaches for high bacterial levels and toxic water, enforce strong water quality regulations and standards, assist local communities in the transition away from septic systems to sewers, and supply funding to regional municipalities to test and monitor their sewage infrastructure ("Take Action on Harmful Algal Blooms & Toxic Red Tides in Florida"). Furthermore, the role of local governments must not be undermined, as they can pass local fertilizer ordinances, examine the maintenance of sewage systems, and execute forward-thinking strategies to control stormwater pollution.

Lastly, on an individual level we can all contribute to the elimination of red tide. Simple acts like picking up your pet's waste and making your yard more ocean friendly

through fertilizer and pesticide reduction can have a tremendous influence on controlling algal blooms. Other gestures, like planting native species in your garden and taking your car to a commercial car wash will help prevent additional runoff from entering storm drains and local waterways.

Interviews

[INTERVIEWS HAVE BEEN LIGHTLY EDITED AND CONDENSED FOR CLARITY].

I. AN INTERVIEW WITH CHAUNCEY GOSS, Governor Rick Scott's Appointment of Chairman to the South Florida Water Management District's Governing Board

DAHLIA LILLESLATTEN (DL): *You were the Executive Director of the Gasparilla Island Conservation, currently serve on the board of Captains for Clean Water, and additionally you were recently elected as the Chairman of South Florida Water Management District's Governing Board. You play an important role in advocating for important community initiatives - what do some of your responsibilities look like?*

CHAUNCEY GOSS (CG): My primary responsibility now is to the 8.7 million people who live within the boundaries of the South Florida Water Management District (SFWMD)

which run all the way from Orlando to the Florida Keys. The District has 1,500 employees, a budget of a billion dollars and is responsible for 1.) flood control, 2.) water supply, 3.) environmental protection, and 4.) the restoration of the Everglades. Those four responsibilities are sometimes in conflict with each other which makes the job of the Governing Board difficult. The Governing Board is appointed by the Governor and confirmed by the Senate and is comprised of nine members who live in different parts of the District. My goal, as Chairman, is to ensure that we provide balance to the decisions we make so that no one area is under or over-represented.

As we struggle with water supply decisions in the winter and spring (dry season) and flood protection decisions in the summer and fall (rainy season), I want to ensure we are looking at those decisions from the lens of the entire District and its associated ecosystems. As a result, I have the opportunity to work closely with the agricultural community that needs water, the municipalities that need water, the environmental community (which speaks for the environment to ensure natural systems receive water), other state agencies, the Corps of Engineers (our partner on Everglades restoration), the Department of Interior, and the Miccosukee and Seminole Tribes of Florida.

DL: *What impact did red tide have on Southwest Florida's economy, and why should local citizens care about clean water initiatives?*

CG: The Red Tide bloom we had in 2018 came on the heels of Lake Okeechobee discharges during the winter of 2016 that had a detrimental impact to Southwest Florida’s economy during its high (tourist) season. Combined, the Red Tide, the Blue

Green algae outbreak in the river, and the discharges of 2016 painted Florida, and particularly Southwest Florida in a poor light. Because much or our economy is based on hospitality, real estate, and construction, poor water quality is untenable. This region of the state, like most of Florida, depends on its quality of life as a magnet for tourism and residents alike. The impact on just Sanibel and Captiva from Red Tide in 2018 was an $8 million loss in revenue for businesses between August and October which does not include the millions spent on beach clean up (removing tons of dead fish and sealife from beaches) nor does it include the loss of real estate sales or the impact on real estate values. Quite simply, without clean water, Sanibel's – and I would also argue Lee County's – economy would wither. The Chamber of Commerce or the City will have better specific numbers if you need them.

DL: *How is the DeSantis administration working to mitigate future outbreaks?*

CG: On his second day in office Governor Desantis signed Executive Order 19-12 which addresses the way the state manages water, the way the state addresses pollution of waterways, and how to pay for water quality initiatives. He requested $2.5 billion from

The legislature over four years to help build some of the water infrastructure projects we need to prevent harmful discharges from Lake Okeechobee (EAA Reservoir, C-43 Reservoir, and C-44 Reservoir) and to move water from the Lake south to the Everglades and ultimately to Florida Bay. This is the way the water flowed historically prior to our efforts to move water away from the Everglades for development

and agriculture. Governor Desantis also asked for the resignation of the entire Governing Board of the SFWMD which is unprecedented and then appointed a whole new Governing Board.

DL: *What advice do you have for local citizens looking to get involved with clean water advocacy programs?*

CG: The main piece of advice I can give anyone who is interested in this is to stay involved and to pay attention. Water quality started as an environmental issue and gained relatively little traction as such. After discharges in 2013, 2016, the business community became more involved and water quality gained a much-needed economic component. The discharges of 2018 brought in a health component as people were becoming ill from red tide and blue green algae and pets and wildlife were dying. The system can be fixed with infrastructure projects, but those projects are expensive and there is always another demand on the funds.

Yesterday, the Governor and the legislature were focused on water quality, but that focus will become diluted by our next crisis and funds will become scarce. COVID-19 is already a threat as the Governor looks to his budget and watches his revenues evaporate. My advice for anyone who wants to become involved is to stay focused on tomorrow. Help keep the pressure on the legislature to fund projects and to pass laws that reduce pollution. There are many avenues to become involved and many good nonprofits that can provide you with action alerts to help you communicate with the legislature and local elected officials. I have had the chance to work with Captains

for Clean Water (formed as a result of 2016 discharges) and have watched how they work both with grass roots of the fishing community as well as their industry partners to help move the ball forward. Luckily they are not alone and there are many organizations that help speak with a strong voice including the SWFL Chamber alliance which is made of seven or eight Chambers of Commerce from SWFL to advocate for clean water and smart water policy.

II. AN INTERVIEW WITH DR. ERIC MILBRANDT, Marine Laboratory Director and Research Scientist at the Sanibel-Captiva Conservation Foundation

DAHLIA LILLESLATTEN (DL): *How does fertilizer runoff and byproducts such as nitrogen and phosphorus impact the severity of blooms? On a similar note, can you address the main causes for red tide and the role humans play in magnifying the severity of blooms?*

DR. ERIC MILBRANDT (EM): Coastal areas are the downstream recipient of runoff from urbanized areas, farms, and natural areas. Nitrogen and phosphorus dissolved in the runoff causes degradation of coastal waters because of algae blooms, hypoxic events, and habitat loss. The source of runoff is nonpoint, there is not one industrial effluent source that can be turned off. The runoff comes from all of the land in southwest Florida. The land use that makes up the highest percentage of the nitrogen to the

Caloosahatchee is livestock grazing land (cattle). If you look it up livestock has a huge nitrogen footprint and the nitrogen fertilizer that we've made from the air (air is 78%) and put on the land is taken up by plants used to feed livestock. In laboratory studies, when you add nitrogen and/or phosphorus to red tide water, the cells grow more quickly and worsen the impact of the bloom.

The main causes of an algae bloom are calm, warm water and nutrients. Each species of microscopic algae or phytoplankton has its own optimal growing conditions. The conditions for Karenia brevis is warm water, salinities around 30 and the gulf coast of south Florida. It blooms every year in the fall but the severity of the bloom varies from year to year. Every decade or so, there is an extremely widespread and severe bloom causing major ecological devastation. Scientists suspect that these super blooms are fueled by human and agricultural wastewater discharges through septic tanks, stormwater discharges, and from atmospheric deposition (vehicle emissions), submarine springs, and coastal river discharges.

The best mitigation for red tide is to collect more samples from boats. This is very expensive but people on Sanibel can support SCCF and encourage state agencies to dedicate more funding to red tide research. The reason this is a good strategy is that real-time red tide abundance maps can be used to find out what beaches or areas are affected that day or week. Red tide is patchy, it is not uniform. It can be highly concentrated in one area (1km by 1km) and very low concentration everywhere else. The other thing people on Sanibel can do is support legislation to curb nitrogen and

phosphorus runoff. For example, mandatory septic tank inspection requirements, improve stormwater capture and treatment designs, mandatory agricultural runoff rules.

DL: *What has been your experience studying and monitoring harmful algae blooms? Has it changed as time has progressed?*

EM: My experience in red tide research is that a majority of the research funding goes to USF and FWRI, both located in St. Petersburg, FL. These large research labs employ dozens of staff and scientists, but because of travel logistics and the somewhat unpredictable nature of red tide blooms, the blooms around Sanibel and Captiva were not sampled. Without sampling, it is difficult to mitigate (i.e., tell our community what's going on) and impossible to study the environmental conditions as it relates to the location and duration of the blooms. I do not consider myself a specialist in harmful algae blooms but given the shortage of funding and manpower, the SCCF Marine Lab is trying to fill some geographic gaps with no dedicated government funding. I also think that people and scientists are not paying enough attention to shifting baselines. Accepting poor water quality as the new normal and ignoring the problem by continuing to spend millions every year on advertising to attract tourists. We should be spending more of that bed tax money to have a consistent research program on Sanibel dedicated to red tide.

DL: *How does red tide impact the health and equilibrium of aquatic ecosystems? Should humans be concerned for their own health and the threat of consuming contaminated seafood?*

EM: Disturbances such as fire and hurricanes change ecosystems. It's not all negative though. Many of the aquatic and marine ecosystems are adapting to be resilient and respond to disturbances because they have always been present here. However, when you add overfishing, pollution, and changes to the timing and duration of freshwater flows, the ability of these ecosystems to recover is hampered. A great example of what's happening in southwest Florida is the stranding of seaweed on Sanibel's beaches. The seaweed is fueled by nitrogen and phosphorus from runoff and is growing throughout the region. It can be beneficial to the ecosystem (food, habitat), but it becomes too abundant.

Red tide kills many fish that can help keep macroalgae or seaweed under control so it doesn't overgrow everything and end up as big stinky piles on the beach. Red tide exasperates a problem that is pre-existing in the ecosystem by delivering a major disturbance (removal of fish). The removal of fish by red tide before Florida was developed may have had some benefit to allow other young fish to expand their range (for example).

Fish have been tested extensively for red tide toxins. If you just eat the muscle, there is nothing to worry about. A more philosophical problem for me is that all of the earth's fisheries are overfished. This causes major changes to ecosystems and makes them more vulnerable to disturbances.

III. AN INTERVIEW WITH CHUCK O'NEAL, *Orlando Politician and Environmental Activist*

DAHLIA LILLESLATTEN (DL): *Thank you so much for taking the time to speak with me about ecological restoration initiatives in Florida, particularly those concerning toxic algae blooms! You have been a very active proponent for restoration initiatives in Florida, including the protection of springs, estuaries, and coastal ecosystems. What inspired you to get involved with environmental issues?*

CHUCK O'NEAL (CO): My early childhood was spent growing up in Florida. My uncle also had a home in the Catskill Mountains, and I would go on long walks in the mountains with my family. My attachment to nature began early, and I firmly believe that parents should immerse their children in nature. Many elected officials aren't grounded in the place they are governing, and that's the problem. Rick Scott, for example, did not have much interest in governance or Florida before he ran for governor. He is originally from Texas, and in his past career, he started a hospital chain. Many politicians don't have any sense of place, and I believe that it is important that the people who govern an area have an attachment to the place they are living in. When people get into governance and don't have a meaningful connection to the location, they make decisions based solely on money.

DL: *Why should we as Floridians prioritize the conservation of Florida's coastal ecosystems?*

CO: Everything that happens in our state leads back to nature and our waterways — take tourism, for example! Tourists come here for the nature and the essence of Florida. Even if you have no attachment at all to nature, you should be deeply involved and deeply committed to preserving the values and ecosystems within the state. We also have to acknowledge the importance of supplying a growing population with food, water, and decent work opportunities.

DL: *One of the largest contributors to toxic algae blooms stems from our mass consumption of fertilizer. I was wondering if you could discuss potential solutions to the fertilizer runoff epidemic in Florida?*

CO: In Orange County, a recent charter amendment was proposed to the Charter Review Commission Board and was studied to ensure that the language used was acceptable. During the last meeting, however, the Executive Director of Orange County Farms proposed that this charter amendment should exempt agriculture. Agriculture is a quarter of the problem — there is no way to effectively limit fertilizer consumption if agriculture is not monitored! There should be a limit to the water farmers use and the nutrients they put in the water stream. If you go to all the trouble and expense to monitor your fertilizer con-sumption, and your neighbor is overloading to maximize their yield, you are at a financial disadvantage to him. It is important to level the playing field so that everyone obeys the rules and we move forward.

DL: *A recent red tide mitigation bill (filed by Sen. Joe Gruters, R-Sarasota) won widespread bipartisan support. Some argue, however, that mitigation efforts don't extend far enough to prevent red tide from occurring in the future — they are remedial as opposed to preventative measures. What role does the Florida Legislature play in controlling and preventing red tide outbreaks, and should more be done by the current administration?*

CO: There definitely needs to be more done by the current administration! Red tide, or Karenia brevis, is fed by nutrients filtering in from Lake Okeechobee. We are es-sentially running a massive feeding operation. It has been fully debunked that there is no correlation between red tide and fertilizer, and we are not helpless victims in this process, as we may like to think. We, as humans, dispel waste and wastewater into the system, and are the source of the problem. Change begins on an individual level and goes all the way up to the governor's office.

DL: *What can Florida residents do to address this issue - what power do we have as individuals?*

CO: Lobby on behalf of the environment! It is imperative that citizens get involved with the Rights of Nature Movement at the local level. You can also get involved with the drafting of charter amendments, and create petitions to get them signed onto the ballot. Start from the grassroots up and decide what you want to protect. My dream is for Florida to become known as the clean water state — we have a tremendous opportunity to reverse the damage that has already been inflicted.

Key Takeaways

Interviewing prominent community members reinforced in my mind the necessity of interdisciplinary and cross functional collaboration. The solution to ecological restoration is known, but what we lack is a comprehensive game plan and targeted actions to move plans forward in a timely manner. Restoring Florida's coastal communities requires the reduction of nutrient-ridden discharge, which in turn is dependent upon public engagement and advocacy. As noted by Chauncey Goss, political will drives progress and elected officials hold the key to our clean water future. As informed members of the community, we need to advocate for a radical shift in the conversation about ecological restoration, proposing it as a way of life that offers tremendous opportunities for economic growth. *Then people will start listening.*

Conclusion

This thesis has demonstrated the harmful impact of toxic red algae blooms to water ecosystems, human health, and local businesses which largely rely on tourism generated from ocean industries. By including interviews with prominent community members (namely — marine biologists, water-quality activists, and local politicians) I presented a unique glimpse into the value of interdisciplinary collaboration and the effectiveness of coordinated and systematic efforts. Furthermore, throughout my findings I sought to increase awareness about the toxicity of red algae blooms along the

coast of Florida, along with promoting activism and conscious consumerism to eradicate ocean pollution. The powerful role of social enterprises cannot be undermined in the process of addressing red tide in Southwest Florida, and the dissemination of new technologies and ‘blue ocean strategies’ will transform social practices in years to come. Social innovations, not unlike grassroots organizations, rely progressive governance, bottom-up movements, and multi-faceted collaboration. There is no doubt in my mind that the pressing concerns of toxic algal blooms will mobilize the vision, energy and social spirit of those who seek to change the world for the better.

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