Impacts of Water Quality on the Southwest Florida Economy

FINAL REPORT

Prepared for:

SCCF SANIBEL-CAPTIVA CONSERVATION FOUNDATION

CAPTAINS FOR CLEAN WATER

CONSERVANCY of Southwest Florida
OUR WATER, LAND, WILDLIFE, FUTURE.

CONNECTING OUR WATER, ECONOMY AND QUALITY OF LIFE

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Contents

Table of Tables

Table of Figures

Executive Summary

The coastal ecosystems of southwest Florida support local economies and lifestyles in the region through tourist and visitor revenues stimulating jobs and income, fisheries, property values, and general access to recreation and the outdoors. When large detrimental water quality events occur – like the harmful algal bloom (HAB) that occurred in Southwest Florida in 2018 – the economy contracts as estuaries, beaches, and canals are impacted by toxic algae. Hence water quality is fundamental to both the ecosystem and economic system. Captains for Clean Water, the Conservancy of Southwest Florida, and the Sanibel Captiva Conservation Foundation retained Greene Economics to quantify the economic impacts of harmful water quality events and degraded water quality on the southwest Florida economy. The goal of this report is to measure the impact of poor water quality on the economies of Charlotte, Lee, and Collier counties. These economic impacts also shine light on the fact that good water quality has a positive economic impact, and financial investments in projects and policies that improve water quality will pay off through a more robust economy.

> *"Water is the heart of everything here, everyone is here for the water, one way or another."*
>
> *architect, developer, fisher*

The results of the analysis show that with another event in Charlotte, Lee, and Collier Counties similar to the HABs experienced in 2005/6 and 2018, the study area would lose over $460 million in commercial and recreational fishing, over 43,000 jobs, $5.2 billion in local economic output, $17.8 billion in property values with an associated $60 million in property tax revenue, and finally $8.1 billion in the value of outdoor recreation (or, quality of life). Results are presented below in Table ES-1.

Table ES-1: Summary of Annual Economic Losses from HAB Event

Type of Economic Asset	Charlotte	Lee	Collier	Study Area
Fishing (Commercial and Recreational)	$24 million	$194 million	$243 million	**$460 million**
Coastal Economy – Jobs	4,353	24,808	13,933	**43,094**
Coastal Economy - Output	$466 million	$3.0 billion	$1.7 billion	**$5.2 billion**
Property Values	$1,715	$6,700	$9,400	**$17.8 billion**
Property Tax Revenue	$3.2 million	21.4 million	35.7 million	**$60.3 million**
Value of Outdoor Recreation (Quality of Life)	$518.6 million	$5.3 billion	$2.3 billion	**$8.1 billion**

Each of the economic assets analyzed in this report has a different kind of importance, and that is why each has been analyzed – with the goal of demonstrating a comprehensive economic assessment. Details

of the approaches to estimate economic loss, the sources of data, and the reasoning behind each of the analyses are provided in the main body of the report. Some key points include,

- Both recreational and commercial fishing estimates are a subset of the coastal economy jobs and output estimates.
- The jobs and output estimates (the Coastal Economy in Table ES-1) deal with just the six sectors of the economy that are directly affected by the ocean following the approach used by National Oceanic and Atmospheric Administration (NOAA) in the Economics: National Ocean Watch, or ENOW data set, and therefore may be considered conservative estimates of the impact of water quality on jobs and output.
- Property values are not part of the job losses and output impacts to the Coastal Economy.
- The Value of Outdoor Recreation, or Quality of Life results, are estimates of what is known as the 'non-market' value of outdoor recreation, because people don't have to pay to take a walk on the beach or a swim in the Gulf of Mexico typically. However, these estimates are appropriate for use in a federal, or state regulatory benefit cost analysis.

This analysis focuses on the impacts in Charlotte, Lee, and Collier Counties, as shown below in Figure ES-1, although the impacts are not confined to this geography. Each county was evaluated based on the unique set of economic and environmental assets in the county. As a result, the degree to which poor water quality impacts each county differs. Results of the estimated economic impacts of another HAB in each county is provided below followed by an overview of how these impacts could play out in the future under different scenarios.

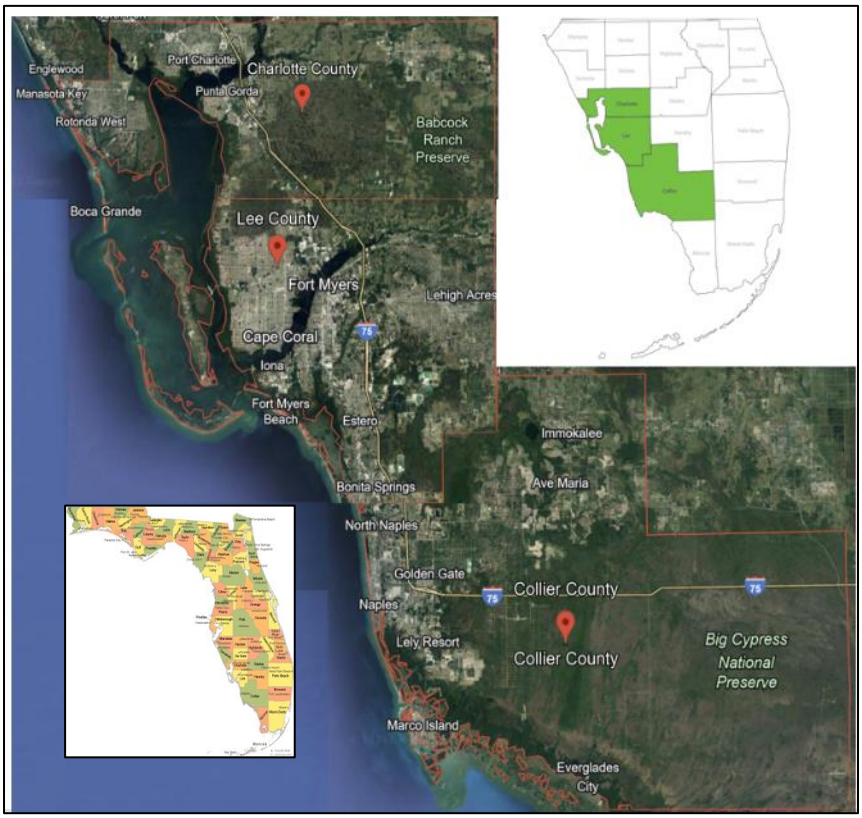


Figure ES-1: Map of Study Area

Charlotte County

Charlotte County is the northernmost county in the Study Area, home to a population of nearly 203,000, and with annual visitors estimated at over a million in 2023. For Charlotte County, the estimated losses from a HAB total $24 million in recreational and commercial fishing revenues and expenditures. The potential jobs lost in one year is estimated to be 4,353, and the loss in output is estimated to be $466 million. Property value losses are estimated to be a loss of $847 million with an associated $3 million in lost property tax revenue. The non-market value of outdoor recreation (or, quality of life) lost would be $518 million. Table ES-2 shows the estimated losses to Charlotte County. For each category of loss, the total value of the economic asset is shown, followed by the expected loss.

Table ES-2: Asset Value and Loss Expected from a HAB in Charlotte County

Type of Economic Asset	Value	Loss
Fishing– Recreational/Commercial	$76.3 million	**$24.1 million**
Coastal Economy – Jobs	15,404	**4,353**
Coastal Economy – Output	$1.7 billion	**$466 million**
Property Value Near Coast	$4.2 billion	**$847.2 million**
Property Tax Revenue	$18.7 million	**$3.2 million**
Value of Outdoor Recreation (Quality of Life)	$1.6 billion	**$518.6 million**

Lee County

Lee County sits between Charlotte and Collier County and is the most populous of the three, with over 822,000 permanent residents and over 5.1 million visitors estimated in 2023. In Lee County, the estimated losses from another HAB total $195 million in recreational and commercial fishing revenues and expenditures. The potential jobs lost in one year is estimated to be 24,808, and the loss in output is estimated to be $3 billion. Property value losses are estimated to lose $3.8 billion with an associated $21.4 million in lost property tax revenue. The value of non-market recreation (or, quality of life) lost is estimated to be $5.3 billion. Table ES-3 summarizes the losses to Lee County.

Table ES-3: Asset Value and Loss Expected from a HAB in Lee County

Type of Economic Asset	Value	Loss
Fishing – Recreational/Commercial	$618 million	**$195 million**
Coastal Economy – Jobs	87,300	**24,808**
Coastal Economy – Output	$11.1 billion	**$3.0 billion**
Property Value Near Coast	$19.1 billion	**$3.8 billion**
Property Tax Revenue	$122.4 million	**$21.4 million**
Value of Outdoor Recreation (Quality of Life)	$16.6 billion	**$5.3 billion**

Collier County

Collier County is the southernmost county in the study area, with 397,994 permanent residents, and over 2.5 million visitors estimated in 2023. In Collier County, the estimated losses from another HAB total $245 million in recreational and commercial fishing revenues and expenditures. The potential jobs lost in one year is estimated to be 13,933, and the loss in output is estimated to be $1.7 billion. Property value losses are estimated to decline by $6.8 billion with an associated $35.7 million in lost property tax revenue. The value of non-market recreation (or, quality of life) lost would be $2.3 billion. Table ES-4 summarizes the losses to Collier County.

Table ES-4: Asset Value and Loss Expected from a HAB in Collier County

Type of Economic Asset	Value	Loss
Fishing – Recreational/Commercial	$773.1 million	**$245.5 million**
Coastal Economy – Jobs	48,576	**13,933**
Coastal Economy – Output	$6 billion	**$1.7 billion**
Property Value Near Coast	$33.9 billion	**$6.8 billion**
Property Tax Revenue	$195.3 million	**$35.7 million**
Value of Outdoor Recreation (Quality of Life)	$7.3 billion	**$2.3 billion**

Approach

The analysis in this study depends heavily on the wealth of related information and previous work that has been produced establishing connections between water quality and the economies of southwest Florida and other regions. The research team conducted a literature review of over 100 documents, reports, presentations, and articles related to water quality, many of which focused on the economic impact of HABs both in Florida and other locations around the US. Though data sources and study regions differ, across the board these studies have used a similar approach to measuring economic impacts from HABs. This involves establishing a baseline economy, determining to what degree harmful algal blooms impact economic sectors of interest, and calculating the monetary losses from these types of events. The methodologies utilized in these reports both inform and align with our approach to measuring water quality impacts on the southwest Florida economy.

The research team also considered other chronic water quality issues that exacerbate the frequency and duration of harmful algal blooms, and in turn, amplify local economic losses. Some examples include failing stormwater and wastewater infrastructure, saltwater intrusion, and hypoxia, which are often intensified by climate change and increased storm/hurricane intensity and frequency. Finally, the team reviewed and used several local datasets for our analysis. Much of the data used in the analysis was produced or shared through the Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP), Florida Fish and Wildlife Conservation Commission (FWC), and National Oceanic and Atmospheric Administration (NOAA).

In addition to the extensive literature review, the team conducted multiple interviews with local stakeholders impacted by water quality, including developers, elected officials, real estate professionals, regulators, wildlife biologists, local business owners, and established fishing guides and fishermen. The goal of the interviews was to better understand the impacts of discrete and chronic water quality events on the regional economy and environment. After speaking with these individuals, it is clear that southwest Florida is a "water community;" the water draws both tourists and residents to the region and is an essential part of everyday life.

Looking Ahead

The economic impact of HABs is expected to continue, and in the long run, it is critical to understand how these economic losses could compound in the future. As the ecosystem changes with the changing climate and other forces, HABs and events that are harmful to water quality may be increasing in frequency and neither the environment nor the economy may be able to recover between events. Such repeated events could result in potentially irreversible downward trends in the economies of the region. The goal of developing the economic information in this report is so that communities may better understand what is at risk from poor water quality, and decision-makers can assess the costs associated with a 'do nothing', or 'business as usual' approach, versus taking the steps necessary to invest in improved water quality.

> *"It takes two to three years to recover from an event, people go to nearby counties instead."*
> *Chamber of Commerce*

Because it is difficult to know how the chance of having a HAB, or the reduced magnitude of a HAB might be affected by investing in water quality improvement programs, economists often consider several

different scenarios. For example, the graph below (Figure ES-2) shows how a HAB like the 2018 HAB would cause losses if it were to reoccur in 2025; and assuming, for the sake of this specific scenario analysis, the ecosystem and economy were to recover within a period of one year. The graph has two components because the magnitude of the dollar values is different for the different types of economic assets at risk. For total fishing values (in orange) the value is about $1.5 billion in 2022, and about $860 million for property taxes (in yellow). In the lower portion of the figure, economic activity (in blue) starts at about $19.1 billion for the study area and quality of life (in green) starts at $25.6 billion. The dotted lines in these figures show the baseline economic expectation without a HAB.

Figure ES-2: HAB in 2025 Assuming One Year Recovery Period

Given that poor water quality comes from many sources, it is also plausible that the ecosystem might take three years to fully recover, and in such a scenario, the economic losses would persist for an additional two years. Another scenario could be that a second HAB occurred on the heels of the first one and could then further delay the ecologic recovery and increase the economic losses. For example, suppose a HAB

were to occur in 2025 with the assumed three-year recovery period, and then in 2027, before the economy has recovered fully, a second HAB occurs, further delaying, and calling into question the economic recovery at all. This is portrayed graphically in Figure ES – 3.

These scenarios are developed to illustrate how the uncertainty of HABs and underlying water quality could play out over time and affect the economies of these counties into the future. This consideration lays the groundwork for thinking about investment decisions. A spreadsheet tool has been developed so that local decision-makers might view and interpret results for a variety of scenarios related to economic growth and development, HAB occurrences and frequencies, and ecologic recovery periods.

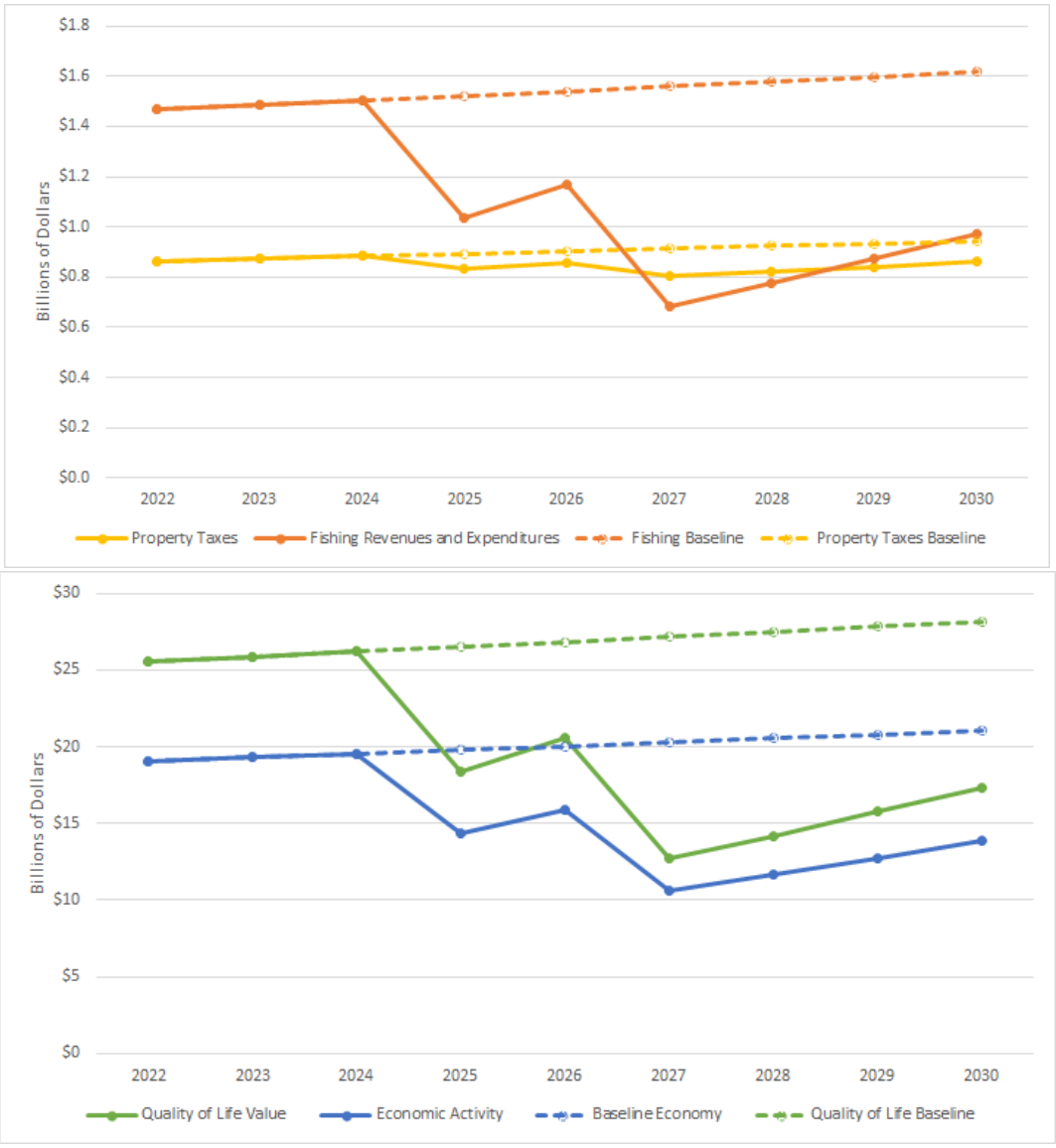


Figure ES-3: Potential Economic Impacts of HAB in 2025, and again in 2027 Assuming Three Year Recovery Period

The purpose of this report is to analyze the economic value of water quality in southwest Florida. Overwhelmingly, the available research concludes that HABs are a major threat to economic prosperity,

severely impacting several industries which serve as key elements of the regional economy. Due to the abundance of data, much of this report is dedicated to HABs and their various effects. However, there are other chronic water quality issues which have been shown to have significant economic impacts but have been studied to a much lesser degree. Topics like these, such as wastewater infrastructure, saltwater intrusion, and hypoxia, are deserving of greater focus, but insufficient data makes reporting on them a difficult task. Therefore, this report attempts to identify the full impact of water quality issues relevant to the economies of Charlotte, Lee, and Collier Counties, with an emphasis on HABs, and suggestions for further research regarding the future health and security of the region.

The ultimate analysis confirms that negative water quality events have clear quantifiable impacts on all sectors of the local and regional economies, that the magnitude of those negative impacts is likely to increase as the frequency and intensity of events compound on an already weakened ecosystem, and that over time the ramifications of continued degradation will threaten the overall character of the region and the quality of life that residents and visitors have come to expect from it.

1. Introduction

The coastal ecosystems of southwest Florida support local economies and lifestyles in the region through tourists and visitor revenues stimulating jobs and income, fisheries, property values, and general access to recreation and the outdoors. Elements of the ecosystems, such as mangroves or seagrass, provide habitat for fisheries and indirectly support the beaches and the coastal environment that provides the economic vitality of the area. As a result of these relationships, the health of the local economies follows the health of the local ecosystems, and the resilience of the economic system also reflects the resilience of the ecosystem. Water quality is a fundamental element of the ecosystem, and the goal of this report is to measure the impact of poor water quality on the economies of Charlotte, Lee, and Collier Counties in southwest Florida. The analysis builds on extensive research assessing the economic value of water quality improvements, recreation, fisheries and habitat improvement, aesthetics and property value impacts, and the overall quality of life in the region. This research underscores the economic importance of protecting natural resources. The Greene Economics research team was retained by the Captains for Clean Water, the Conservancy of Southwest Florida, and the Sanibel Captiva Conservation Foundation (Coalition) to conduct this analysis.

1.1. Study Framework

For all economic studies it is important to clarify the study framework and boundaries of the analysis. Typically, this framework depends on the goals and objectives of the study. From the final Request for Proposals (RFP)[1] from the Coalition, the purpose of the study is to,

> *quantify the financial impact water quality has on Southwest Florida's economy. The goal is to assign a dollar value to clean water and be able to say with certainty how much of an effect polluted water has on the various markets in Southwest Florida and our local communities. We would like to have the ability to quantify and compare the economic impacts of large-scale events that are detrimental to water quality, such as a harmful algal bloom or an increase in pollutants. (RFP, p. 1)*

and the purpose is refined in a later statement from the RFP,

> *The information in the final report should be presented in such a manner that it can be used to effectively recommend policy changes to better protect our natural resources and the local economies that depend on them.*

Ideally, a research effort should clarify a geographic, demographic, and temporal boundary of analysis at the outset of the project. Working together, the research team and the Coalition agreed to examine the three-county area of Charlotte, Lee, and Collier Counties (Study Area). These counties encompass the watersheds and nearshore waters from the Peace River in the Lower Charlotte Harbor to Marco Island just south of Naples Bay, including the Caloosahatchee River and Estuary, Estero Bay, and Naples Bay.

[1] Conservancy of Southwest Florida Request for Proposals, "Economic Study Final RFP," sent to potential bidders, March, 2023.

Given the purpose of the research, the team determined the economic value that is experienced by both the residents and visitors of these three counties. This is especially important because there are many seasonal visitors who live in the area for months at a time. Finally, the analysis is based on the history of water quality but is essentially focused on the potential future scenarios under continued water quality declines, continued outbursts of harmful algal blooms (HABs) and potentially with some improved conditions too. A brief overview of HABs is provided in Appendix A.

The environmental, or natural assets in each of the three counties in the Study Area differ in terms of the ecological features that are placed at risk from detrimental water quality events. The natural assets provide the connection between water quality, and the economic asset classes (see Figure 1-1).

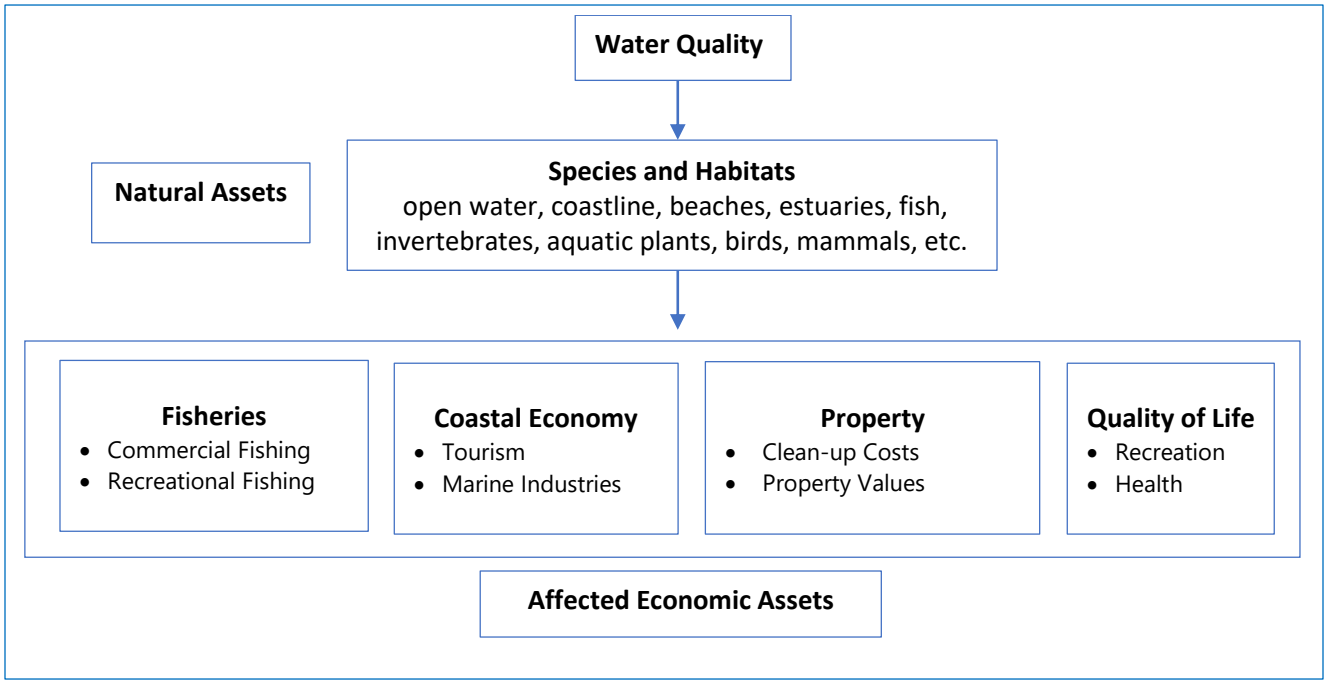


Figure 1-1: Natural and Economic Asset Classes Affected By Water Quality

1.2. Organization of Report

The analysis follows several steps that mirror the chapters and appendices in this report. The first step was to collate available information on these topics from previous researchers and local experts. This involved gathering literature on these subjects and compiling them into a database. Also important was to interview key stakeholders and people knowledgeable about water quality in the area. This information is summarized in Appendix B, "Previous Research and Information Gathered." A separate bibliographic database was also submitted that contains similar information. Appendix C further summarizes the economic values found in the literature review.

The next step in the process involved developing a description of the current natural and economic assets in the Study Area. Together, these pieces establish the baseline water conditions and the baseline economy for those sectors that are connected to water quality. Chapter 2 provides a baseline description of the natural assets in the three counties, and Chapter 3 establishes the baseline economic information related to the fisheries, the local economy, property, and the overall quality of life.

The literature and the baseline information combine in Chapter 4 to produce the resulting estimates of the economic consequences if a HAB like one that recently struck the region in 2018 were to take place again. This chapter lists how a similar event would impact the fisheries, the coastal economies, property, and the quality of life, itemizing the different kinds of economic losses for each at the county level and totaled for the entire region.

Because the large detrimental events like the red tides and blue green algal outbreaks are not independent of the chronic conditions, continued declines in water quality overall mean that the large detrimental events are expected to be more frequent and of longer duration in the future. Nutrient runoff, leaking septic systems, and releases from Lake Okeechobee are facilitating the recurrence of these events. Another overlapping concern is the changing climate and increasing frequency and intensity of hurricanes and in particular the ongoing recovery efforts from Hurricane Ian in 2022. Another force at work relates to rising sea levels and increased coastal development pressure on the aquifers that can lead to saltwater intrusion. These forces compound to paint a concerning picture about how declines in water quality present threats to the region, though there is still quite a bit of uncertainty about HABs and the degree to which each of these forces will combine. Chapter 5 addresses how the economic impacts of water quality in the context of these potentially cascading forces could play out, and how decision makers must include uncertainty in their investment in improved water quality in southwest Florida in order to strengthen the resilience of the local economy.

2. Study Area and Natural Assets

Below is a map of the Study Area highlighting the extensive coastline and other waterways within the Study Area. It is important to understand what coastal ecological systems exist in each county, in terms of both the quantity of these systems and quality so that we know what resources are at risk of HABs and other large detrimental water quality events.

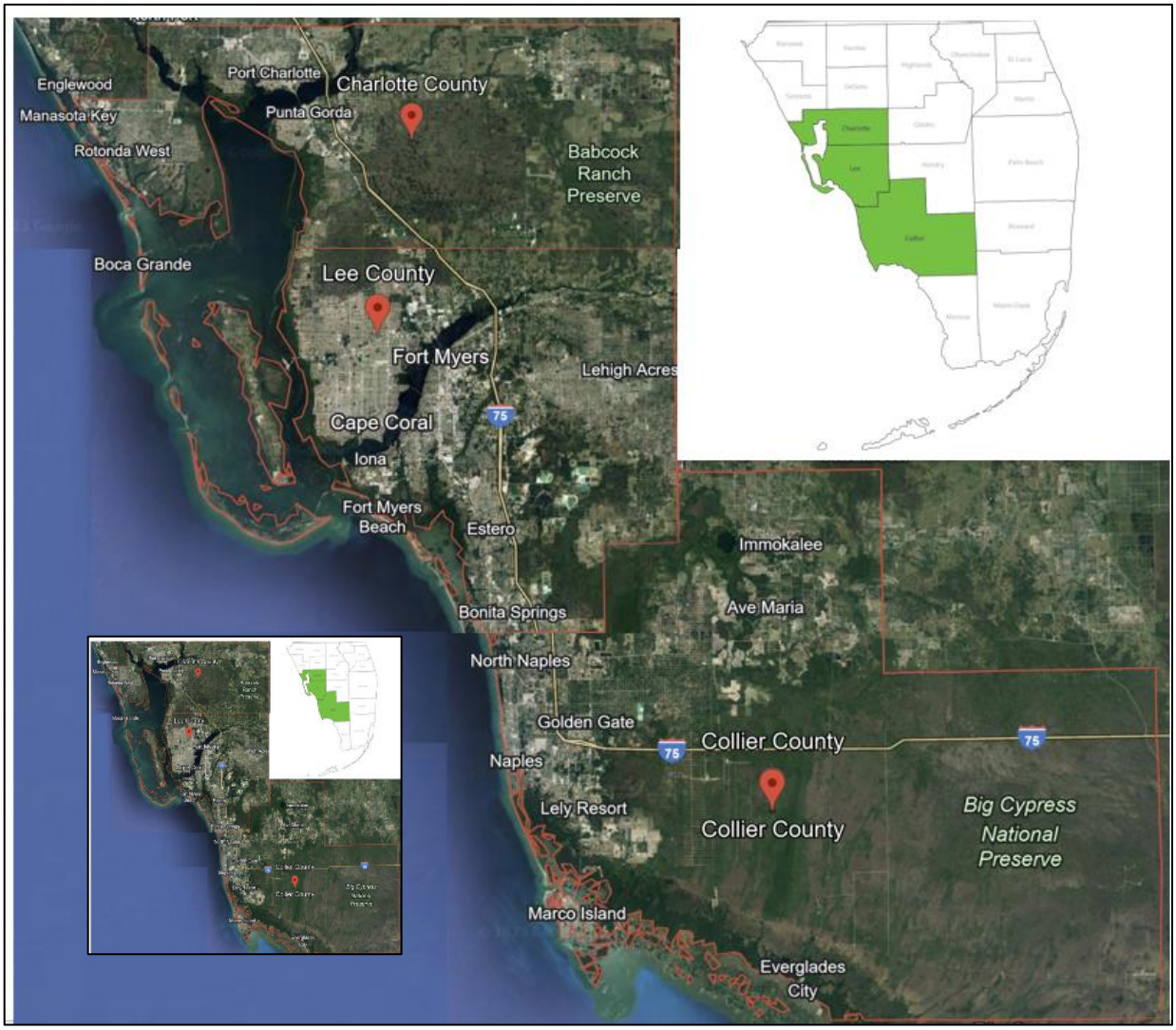


Figure 2-1: Study Area Map

The natural assets in the Study Area are elemental to this report as they are what generate the economic assets and values that are the subject of the report (see Figure 2-2 below). A summary of the natural assets in each county, with attention to water and water quality is provided below, and additional information is available in Appendix D, along with detailed maps of the water features in each county.

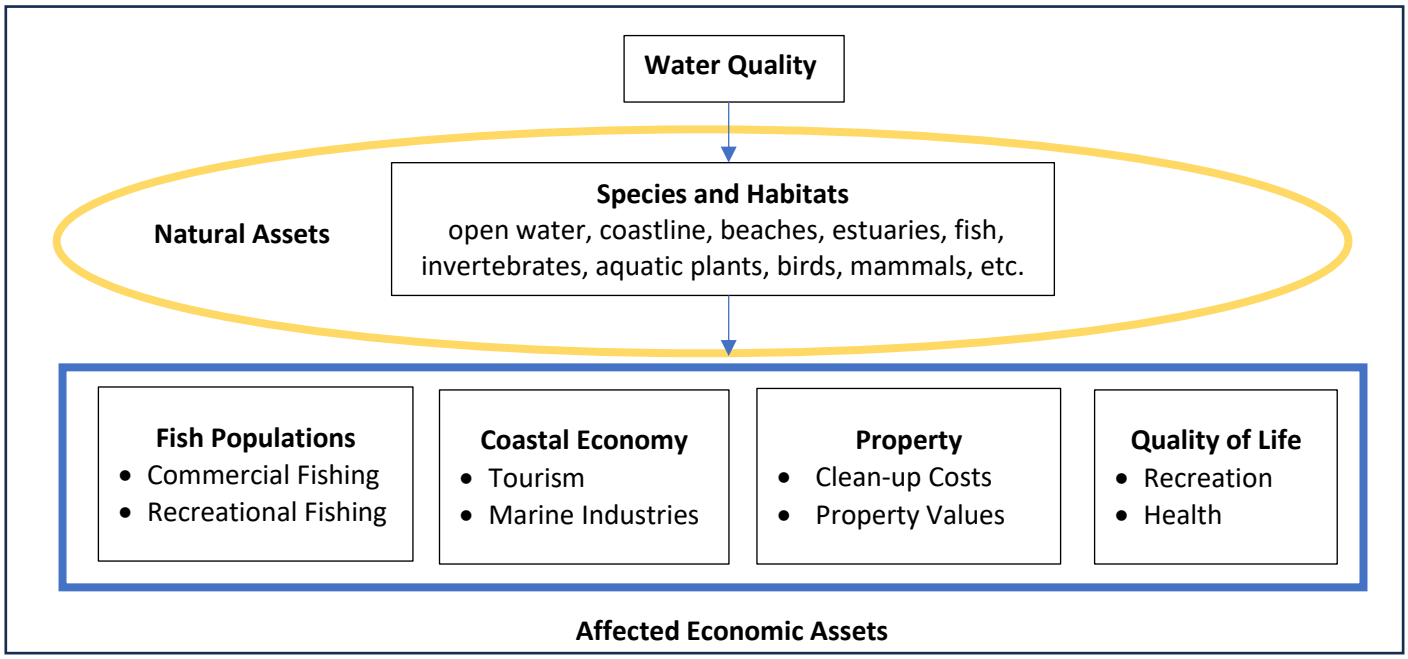


Figure 2-2: Natural Asset Classes Affected by Water Quality

2.1. Charlotte County

Charlotte County is the northernmost county in southwest Florida. The most prominent coastal water resource in Charlotte County is the upper half of Charlotte Harbor. The Peace and Myakka rivers, both significant in size, run through the county and empty into Charlotte Harbor before reaching the Gulf of Mexico. The coastal resources found in Charlotte County are summarized in Table 2-1.

Table 2-1: Charlotte County Coastal Resource Information

Coastal Resource	Description
Sandy Beaches	12 miles
Public Access Points	9
Coastal-Based State Parks and Lands	
In Charlotte County alone	Don Pedro Island State Park (230 acres), Stump Pass Beach State Park (227 acres)
In Charlotte and Sarasota County	Lemon Bay Aquatic Preserve (7,200 acres)
In Charlotte and Lee County	Cape Haze Aquatic Preserve (12,700 acres), Gasparilla Sound-Charlotte Harbor Aquatic Preserve (84,500 acres), Charlotte Harbor Preserve State Park (43,388 acres)
Bays and Inlets	Charlotte Harbor, Lemon Bay, Charlotte Bay
Rivers	Myakka River, Peace River, Trout Creek, Shell Creek

Table Source: Florida Department of Environmental Protection, Available here.

Good water quality is necessary to support diverse biota and local economies. While we know what coastal resources exist in Charlotte County, understanding their status and recent upward or downward

trends in water and habitat quality is essential as it allows us to better predict the future status of these resources and understand what events (chronic or independent) impact these resources. The Florida Department of Environmental Protection (FDEP) tracks the number of water bodies or segments, referred to as waterbody ID units (WBID) that do not meet standard water quality standards for all counties in Florida. From 2018 to 2019, the number of impairments remained consistent in Charlotte County, and the types of impairments (fecal bacteria, excess nutrients, metals, dissolved oxygen, and others) also remain fairly consistent, with 32 percent of WBIDs in the county found to be impaired. The trend shifted slightly downward through 2022, when 40 percent of the county's WBIDs were considered impaired.

2.2. Lee County

Lee County sits between Charlotte County and Collier County. Its coastline provides 47 miles of sandy beaches with over 100 access points. Lee County's entire coastline is protected by barrier islands. From north to south, Lee County is home to Gasparilla Island, Cayo Costa, North Captiva, Captiva Island, Sanibel Island, Fort Myers Beach, Estero Island, Big Hickory Island, and hundreds of smaller islands dispersed in-between. Sanibel Island is home to the J.N. "Ding" Darling National Wildlife Refuge. This refuge provides vital habitat for hundreds of bird species and has miles of mangrove forests that support an abundance of wildlife as well. Another critical water resource is the Caloosahatchee River, which connects to Lake Okeechobee in the center of the state and flows into the Gulf. This river plays an important role in the county for recreation and habitat for several important aquatic species such as snook, seatrout, crevalle jack and other economically important species including shellfish. The Caloosahatchee River and Gulf are greatly impacted by discharges from Lake Okeechobee. Table 2-2 summarizes the vast coastal resources found in Lee County.

Table 2-2: Lee County Coastal Resource Information

Coastal Resource	Description
Sandy Beaches	47 miles
Public Access Points	101
Coastal-Based State Parks and Lands	
In Lee County alone	Cayo Costa State Park (2,461 acres), Estero Bay Aquatic Preserve (13,800), Estero Bay Preserve State Park (11,381 acres), Gasparilla Island State Park (127 acres), Koreshan State Park (305 acres), Matlacha Pass Aquatic Preserve (14,600 acres), Pine Island Sound Aquatic Preserve (58,500 acres), J.N. "Ding" National Wildlife Refuge (7,600 acres), Lovers Key State Park (712 acres)
In Lee and Charlotte County	Cape Haze Aquatic Preserve (11,000 acres), Charlotte Harbor Preserve State Park (45,387 acres), Gasparilla Sound-Charlotte Harbor Aquatic Preserve (84,501 acres)
Bays and Inlets	Charlotte Bay, Estero Bay, San Carlos Bay
Rivers	Caloosahatchee River, Estero River, Hendry Creek

Table Source: Florida Department of Environmental Protection, Available here

As reported by the Calusa Waterkeeper Water Impairment report, Lee County had the greatest number of impaired water bodies/segments in 2019 and 2020 out of all three counties.[2] The county is also home to an estimated 100,000 septic tanks that are contributing to the large number of impairments related to fecal bacteria. Elevated fecal bacteria levels are responsible for approximately 31 impairments annually from 2018 to 2020, and account for the largest percentage of impairments from 2018 through 2022. If this trend continues, over half of all WBIDs in Lee County will not meet basic water quality standards, posing a serious threat to both wildlife and human use of these water resources.

"Slow chronic conditions are compounded by one time surge events…all the inland ponds on Sanibel used to be freshwater, provided habitat for migrating birds, now they are all salty and staying salty…"

Scientist

2.3. Collier County

Collier County is the southernmost county in the Study Area. The county boasts 48 miles of sandy beaches and has over 50 public access points. The southern half of the coast is protected by barrier islands. Ten-Thousand Islands National Wildlife Refuge and Everglades National Park include thousands of small mangrove islands that are publicly owned and protected for conservation. In addition, the Big Cypress National Preserve is also located in Collier County. The natural assets are summarized in Table 2-3 below.

Table 2-3: Collier County Coastal Resource Information

Coastal Resource	Description
Sandy Beaches	48 miles
Public Access Points	53
Coastal-Based State/Federal Parks and Lands	
In Collier County alone	Rookery Bay National Estuarine Research Reserve (110,559 acres), Ten Thousand Islands National Wildlife Refuge (26,605), Delnor-Wiggins Pass State Park (166 acres), Collier-Seminole State Park (7,271 acres), Fakahatchee Strand Preserve State Park (77,116 acres)
In Collier, Miami-Dade, and Monroe County	Everglades National Park (1,542,562 acres), Big Cypress National Preserve (729,000 acres)
Bays and Inlets	Addison Bay, Barfield Bay, Chokoloskee Bay, Clam Bay, Fakahatchee Bay, Goodland Bay, Gullivan Bay, Johnson Bay, Little Hickory Bay, Moorings Bay, Naples Bay, Pelican Bay, Rookery Bay, Tarpon Bay, Water Turkey Bay, Venetian Bay
Rivers	Barron River, Blackwater River, Cocohatchee River

Table Source: Florida Department of Environmental Protection, Available here.

As mentioned previously, the FDEP evaluates water quality with respect to the state water quality standards. In 2007, the Cocohatchee River and Estuary was determined to be impaired by fecal coliform bacteria, and iron.[3] This problem has persisted throughout the county due to the large quantity of septic systems. According to the Calusa Waterkeeper Water Impairment report, dissolved oxygen levels, metal

[2] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.
[3] O'Donnell, K., and Bailey, N. 2008. TMDL Report Fecal Coliform TMDL for the Cocohatchee River Estuary, WBID 3259A. August. Available here.

concentrations and fecal bacteria were the main impairments for water bodies in Collier County.[4] This changed in 2019 when excess nutrients became the most common impairment. Collier County has the fewest number of impaired bodies across all three years and the lowest percentage of impaired WBIDs by over 10 percent in 2022.

2.4. Water Trends Across the Three County Region

In general, water quality has been trending down across the southwest Florida region. Excess nutrients, metals, fecal bacteria, and low levels of dissolved oxygen are prominent issues. Poor water quality paired with other anthropogenic impacts have led to loss of seagrass, wetlands, mangroves, and oyster beds, all of which are critical pieces of local ecosystems. Hurricanes and HABs have increased in intensity and frequency, having longer lasting effects on coastal water resources as well. Climate change is only exacerbating the problem. It brings more storms, sea level rise and saltwater intrusion, compounding the negative impacts from the recent growth in human population and resulting increase in development. That being said, there are numerous restoration efforts both in action and planned throughout the region aimed at improving water quality and aquatic habitat for native wildlife. In specific areas this restoration work has made improvements on a small scale, but the overwhelming trend has remained negative.

The Conservancy of Southwest Florida released a report card for estuaries, rivers, and bays in the southwest Florida region in 2017. The Greater Charlotte Harbor and Ten Thousand Islands received the best grades with a C+ (Table 2-4). The majority of these water resources are so degraded that they were given D's and D-'s. In some cases over 50 percent of the watersheds containing these bodies of water are considered impaired under at least one parameter category. In fact, the Caloosahatchee River watershed was 94 percent impaired, with little aquatic vegetation left and frequent algae blooms. Ultimately, water quality is poor across the region.

Table 2-4: Southwest Florida Estuaries Water Quality Grades

Estuary	Greater Charlotte Harbor	Pine Island Sound	Caloosahatchee	Estero Bay	Wiggins Pass/ Cocohatchee	Naples Bay	Rookery Bay	Ten Thousand Islands
Grade	C+	D	D-	D	D-	D-	C	C+

Source: Conservancy of Southwest Florida. 2017. Estuaries Report Card: A Guide to Understanding the Health of Southwest Florida's Rivers, Estuaries and Bays. Available here.

[4] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.

3. Economic Assets and Approach to Measuring

Building from the natural assets in the Study Area, this chapter describes the economic assets in each of the Study Area counties that are potentially affected by water quality (see Figure 3-1). Fisheries are first described, then the broader coastal economy, then property, and then quality of life. For each asset class, an approach to measuring the economic asset provided, wherever possible borrowing strategies that have been used in the extensive previous research on water quality.

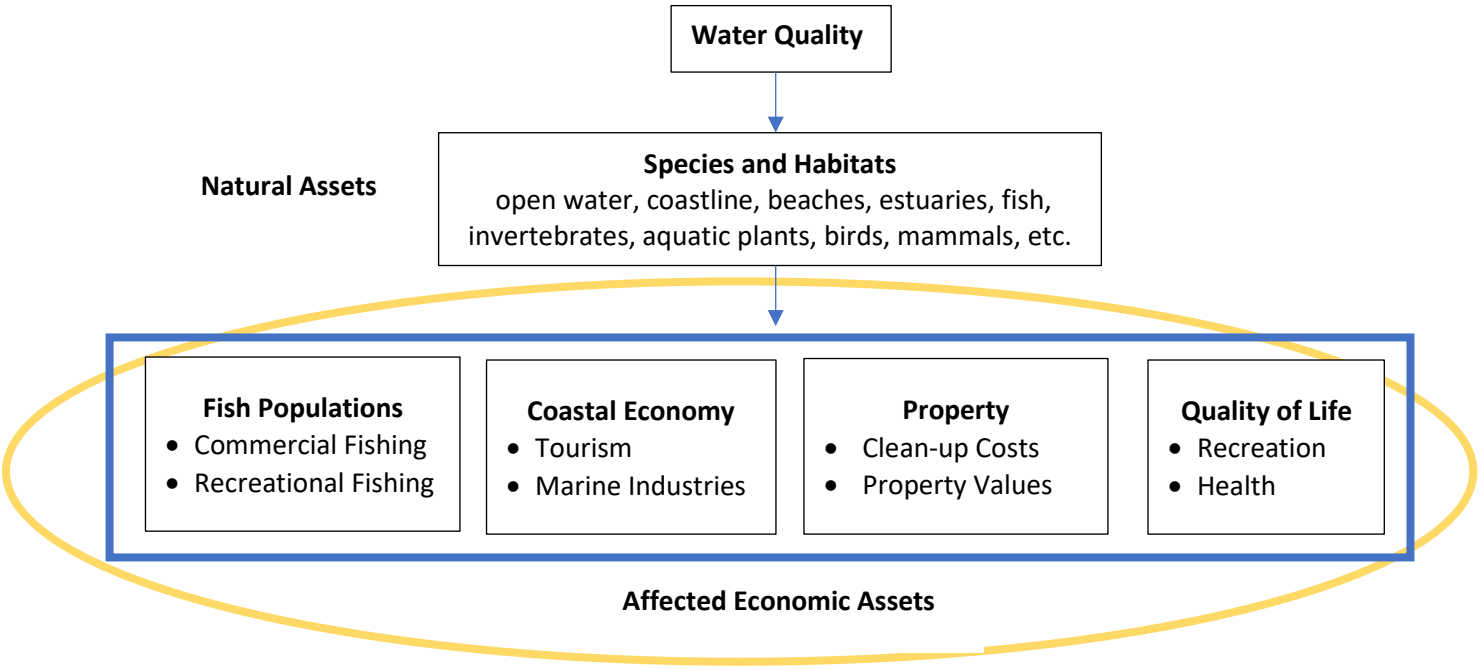


Figure 3-1: Economic Asset Classes Affected by Water Quality

3.1. Fisheries

"fish have feet… if they don't like the habitat they move"

Boat Captain

The unique habitat features of the Study Area have served as the home for a spectacular variety of aquatic species that provide food, recreation, and educational experiences for visitors and local populations. When discussing the issue of tourism and study area amenities at risk from water quality events, the first topic that people address is the fish population. The direct economic benefits of the fish stocks come from commercial fishing, which provides food for locals and distant consumers where the commercial products are shipped, and recreational fishing, which includes independent recreational anglers as well as charter boats. The status of each in economic terms is outlined below by county.

Commercial Fishing

The FWC collects landings data for all commercially harvested fish and invertebrate species through trip ticket collection dockside. Commercial landings data are available from 1986 through the present day 2023, though calendar year landings are not considered final until July of the following year. For this analysis, we looked at landings data from the year 2000 through 2022, the most recently finalized data year. The Commercial Fisheries Landings summaries include species, pounds caught, average price, and estimated value by year by county (county referring to the county in which the catch was brought in, not necessarily the county waters in which it was caught). We were particularly interested in the pounds caught and estimated dockside value for each species, and how these values changed both over time and vary by county.

The figures below highlight the change in total fish landed in each county over time and how the estimated dockside values have changed over the past 22 years. Figure 3-2 draws attention to the change in total tons of commercially caught fish and invertebrates landed in each county over the past 22 years. Lee County has consistently brought in the highest tonnage of fish, always more than the combined tonnage of that of Collier and Charlotte County. Though the county lands a significant number of fish, the overall weight of the annual commercial fishing bounty in 2022 was 35 percent less than it was it was in 2000. Charlotte County similarly experienced a 35 percent decline in tons of fish landed over the same time span. Collier County experienced an even greater decline, with 65 percent lower in landing tonnage over the past 22 years. Though Collier County brings in far less commercially harvested fish than Lee County, its 65 percent decrease is quite substantial, indicating some sort of major change in fish stock, commercial fishing interest, fishing policy, or landing location.

The total tonnage multiplied by dockside prices produces the total revenue or value for the commercial fisheries. Figure 3-3 shows the Lee County 22-year history looks a little different in terms of value, with a greater degree of up and down in the value deriving from price changes. In this graph, the dollar values are all shown in 2023 dollars and earlier years have been adjusted for inflation. There is an average decline of about 30 percent in overall value of commercial fishing between 2000 and 2022 across all three counties. Also, while Figure 3-2 shows that Collier and Charlotte Counties have similar weights of harvest throughout the period, the value of Collier County fish has remained higher than that of Charlotte throughout the period. Details of species and value histories for these fisheries is provided in Appendix E. Overall, these results indicate that the baseline commercial fishing economy is weaker than that of twenty years ago. In 2022, across all three counties, weight landed was between 35 and 65 percent less than it was in 2000. Estimated values for the top ten species in each county also showed a general trend in decline, minus a few outliers that were mostly due to increased demand rather than increased catch (See Appendix E).

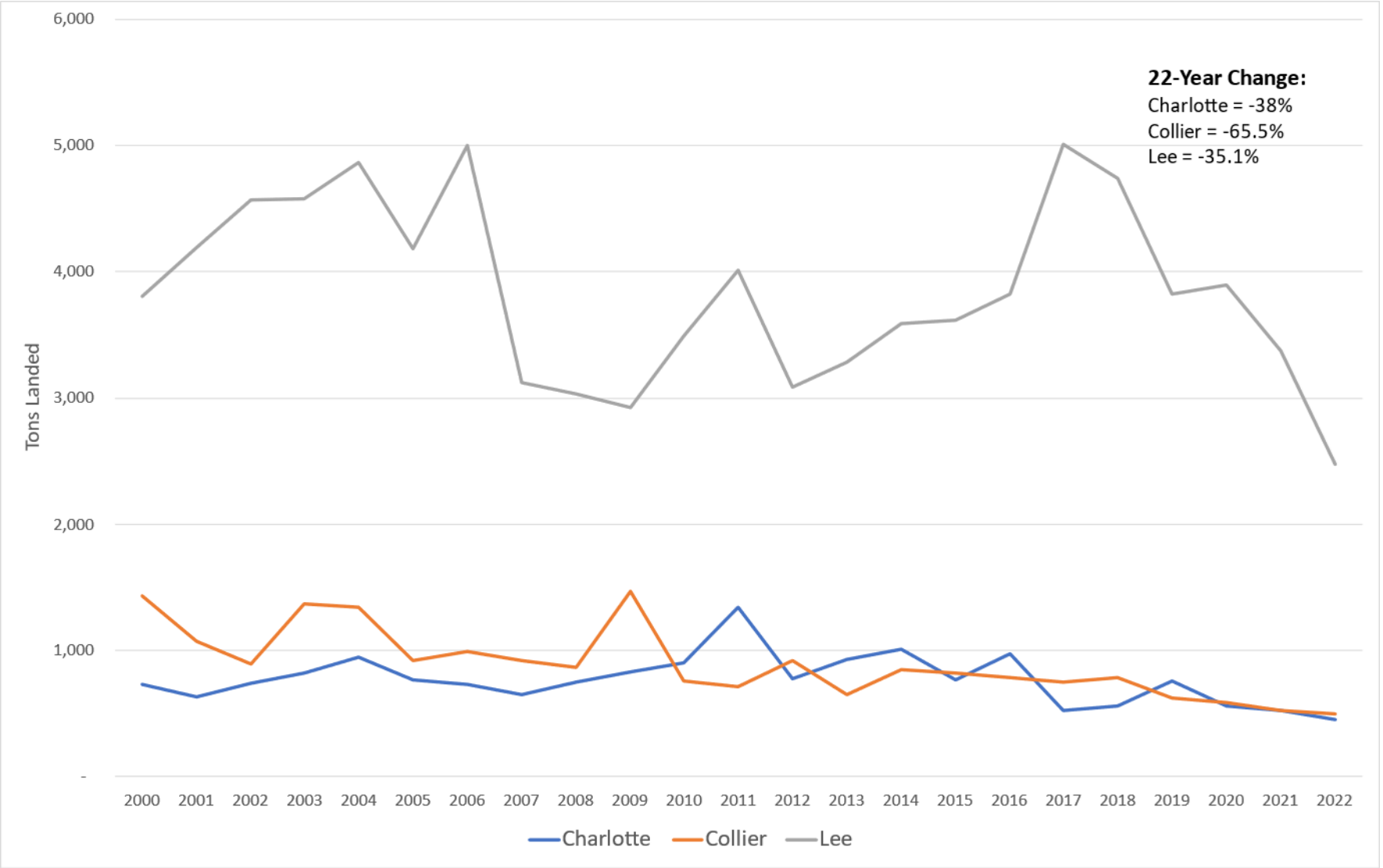


Figure 3-2: Total Tons Landed by County

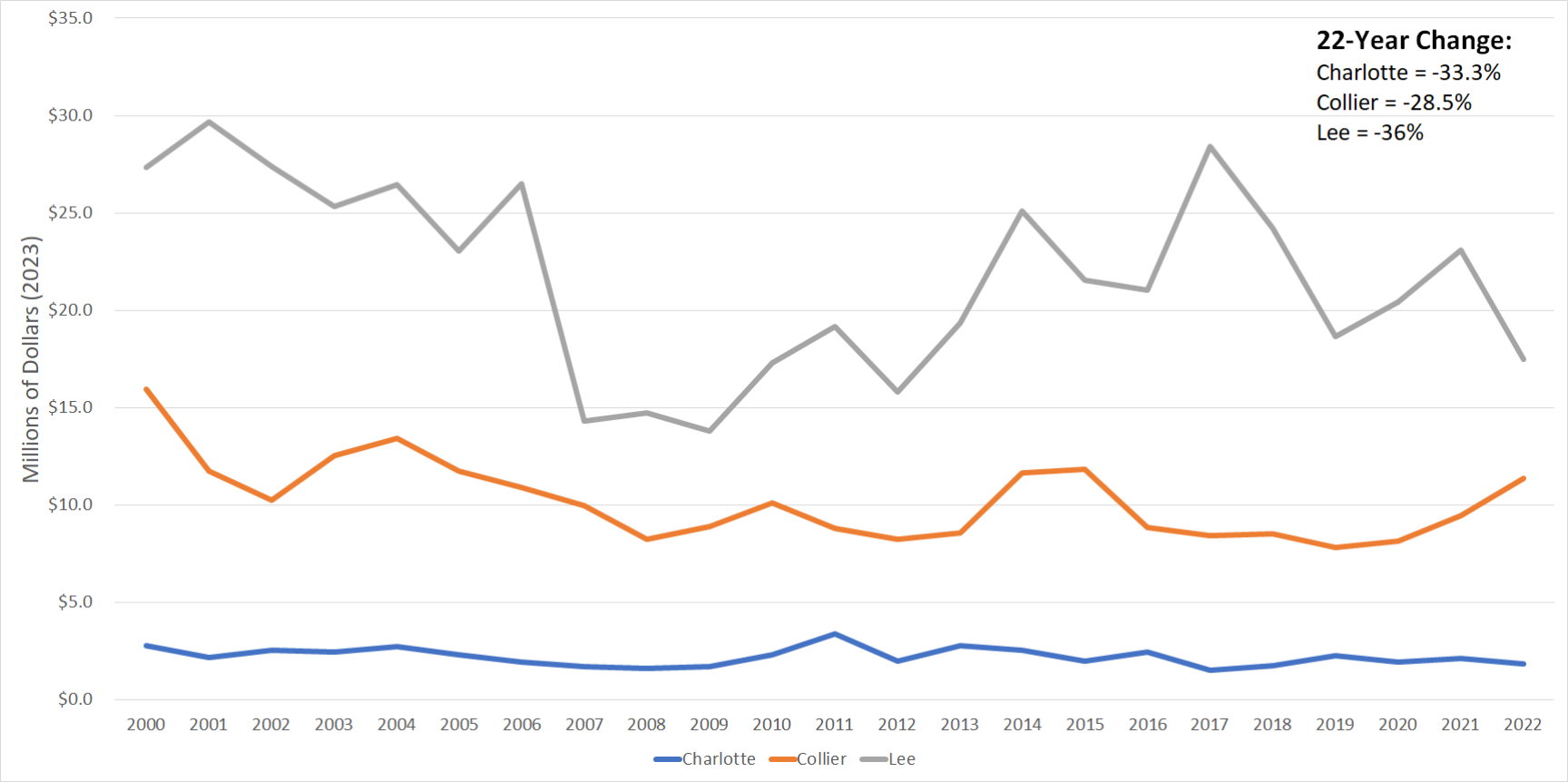


Figure 3-3: Study Area Value of Tons Landed in 2023 Dollars

Recreational Fishing

Another key consideration related to water quality and fisheries is the recreational fishery in the Study Area. Recreational fishing is a major part of life for anglers in southwest Florida, with at least 1.4 million residents and visitors taking over 13 million trips each year. The activity generates income in the economy because the people who fish spend money on their boats, bait, guides, licenses, food, and other provisions for their trips. Some specific fisheries are unique and exceptionally lucrative for local economies, as was mentioned in the review of literature (see Appendix B-1), such as tarpon fishing, which alone was found to generate over 63 million in annual revenue in the Study Area.[5] In addition to this, the anglers who spend money to fish only do so because they will receive the value of the experience, which exceeds the expenditures for the average trip. Hence recreational fishing provides this additional value, which is known as 'consumer surplus.' It is important to the recreationists but does not show up in the expenditures that go through markets. This 'non-market value' is detailed in the section titled "Quality of Life" below.

"In Homosassa and Boca Grande, tarpon fishing used to be a billion-dollar industry… just look at Port Aransas Texas to see the future, and it's grim"
Charter Boat Captain

There are a variety of different sources of information about the estimated participation and spending on recreational fishing in the Study Area. This section highlights some of this information including information on fishing licenses and expenditures with the intent to establish the baseline recreational fishery economy that is potentially at risk of further harm from poor water quality.

Fishing Licenses

The FWC requires all individuals taking or attempting to take native or nonnative freshwater fish to purchase a freshwater fishing license for those aged 17 and older. For saltwater fishing, individuals taking or attempting to take saltwater fish, crabs, clams, marine plants, or other saltwater organisms must have a saltwater fishing license. Like the freshwater permits, all saltwater fishing permits apply to the entire state of Florida regardless of where the resident or non-resident makes the purchase. In addition, specific saltwater fishing permits are needed for state reef fishing from a private vessel, shore-based shark fishing, snook fishing, spiny lobster catching, tarpon fishing, blue crab trapping, and stone crab trapping. These permits are required in addition to the saltwater fishing permit. Additionally, a Charter Captain or Boat license is required to take paying customers saltwater fishing. These permits cover charter boat passengers, meaning these individuals do not need to purchase an independent recreational saltwater fishing license.

The number and types of fishing licenses and permits purchased by residents of Charlotte, Collier, and Lee County tell something about the types of fishing most popular for residents. For freshwater fishing, Lee County (10,260) had more than the total combined number of active licenses in Charlotte (3,560) and Collier (5,369). As of September of 2023, there were 19,000 active recreational fishing permits owned by residents in the Study Area. The most popular permit across the counties was the annual freshwater permit followed by the freshwater/saltwater fishing combination permit and annual Gold Sportsman's permit. For almost every freshwater fishing license type, Lee County residents account for at least half of the region's residential permits purchasers. Though the permit purchaser may use their permit for

[5] Fedler, T. 2011. The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee River and Charlotte Harbor Region of Florida. Prepared for The Everglades Foundation. January. Available here.

freshwater fishing anywhere in the state, the large number of Lee County resident purchasers could be due to the large number of residents in the county who may use their permit in Lee County or any other county in the state.

The saltwater fishing licenses tell a similar story. Lee County residents account for over half of all residential permit holders in the Study Area (43,282), followed by Collier County (24,165) and then Charlotte County (14,331). Between charter boat captains and individual saltwater anglers, the region supports almost 82,000 residential saltwater permit holders. The most common saltwater fishing permit is the annual saltwater permit. The 5-year, lifetime and freshwater/saltwater fishing combination licenses are also popular across the board. Though fishing permit holders may use their permit anywhere in the state, recreational fishing clearly plays an important role in the southwest Florida economy based on the number of residents that participate in this activity. It is especially important in Lee County where the majority of residential saltwater and freshwater fishing licenses are purchased. Additional information about fishing licenses is available in Appendix F.

Participants and Expenditures

As mentioned above, in addition to understanding who, where, and which types of fishing are popular in the southwest Florida region, determining how much these anglers contribute to the local economy through expenditures is also important. As key players in the tourism industry, anglers contribute significantly to local economies through their spending on equipment, transportation, licenses, and potentially lodging. There is a broad variety of research about spending for different types of anglers, (e.g. tarpon anglers, charter boat fishing, visitors and residents, freshwater vs. saltwater fishing, etc.) and much of that is reviewed in Appendices B and C. The remainder of this section demonstrates the sources of information used to estimate the baseline numbers of fishing trips and participants and expenditures in the Study Area. This section includes significant values from the literature review, an explanation for the values chosen for our analysis, and the value of expenditures by west coast Florida anglers.

For the analysis of baseline, or the status quo of recreational fishing, the best available information was found in the FDEP Statewide Comprehensive Outdoor Recreation Plan (SCORP).[6] The SCORP is updated every five years. The 2019 SCORP for Florida and appendices include estimates for the number of participants, both resident and visitor, for various recreational activities in 2016, and the estimated expenditures made by participants annually. The FDEP distributes online public surveys, one for the general public and one for public recreation providers to inform demand for and supply for 35 outdoor recreational opportunities. Participation numbers are provided at the state and region level. Expenditures related to recreational activities are provided at the state, regional and county level.

The research team narrowed down the list of recreational activities to those that likely involve water resources either directly or indirectly. Information about water-related recreation that is not fishing is described more below in the next subsection titled, "Tourism and Other Recreation." The approach to estimating the numbers of participants for recreational fishing and expenditures is the same as the approach used in the Tourism and Recreation section. The SCORP provides total expenditures by each recreational activity, and the total number of participants for each activity in each county. To determine annual expenditures per person per recreational activity, we divided the expenditures per activity for the

[6] Florida Department of Environmental Protection. 2019. Outdoor Recreation in Florida 2019: Florida's Statewide Comprehensive Outdoor Recreation Plan. Division of Parks and Recreation. Available here.

southwest Florida region by the number of participants for that activity. The SCORP data are useful because they offer the numbers of both residential and visitor participants. The estimates of expenditure per participant for fishing recreational activities were updated from 2017 dollars to 2023 dollars using the Bureau of Labor Statistics Consumer Price Index.

Interpreting the SCORP data and updating the dollar values to 2023 dollars shows how Charlotte, Lee and Collier Counties experience expenditures for resident and visiting recreational fishing that total more than $1.4 billion per year. These expenditures become income and proprietor profits for the county economies and provide jobs for the county residents (See Figure 3-4 through 3-6).

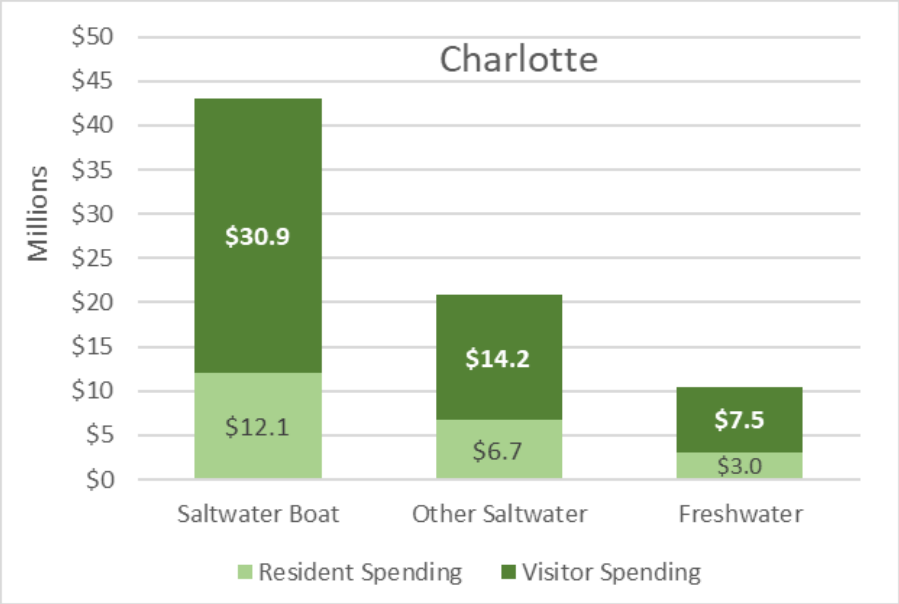


Figure 3-4: Annual Expenditures for Recreational Fishing in Charlotte County

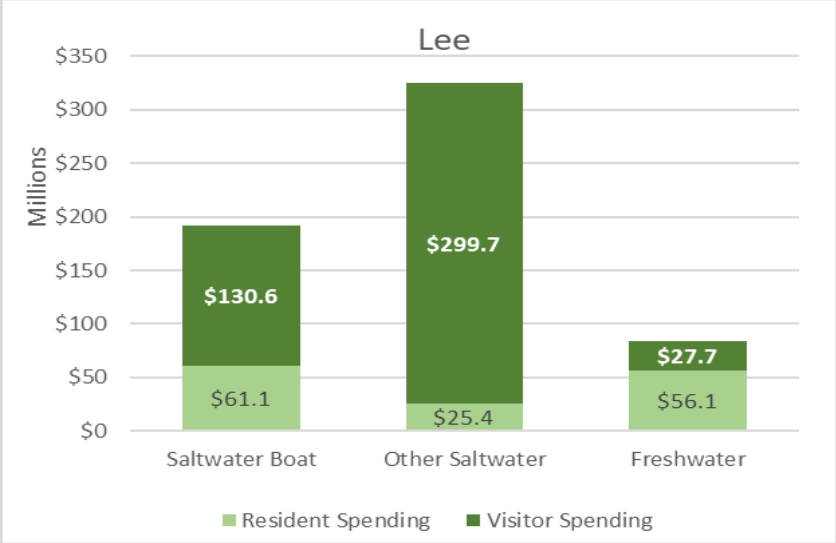


Figure 3-5: Annual Expenditures for Recreational Fishing in Lee County

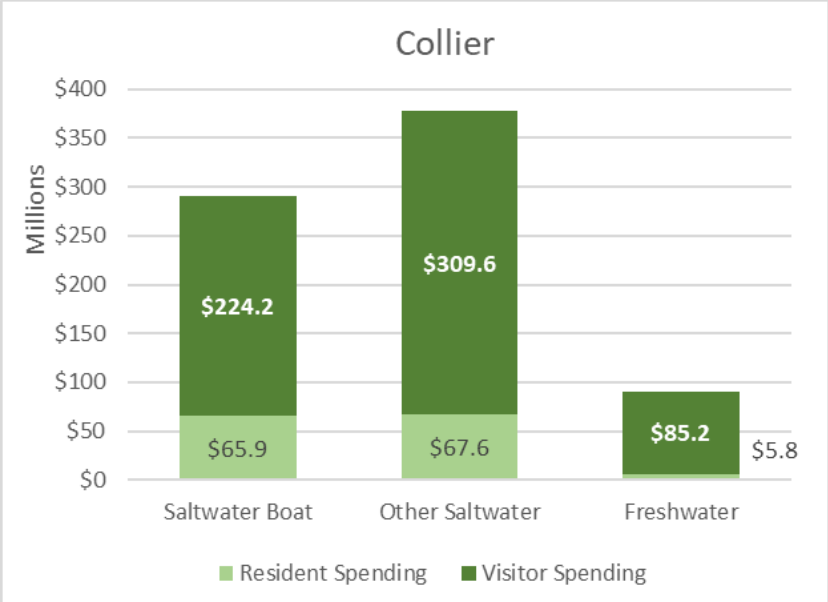


Figure 3-6: Annual Expenditures for Recreational Fishing in Collier County

The estimated numbers of participants each year (based on SCORP data for 2016) shows again that the visitors account for the majority of saltwater anglers in all counties and the majority of freshwater anglers in Charlotte and Collier Counties (see Figures 3-7 through 3-9). Together these figures demonstrate the importance of recreational fishing as an activity that strengthens the local economies of Study Area counties, attracting visitors and their associated spending from areas outside the Study Area.

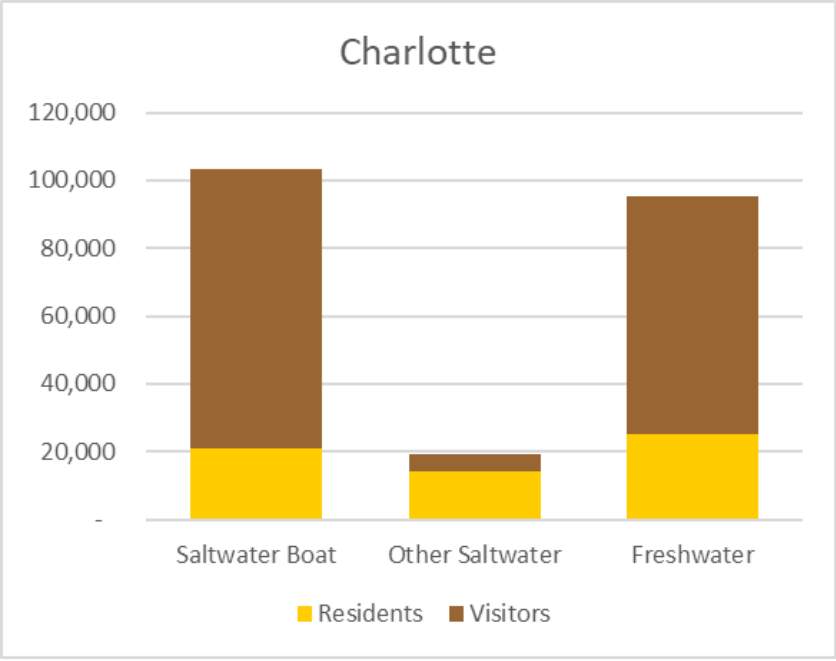


Figure 3-7: Annual Recreational Fishing Participants in Charlotte County

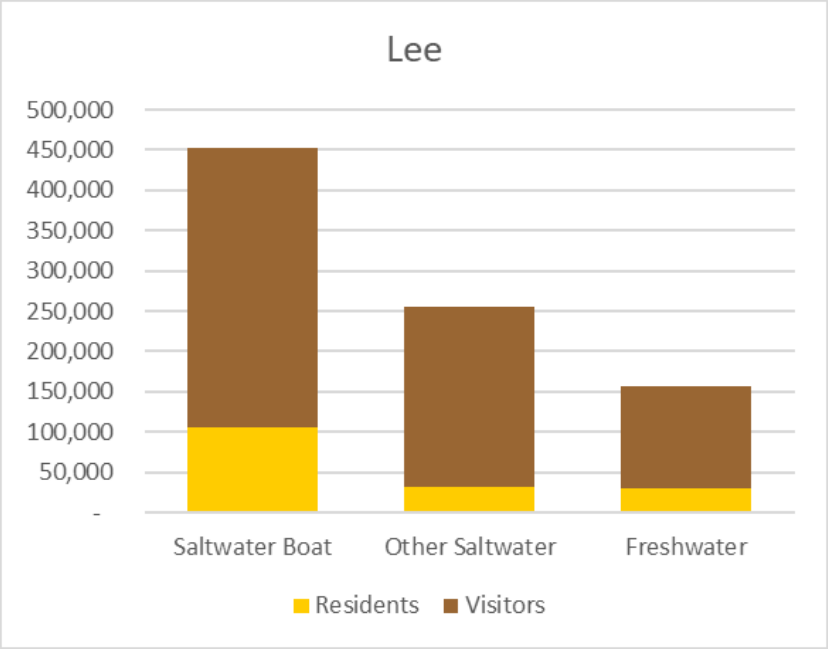


Figure 3-8: Annual Recreational Fishing Participants in Lee County

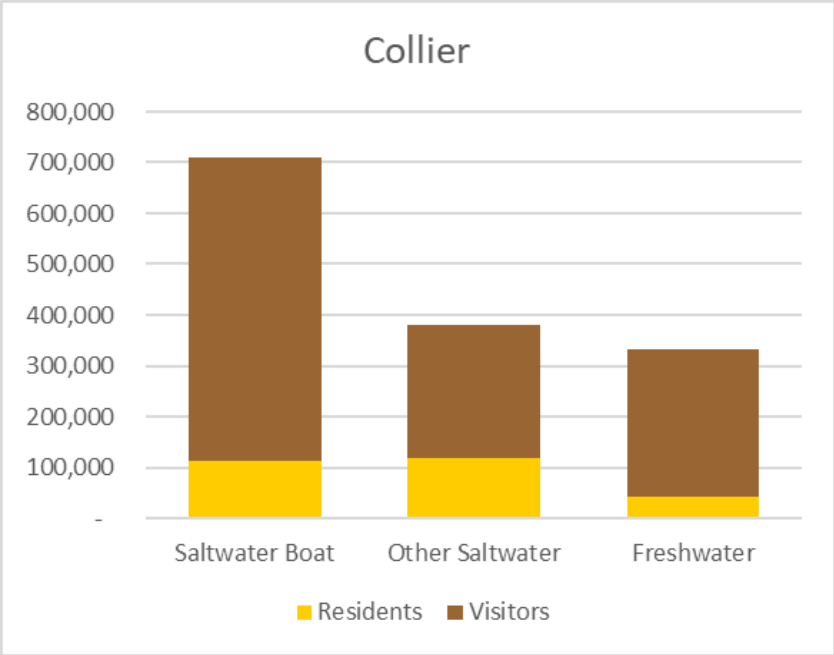


Figure 3-9: Annual Recreational Fishing Participants in Collier County

When using the SCORP recreational expenditure data, our analysis found that total recreational fishing expenditures are greater in Collier County than in Lee County, despite Lee County boasting twice the number of residents with fishing licenses. There are several reasons that can explain this discrepancy. For one, the FWC license data does not include tourist licenses because these licenses expire in one to seven days. Therefore, out of state recreational anglers are not accounted for in the licensing data and could be

far greater in Collier County than in Lee County. Also, though the FWC makes note of which county Floridians reside in when they purchase the license, this does not ensure these individuals are fishing in their home county. Some may travel from Lee County into Collier County to fish. In addition, the SCORP determines participant and expenditure data via a survey distributed every five years. These values could be imprecise, as the survey does not capture every angler in each county, but rather captures a rough picture of recreation participation and spending in each county. Finally, specific fishing opportunities like tarpon fishing could be stronger in Collier County, bringing more anglers to this county than the others. There is no definitive answer as to why recreational fishing expenditures are greater in Coller County than in Lee County, but there are several factors at play that likely contribute to this unexpected finding.

Additional details on the types of fishing activities and participation are covered in the next section on tourism and recreation, and again in the Quality-of-Life section.

3.2. Tourism and Other Recreation

Tourism generates a substantial portion of economic activity within the Study Area by attracting visitors to the coastline to enjoy the weather, enjoy the natural beauty of the area, and participate in the water-related recreation. This section first provides an overview of Study Area tourism in general, describes the economic implications of tourism, and addresses the other types of recreation that are related to water and potentially at risk of decline with a HAB or continued degradations of water quality.

> *"Visitors come, but if they don't have a nice time, they go somewhere else. The golden goose is not going to be golden forever- we need to start doing things differently."*
>
> *Scientist*

Tourism

Southwest Florida is a tourist destination for in-state, domestic and international visitors alike. The recreational opportunities, especially those connected to the expansive water resources, draw in tourists from around the world. The Visitors and Convention Bureaus for Charlotte, Collier, and Lee County are focused on maintaining and building year-round tourism in their respective counties. To track and report on their success, the bureaus create visitor tracking, occupancy, and economic impact studies monthly, quarterly, and annually. Each county had a complete total annual visitor estimate for 2022 and a partially completed estimate for 2023. We used tourist values from the 2022 reports to estimate the remaining portion of unknown tourist values in 2023. For example, we did not have estimates for the last quarter of 2023 in Charlotte County. To estimate the unknown visitors, we determined the percentage of tourists that visited in the last quarter of 2022 and used this percentage to estimate the number of tourists likely to visit in the last quarter of 2023 (see Table 3-1).

Over 8.4 million visitors are expected to visit the Study Area this year. Almost 60 percent of the visitors travel to Lee County (5.1 million), followed by Collier County (2.5 million), and then Charlotte County (1.0 million).

Table 3-1: Estimated Number of Visitors in 2023 by County

County	Visitors in 2023
Charlotte	1,041,653
Lee	5,104,345
Collier	2,524,359
TOTAL	**8,400,356**

Sources: The Beaches of Fort Myers and Sanibel Visitors and Convention Bureau. Quarterly Visitor Profile Reports. Available here. Naples, Marco Island, Everglades Convention and Visitors Bureau. Visitor Statistics. Available here. Punta Gorda, Englewood Beach Convention and Visitors Bureau. The Punta Gorda/Englewood Beach Research. Available here.

Rockport Analytics analyzed tourist expenditures in the state of Florida in 2019 and 2021. Using Florida visitor volumes and spending estimates, they determined the average visitor spending/trip for both domestic and international visitors. The results are included in Table 3-2 below. The 2019 expenditures are less than the 2021 expenditures due to a slowing economy and a reduction in state funding for tourism marketing. The 2021 results are more indicative of the current economy which has begun to bounce back from this setback.

Table 3-2: Tourist Expenditures Across Florida (in 2023-dollar value)

	2019 Expenditures	2021 Expenditures
Average Visitor Spending/Trip	$817	$878
Domestic Visitor Spending/Trip	$750	$860
International Visitor Spending/Trip	$1,430	$1,394
Total Visitor Spending	**$119.0 billion**	**$119.4 billion**

Source: Rockport Analytics. 2019. Florida's Tourism Economy Experiences Another Record Year in 2019 But Shifts into a Lower Gear of Growth: 2019 contribution of Travel and Tourism to the Florida Economy. Available here. Rockport Analytics. 2022. Travel and Tourism Makes a Convincing Recovery From the COVID-19 Pandemic: The 2021 Economic and Fiscal Impact of Tourism in Florida. Prepared for VISIT FLORIDA. Available here.

Assuming that visitors in each county make at least one trip per year, expenditures in each county were estimated by multiplying the number of visitors by the average spending per visitor assuming visitors make one trip per year.

Table 3-3: Estimated Annual Visitor Expenditures by County in 2023

County	Total Annual Expenditures by Visitors in 2023
Charlotte	$914,600,000
Collier	$2,216,400,000
Lee	$4,481,600,000
TOTAL	**$7,376,000,000**

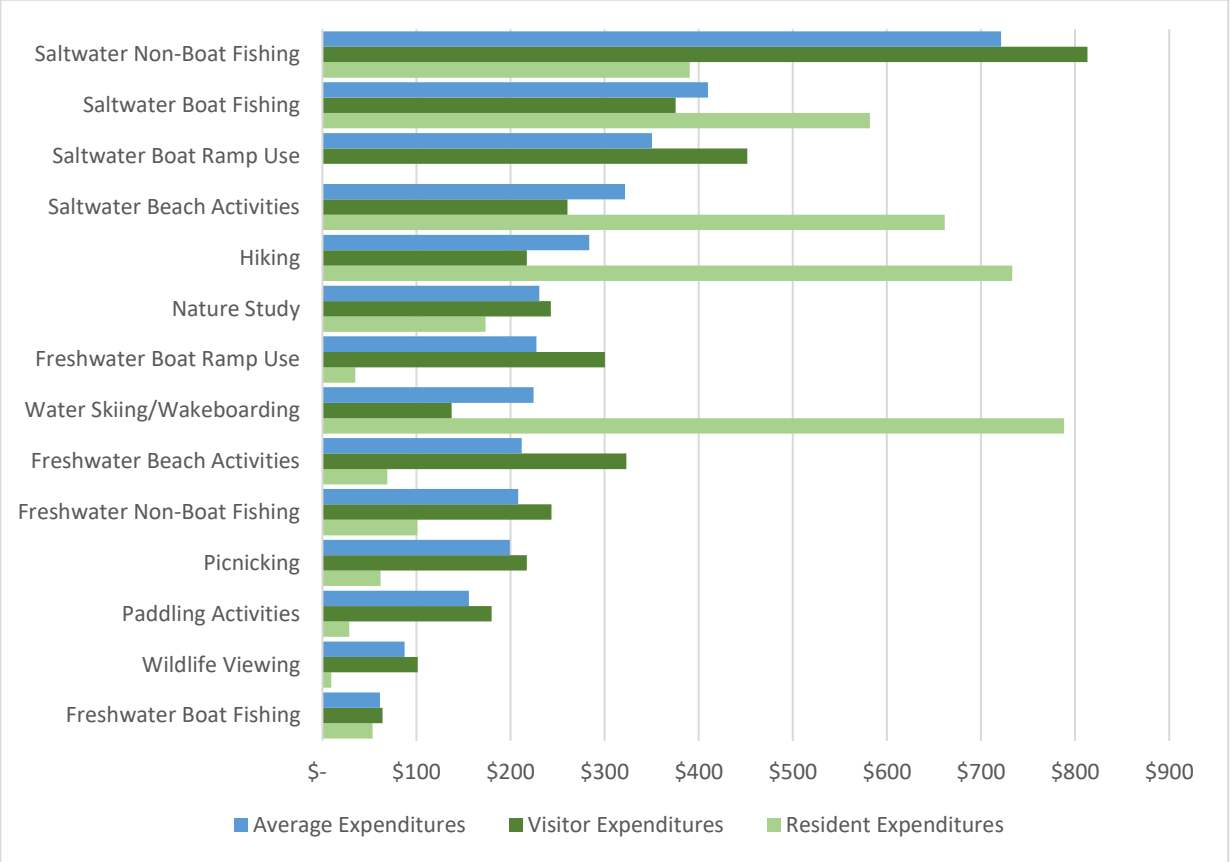
Other Recreation

> *All the famous things hook you, as you live here and spend time, over a decade, experience it, see the news, then you start to then become concerned and get involved"*
> *Realtor, General Contractor*

The FDEP produces a SCORP[7] every five years. Florida's 2019 SCORP and appendices include estimates for the number of participants, both resident and visitor, for various recreational activities in 2016, and the estimated expenditures made by participants annually. For this report, we narrowed down the list of recreational activities to those that likely involve water resources either directly or indirectly. For example, hiking and nature study do not require water features, but the majority of hikes and wildlife viewing are centered around the numerous water-based ecosystems in southwest Florida. To determine annual expenditures per person per recreational activity, we divided the expenditures per activity for the southwest Florida region by the number of participants for that activity in southwest Florida by residents, visitors, and total recreational participants. This value was then updated from 2017 dollars to 2023 dollars using the Bureau of Labor Statistics Consumer Price Index.

Figure 3-10 below includes the annual expenditures on recreational activities per person in the southwest Florida region by resident, visitor, and total participants. Saltwater non-boat fishing has the highest average expenditure per participant ($721) and the highest expenditure per visitor participant ($813). Residents spend the most money on water skiing and wakeboarding activities ($788), followed by hiking ($733) and saltwater beach activities ($661). Recreational participants spend the least on freshwater boat fishing and wildlife viewing activities. Interestingly, recreational participants spend an average of 6.5 times more on saltwater boat fishing than freshwater boat fishing and almost 3.5 times more for saltwater non-boat fishing than freshwater non-boat fishing. The difference between fresh and saltwater expenditures for all participants is far less for beach use and boat ramp use.

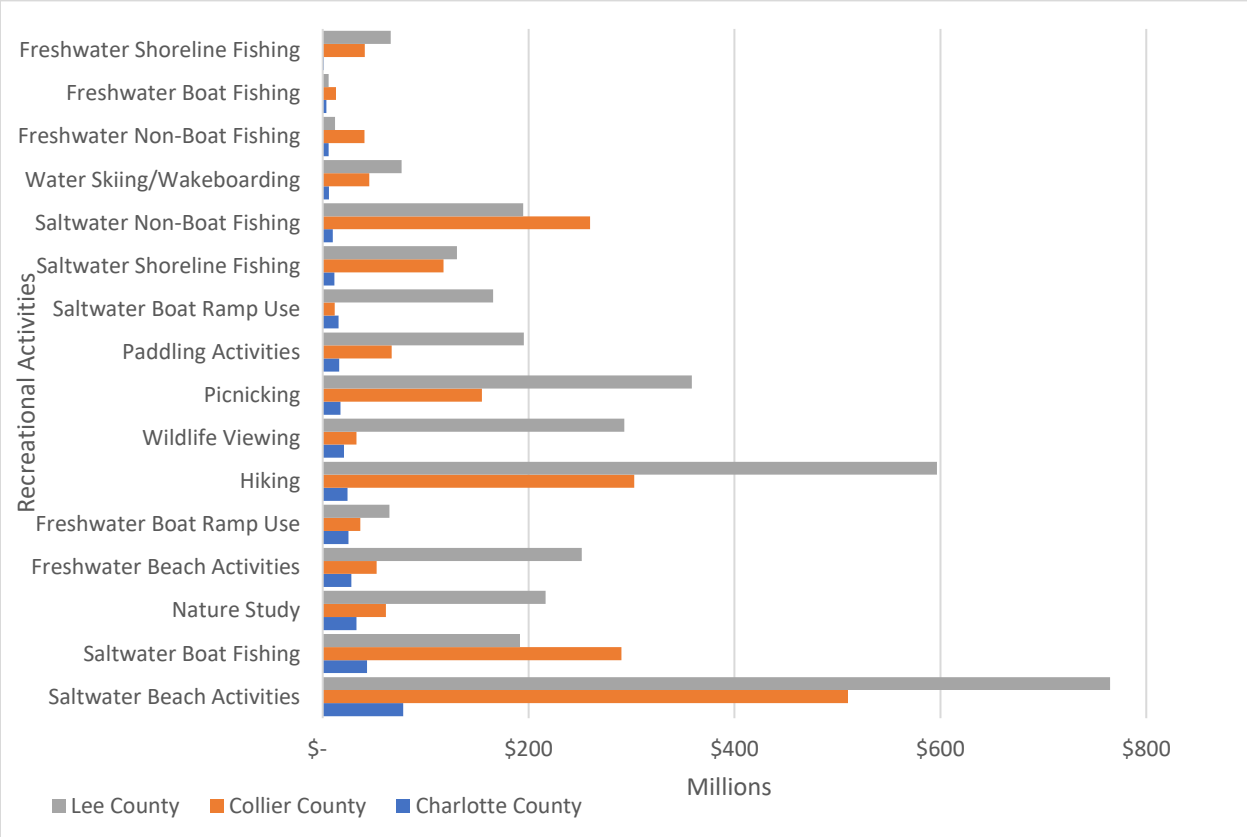
[7] Florida Department of Environmental Protection. 2019. Outdoor Recreation in Florida 2019: Florida's Statewide Comprehensive Outdoor Recreation Plan. Division of Parks and Recreation. Available here.



Note: The two shoreline fishing activities are left blank due to lack of participant data.

Figure 3-10: Annual Expenditures on Recreational Activities Per Person for SW Florida Region (in 2023 dollars)

Though saltwater non-boat fishing had the greatest annual expenditures per participant, it is not the greatest contributor to total recreational expenditures in Charlotte, Collier, or Lee County. As seen in Figure 3-11 below, saltwater beach activities is the greatest contributor to total recreational expenditures across all three counties. In Lee County (Figure 3-12 and Table 3-4), this activity is followed by hiking, picnicking, and wildlife viewing. In Charlotte County, (Figure 3-13 and Table 3-5) saltwater beach activities are followed by saltwater boat fishing, nature study and freshwater beach activities. In Collier County, (Figure 3-14 and Table 3-6) saltwater beach activities are followed by hiking, saltwater boat fishing, and saltwater non-boat fishing.



Note: The two shoreline fishing activities are left blank due to lack of participant data.

Figure 3-11: Total Expenditures on Recreational Activities by County

Charlotte County

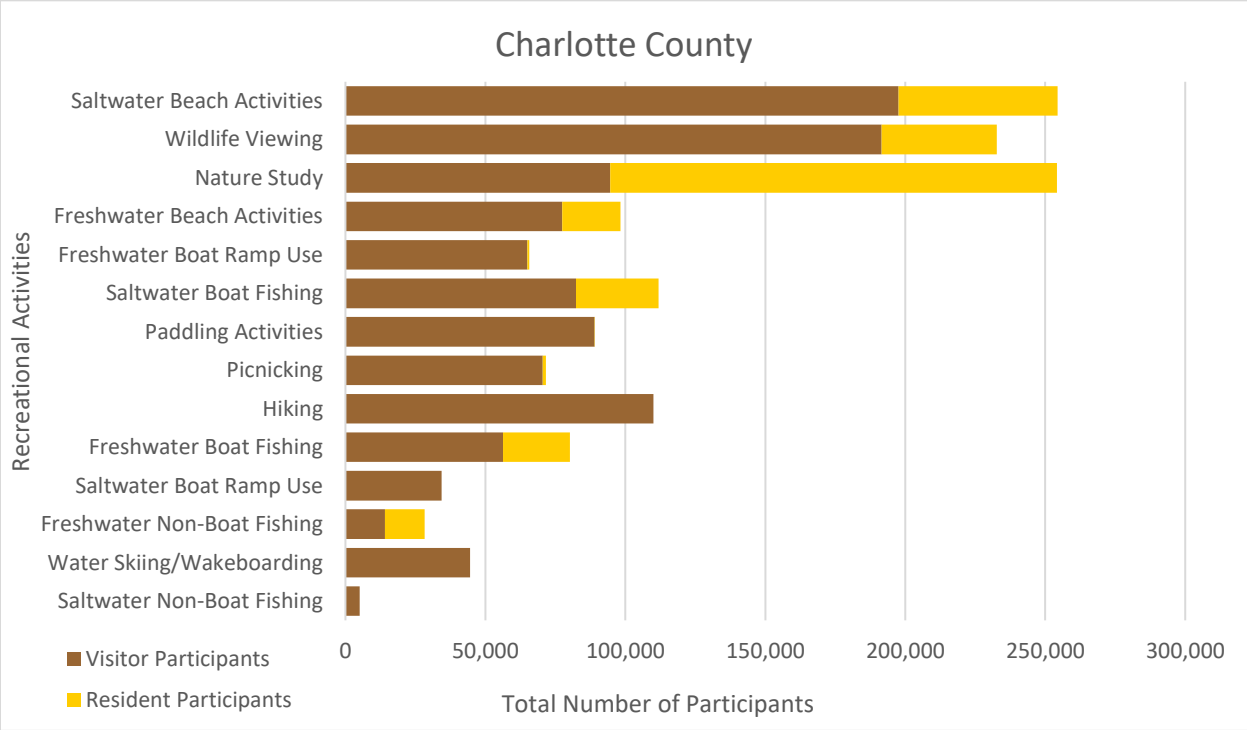


Figure 3-12: Recreational Participants in 2016 in Charlotte County

Table 3-4: Estimated Resident and Visitor Annual Spending on Recreation

Activity	Resident Spending	Visitor Spending	Total Spending
Saltwater Beach Activities	$26,857,149	$51,463,242	$78,320,392
Saltwater Boat Fishing	$12,112,292	$30,929,718	$43,042,010
Nature Study	$9,870,980	$22,967,501	$32,838,480
Freshwater Beach Activities	$2,845,896	$24,998,641	$27,844,537
Freshwater Boat Ramp Use	$5,583,894	$19,530,188	$25,114,082
Hiking	$120,848	$23,914,515	$24,035,364
Wildlife Viewing	$1,342,093	$19,370,757	$20,712,850
Picnicking	$1,825,676	$15,321,233	$17,146,909
Paddling Activities	$18,585	$16,007,458	$16,026,043
Saltwater Boat Ramp Use	NA	$15,492,157	$15,492,157
Saltwater Shoreline Fishing	$1,196,213	$10,038,953	$11,235,165
Saltwater Non-Boat Fishing	$5,532,816	$4,134,172	$9,666,988
Water Skiing/Wakeboarding	NA	$6,122,116	$6,122,116
Freshwater Non-Boat Fishing	$2,417,038	$3,443,690	$5,860,727
Freshwater Boat Fishing	$62,016	$3,587,177	$3,649,193
Freshwater Shoreline Fishing	$562,209	$430,461	$992,671
TOTAL	**$70,347,705**	**$267,751,979**	**$338,099,686**

Lee County

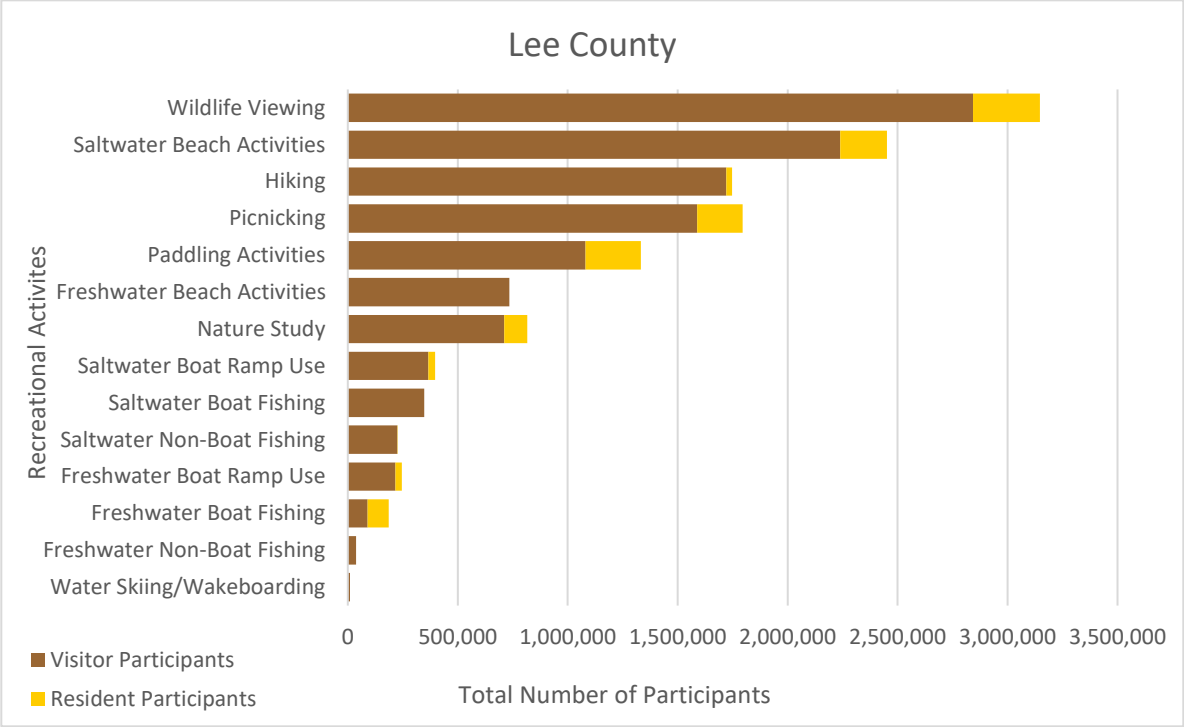


Figure 3-13: Recreational Participants in 2016 in Lee County

Table 3-5: Recreational Expenditures in Lee County in 2016 (2023 Dollars)

Activity	Resident Spending	Visitor Spending	Total Spending
Saltwater Beach Activities	$181,356,943	$583,408,060	$764,765,002
Saltwater Boat Fishing	$61,094,006	$130,577,538	$191,671,545
Nature Study	$43,709,074	$172,682,633	$216,391,707
Freshwater Beach Activities	$14,266,170	$237,361,621	$251,627,791
Freshwater Boat Ramp Use	NA	$64,858,652	$64,858,652
Hiking	$222,769,244	$373,994,818	$596,764,061
Wildlife Viewing	$5,566,344	$287,462,171	$293,028,514
Picnicking	$13,094,377	$345,365,265	$358,459,643
Paddling Activities	$766,792	$194,575,957	$195,342,749
Saltwater Boat Ramp Use	NA	$165,457,986	$165,457,986
Saltwater Shoreline Fishing	$13,165,766	$117,134,569	$130,300,336
Saltwater Non-Boat Fishing	$12,214,269	$182,557,978	$194,772,246
Water Skiing/Wakeboarding	$75,153,306	$1,437,311	$76,590,617
Freshwater Non-Boat Fishing	$3,067,169	$8,983,193	$12,050,362
Freshwater Boat Fishing	$852	$5,749,244	$5,750,096
Freshwater Shoreline Fishing	$53,055,887	$12,935,798	$65,991,685
TOTAL	$699,280,198	$2,884,542,796	$3,583,822,993

Collier County

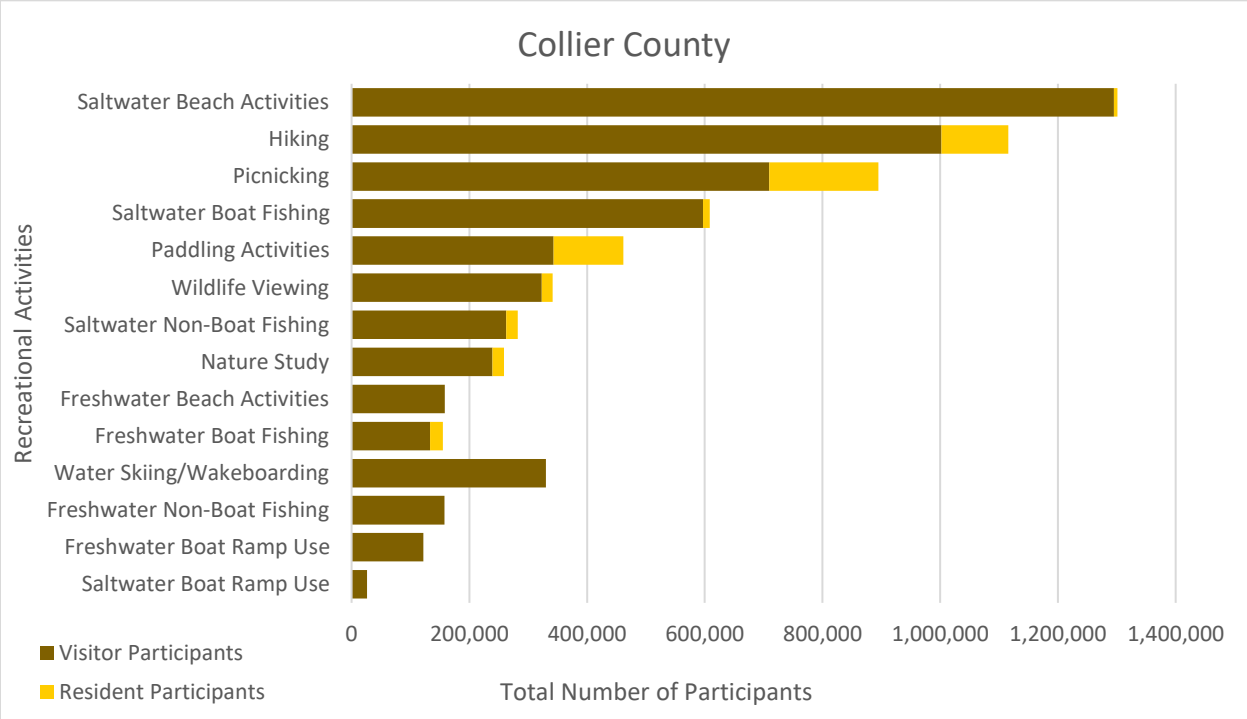


Figure 3-14: Recreational Participants in 2016 in Collier County

Table 3-6: Recreational Expenditures in Collier County (in 2023 Dollars)

Activity	Resident Spending	Visitor Spending	Total Spending
Saltwater Beach Activities	$172,997,970	$337,374,149	$510,372,119
Saltwater Boat Fishing	$65,928,972	$224,221,716	$290,150,688
Nature Study	$3,237,825	$58,058,325	$61,296,150
Freshwater Beach Activities	$1,372,813	$51,103,421	$52,476,234
Freshwater Boat Ramp Use	NA	$36,588,840	$36,588,840
Hiking	$84,873,589	$217,809,435	$302,683,024
Wildlife Viewing	$107,628	$32,657,808	$32,765,437
Picnicking	$375,876	$154,249,825	$154,625,701
Paddling Activities	$5,273,797	$61,743,668	$67,017,465
Saltwater Boat Ramp Use	NA	$11,736,050	$11,736,050
Saltwater Shoreline Fishing	$21,336,937	$96,126,184	$117,463,121
Saltwater Non-Boat Fishing	$46,289,326	$213,454,366	$259,743,692
Water Skiing/Wakeboarding	NA	$45,358,066	$45,358,066
Freshwater Non-Boat Fishing	$2,167,085	$38,327,566	$40,494,651
Freshwater Boat Fishing	$1,055,419	$8,504,652	$13,016,521
Freshwater Shoreline Fishing	$2,530,369	$38,327,566	$40,857,934
TOTAL	**$407,547,604**	**$1,625,641,637**	**$2,036,645,691**

3.3. Coastal Economy

The entire coastal economy in the Study Area is related to the water and coastline, but not all of the economy in the counties is strictly tied to the coast. For the purpose of exploring the portion of the local county economies that is potentially affected by detrimental water quality events, there are several approaches to consider. In this section we will describe data sources that address the coastal economies in terms of jobs and economic output. Different data sources from the National Oceanic and Atmospheric Administration (NOAA, and from IMPLAN will be used in the analysis to estimate the potential impacts of water quality on the local economies. The first approach is to consider the specific economic sectors that are potentially directly affected by water quality and establish those as a way to further explore how an impact in those sectors has a potential 'ripple effect' through the rest of the economies.

Many have suggested that the direct sectors do not include the fact that nearly the entire economy of a coastal county is based on the coastline. A second approach using a different data set explores all the sectors of the economy that are located within any of the zip codes that have coastal property. This approach is analyzed in Appendix G as a point of comparison.

Sectors Directly Related to Water

The Economics: National Ocean Watch (ENOW data are produced by NOAA Office of Coastal Management. The data focuses on the six economic sectors that are dependent on the oceans and Great Lakes. ENOW provides data for about 400 counties, 30 coastal states, 8 regions, and the nation. The ENOW data set captures economic indicators in six marine-dependent sectors at the national, regional, state, and county levels, which are laid out in the Table 3-7 below.

Table 3-7: Economic Indicators in Six Marine-Dependent Sectors

	Sector	Industry
1	Living Resources	Fishing; Fish Hatcheries and Aquaculture; Seafood Processing; Seafood Markets
2	Offshore Mineral Extraction	Limestone, Sand and Gravel; Oil and Gas Exploration and Product
3	Marine Transportation	Deep Sea Freight; Marine Passenger Transportation; Marine Transportation Services; Search and Navigation Equipment; Warehousing
4	Marine Construction	Marine Related Construction
5	Ship and Boat Building	Ship Building and Repair; Boat Building and Repair
6	Tourism and Recreation	Zoos and Aquaria; Boat Dealers; Eating and Drinking Places; Hotels and Lodging Places; Marinas; RV Parks and Campgrounds; Scenic Water Tours; Sporting Goods Manufacturing; Amusement and Recreation Services

ENOW data totals for business establishments, employment, and wages are based on the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) data. ENOW totals for gross domestic product (GDP) are based on the Bureau of Economic Analysis' GDP-by-state statistics. Though ENOW includes direct employment, wage, and GDP, it does not measure the indirect and induced impact economic activity within these sectors provide the greater county economy. To determine this, we used the regional economic input-output model called IMPLAN.

IMPLAN

IMPLAN reports economic contributions at three levels: (1) direct effects, (2) indirect effects, and (3) induced effects. The sum of the three different impacts represents the total impact of a change on the local economy. The input-output model results indicate how spending in one sector of a regional economy creates additional employment, income, and output in other sectors. Each of the three types of impacts is described briefly below.

- **Direct impacts** measure the total amount of economic activity in terms of the monetary value and employment that are brought into the local economy (or lost in the local economy) directly from the activity in that sector.
- **Indirect impacts** measure the response of local industries to the increased demand from the direct impacts.
- **Induced impacts** measure the change in spending resulting from changes in household income generated from direct and indirect impacts.

To study these economic "ripple effects" of the industries directly related to water, we matched the IMPLAN codes to the NAICS codes which are included in the ENOW data (as defined by ENOW). We included the IMPLAN sectors with the NAICS which are included in ENOW to be consistent between data sets. A crosswalk table between the two datasets is included in Appendix G. The IMPLAN data assessed is from 2021. IMPLAN data is expected to be larger than any of the ENOW sectors for all variables because the IMPLAN sectors are much broader than ENOW/NAICS, as most include several NAICS codes (unlike the ENOW data). Also, the ENOW data attempts to exclude businesses that are not coastal.

For this analysis, we are looking at employment and output. Employment is the number of jobs on an annual average basis, including full-time, part-time, and seasonal, in each of the sectors. This is not the same as full-time equivalents, and it does not measure the number of employed persons, only jobs. Output is the total production value within a sector. IMPLAN documentation states that it includes all components of production value or output, so output equals employee compensation plus proprietor income plus tax on production and imports, plus other property income plus intermediate inputs. For this analysis we are equating this with GDP or GSP.

It is important to note that for some industrial classes, only those establishments located in shore-adjacent zip codes are included in the sector totals for ENOW. For example, given that hotels and restaurants may or may not be dependent on the ocean, only those establishments that are nearest to the coast are included in the ocean economy. Other industries, like "deep sea freight," are defined in terms that make it possible to include the entire industry in the ocean economy.

As shown in Table 3-8 below, all six sectors combined account for 17.5 percent of the tri-county economy and 11.4 percent of the tri-county GDP. The most impactful sector is tourism and recreation across all three counties in terms of both employment and GDP. The following sections will elaborate specifically on each of the three counties within the study region.

Table 3-8: Employment and Output in Six Sectors Directly Related to Coastal Activity by County

	Charlotte		Collier		Lee		Total	
	Total	**Share of County**	**Total**	**Share of County**	**Total**	**Share of County**	**Total**	**Share of County**
LIVING RESOURCES								
Employment	2,025	2.8%	6,041	2.6%	9,731	2.5%	17,797	2.6%
GDP	$181,774,290	1.6%	$707,377,195	1.8%	$1,171,752,602	1.9%	$2,060,904,088	1.8%
OCEAN MINERAL EXTRACTION								
Employment	727	1.0%	2,119	0.9%	4,498	1.1%	7,344	1.1%
GDP	$131,932,757	1.2%	$417,611,745	1.0%	$752,867,824	1.2%	$1,302,412,326	1.1%
MARINE TRANSPORTATION								
Employment	452	0.6%	719	0.3%	2,168	0.6%	3,339	0.5%
GDP	$51,577,432	0.5%	$73,849,862	0.2%	$236,890,417	0.4%	$362,317,711	0.3%
MARINE CONSTRUCTION								
Employment	443	0.6%	1,547	0.7%	2,893	0.7%	4,883	0.7%
GDP	$67,168,356	0.6%	$261,212,208	0.7%	$462,656,026	0.7%	$791,036,590	0.7%
SHIP AND BOAT BUILDING								
Employment	4	0.0%	13	0.0%	323	0.1%	340	0.1%
GDP	$1,232,858	0.0%	$264,521,507	0.7%	$548,759,032	0.9%	$814,513,396	0.7%
TOURISM AND RECREATION								
Employment	9,144	12.5%	30,703	13.4%	48,584	12.3%	88,431	12.7%
GDP	$809,992,790	7.3%	$3,063,665,970	7.6%	$4,629,374,675	7.4%	$8,503,033,435	7.5%
ALL SIX SECTORS COMBINED								
Employment	**12,065**	**16.5%**	**39,010**	**17.0%**	**65,706**	**16.7%**	**121,794**	**17.5%**
GDP	**$1,110,512,869**	**10.0%**	**$4,106,105,236**	**10.2%**	**$7,016,651,127**	**11.2%**	**$13,019,704,151**	**11.4%**
ALL COUNTY								
Employment	73,034		229,965		393,953		696,952	
GDP	$11,043,641,213		$40,137,741,578		$62,928,502,998		$114,109,885,789	

Sources: IMPLAN. 2021. Charlotte County, Collier County and Lee County, Florida Data. Purchased at: www.implan.com on May 4, 2023.

Charlotte County

Though small in geographic size, Charlotte County's percentage or share of people employed in sectors related to coastal activities is approximately the same as the other two larger counties (16.5 percent), as is its percentage of wages and GDP dedicated to these sectors. Like the other two counties, tourism and recreation account for the largest share of employed persons, wages, and GDP compared to the other five coastal and water related sectors. Living resources and ocean mineral extraction are other important sectors in this county, though they contribute only 1 to 2.8 percent of the county's overall employment and 1.2-1.6 percent of its GDP. As would be expected, Charlotte County contributes the smallest share to the three-county area for both total economic activity and coastal economic activity, providing 10 percent (12,000) of the tri-county area's water related employment and 8.5 percent ($1.1 million) of its water related GDP.

Lee County

Lee County has the largest population of all three counties analyzed and has the largest number of people employed in every coastal activity sector. However, these sectors contribute a similar percentage to the county's total employment, wage, and GDP compared to Collier and Charlotte County, except for ship and boat building. Again, tourism and recreation is the most significant coastal sector for Lee County, accounting for 12.3 percent of the county's employment and 7.4 percent of its GDP. In Lee County, tourism and recreation, living resources, and ocean mineral extraction contribute most significantly to the county's economy. Ship and boat building, though not hugely significant in its total economic contribution, is more robust in Lee County than the other two. Lee County accounts for more than half of the tri-county water-related employment (65,700) and GDP ($7 million), highlighting both its reliance on water resources and importance in the tri-county water-related economy.

Collier County

Though largest in geographical size, Collier County has the second largest workforce behind Lee County. Like the other two counties, tourism and recreation is the most significant coastal related sector in terms of contribution to employment (13.4 percent) and GDP (7.6 percent). Living resources and ocean mineral extraction are other significant sectors for the county. Though these sectors contribute the highest percentages in terms of employment and GDP to the county's overall economy, living resources and mineral extraction account for slightly higher percentages of Charlotte's and Lee's County economy respectively. Collier County contributes about one-third of the tri-county area's total employment and GDP directly related to water resources.

The information in Table 3-8 is portrayed graphically in Figures 3-15, showing the numbers of jobs supported by the direct marine activities, and in Figure 3-16 that shows the GDP output from these industries. It should be noted that unlike Table 3-8, which includes only the direct impact of the coastal sectors within the coastal economy, Figures 3-15 and 3-16 include the indirect and induced impacts as well. As mentioned previously, the three levels of impact cumulatively capture the ripple effect of these sectors, or their overarching impact on the local economy.

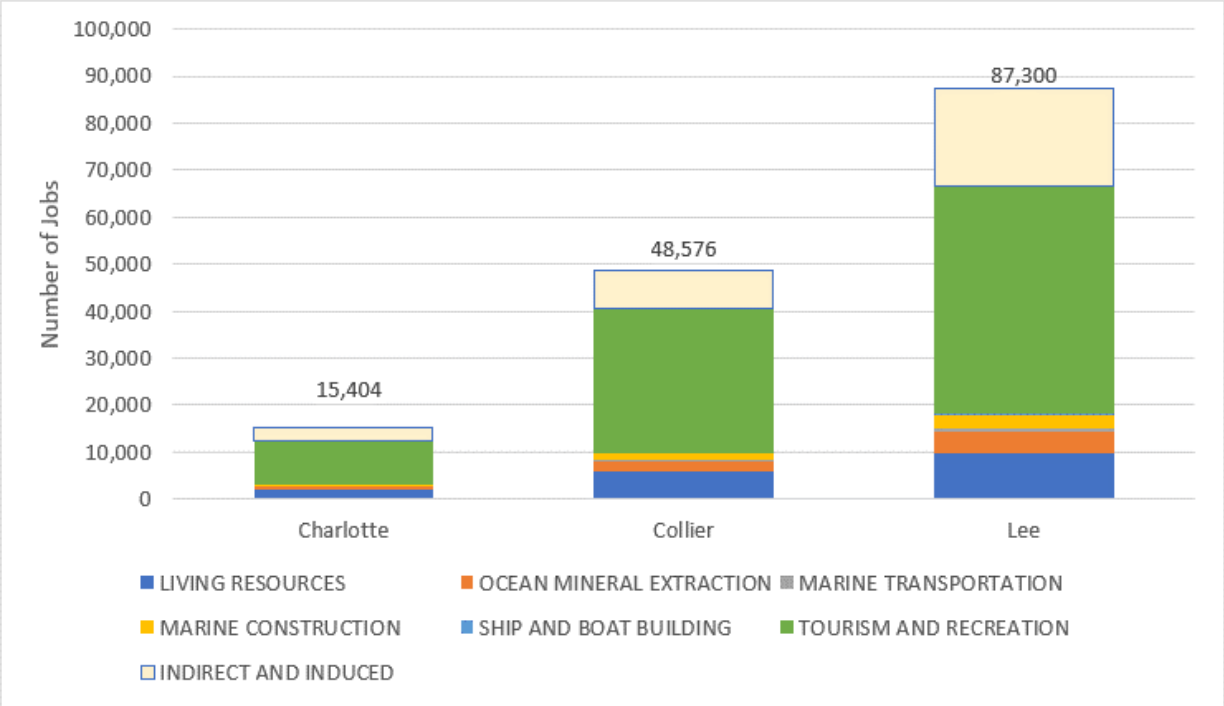


Figure 3-15: Employment in Six Coastal Industrial Sectors

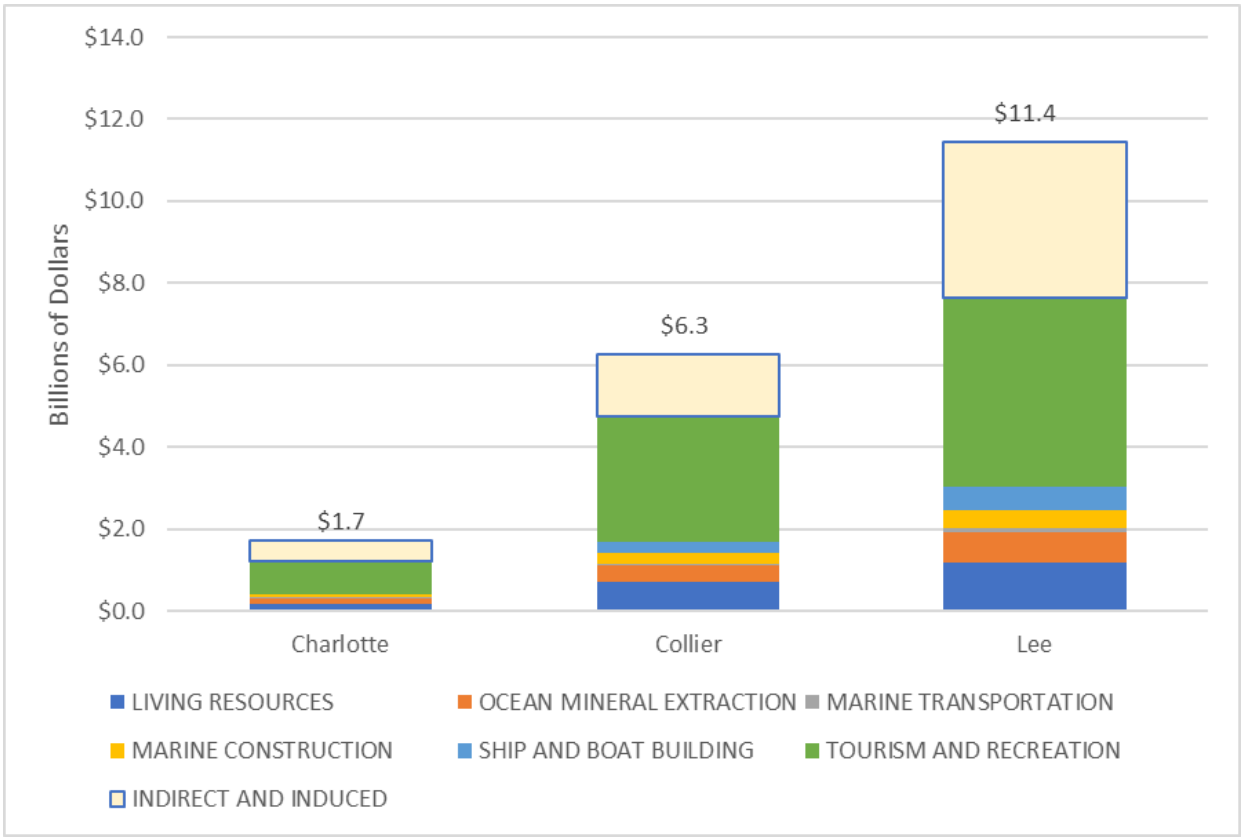


Figure 3-16: Output in Six Coastal Industrial Sectors by County

3.4. Property

Another category of assets in the Study Area is the property – especially the coastal property including homes and public infrastructure. The value of this property has been shown to be directly related to water, and water quality has been shown to impact the value of these properties (see Appendices B and C). In turn the property tax revenues collected by the counties will be affected by water quality. During the HABs, coastal properties are also inundated with debris that requires cleaning which can be costly and is briefly discussed in this section.

Property Values

Much of the research on the relationship between water and property values has focused on the positive, establishing that when controlling for all other factors, the closer a parcel is to a coast or other desirable natural water feature (river, canal, estuary, etc.) the higher its value. This higher value is typically referred to as a proximity, location, or amenity premium. The underlying assumption for this work is that this premium is realized when the associated water feature is clean and healthy. Conversely, if the feature is unhealthy, or becomes degraded, that premium would be reduced, and value would be lost.

"In 2013 my wife, who is a realtor, commented that her clients were concerned, in 2016 everybody got hammered, by 2018 there's a generalized awareness across the state, it's no longer a localized issue."
Charter Boat Captain

These results are significant for several reasons. Firstly, for many people their home is their single largest investment and single largest source of wealth. In the case of retirees living on fixed incomes, loss in property value has the potential to translate directly into decreased ability to fund health care and other support during retirement years. Secondly, sales and property value translate into tax revenue for affected counties. Loss in home value impacts the homeowner in terms of lost revenue, but it also decreases the annual tax revenue, having a direct impact on county budgets and the county's ability to provide public services which are often funded from property and sales tax revenue, including education, police, and fire services.

Two studies are relevant to the Study Area, and both look directly at the relationship between water quality and property values. One study, published in 2020 by Andrew Bechard looks specifically at the negative relationship between HABs and sale prices for properties where blooms occur compared to sales where no blooms are present. A second important study was conducted in 2015 for the Florida Association of Realtors, and this study identifies a positive correlation between water quality and increased property values in two counties- Lee and Martin. Both studies arrive at similar conclusions- there is an inverse relationship between water quality and property value, and that while single isolated negative water quality events may not have substantial impacts on property values, if those events persist in duration (for four or more months in the case of the Bechard analysis) or increase in frequency (in the case of the Association of Realtors study) the negative impacts of the events are compounded. Each is examined more closely below, and the remainder of this section takes a look at property values and taxes that are currently available for the Study Area and establish the baseline level of value that is at risk due to degraded water quality. For additional information on property values and the relationship between property value and water quality in the Study Area please see Appendix H. The taxable value of the coastal property is also shown as a share of the entire county in Table 3-9.

Table 3-9: Total Baseline Property Values in Study Area and Property Value within One Mile of Waterways

County	Total parcels in county	Total Property Value ($ billions)	Taxable Property Value	Parcels Within a Mile of a Waterway	Property Value w/in 1 mile ($ billions)	Taxable Value w/in 1 mile ($ billions)
Charlotte[8]	213,510	$39.4	$22.6	45,798 (21%)	$13.9 (35%)	$4.2 (19%)
Lee[9]	558,023	$180.6	$112.6	117,774 (21%)	$60.6 (34%)	$19.1 (17%)
Collier[10]	288,581	$185.3	$122.2	57,401 (20%)	$84.5 (48%)	$33.9 (28%)
Total	**1,060,114**	**$405.3**	**$257.4**	**220,973 (21%)**	**$159.0 (39%)**	**$57.2 (22%)**

Once taxable values are established, they are presented to taxing authorities (counties, municipalities, school districts, water management districts, other districts)[11] who then determine millage rates based on the amount of revenue needed for their budgets, subject to maximum millage limitation requirements.[12]

For this analysis, total property taxes for each of the counties were obtained from documents from each of the counties.[13] Average millage rates for each of the counties was calculated by dividing the total property taxes for FY22 in each county by their respective total taxable property values. Average millage rates were then applied to the taxable property values within 1 mile from shoreline and within 1-5 miles from shoreline for each of the three counties to estimate the property taxes within those two areas for each of the counties. This is not an exact calculation as the actual millage rates for each of the properties in these areas were not defined so the average for the full county was used. It is therefore an approximation. The tax revenues at risk for each county were calculated as the sum of the estimated tax revenues within 1 mile from shoreline and those within 1-5 miles from the shoreline for each county. Table 3-10. For the total Study Area, considering the properties that are within five miles of a waterway, the total property tax generated from these properties is $364 million, or 39 percent of the total estimated property tax revenue generated in the Study Area.

[8] 2022 Revised Recapitulation of the Ad Valorem Assessment Rolls Value Data. Charlotte County. Available here.
[9] Lee County 2022 At-A-Glance. Available here.
[10] Collier County Property Appraiser. Available here.
[11] Florida Assessments 2020. Slide 6. Available here.
[12] Maximum Millage Levy Calculation History and General Information. Available here.
[13] Charlotte County BCC Adopted Budget. Pg. 1, Adopted Budget FY21/22. Available here.; Collier County, Florida Board of County Commissioners, FY 2021-2022 Adopted Budget. Pg 75, FY 2022 Adopted budget. Available here.; And Lee County Annual Budget FY 2022-2023. Page 28, FY21-22 Unaudited Actual. Available here.

Table 3-10: Estimated Property Tax Revenue at Risk

County	Total County Estimated Property Tax Revenue	Estimated Property Tax Revenue at Risk Due to Proximity to Waterway
Charlotte[14]	$42.2 million	$18.7 million (44%)
Lee[15]	$465.2 million	$195.3 million (32%)
Collier[16]	$356.8 million	$122.4 million (44%)
Study Area	**$864.2 million**	**$336.4 million (39%)**

Cleanup Costs

In addition to its impact on human health and coastal industries, red tides invoke a costly cleanup fee. The toxins released by the algae are harmful to aquatic species. Fish exposed to enough brevetoxin released by the red tide are killed and then float to shore. The algae also ride the tide onto local beaches where it begins a smelly decomposition process alongside the decomposing fish that were unfortunate enough to get caught in the red tide. Due to lack of available data, this report does not include increased healthcare costs caused by HAB toxin inhalation. Therefore, the overall impact of a HAB on the study area is likely underestimated. The dead fish and rotting algae discourage beach use and create an unhealthy environment for beachgoers. Larger, longer red tide events prolong and intensify poor beach conditions.

Table 3-11 includes a summary of red tide clean up expenditures from events dating back to 2004 through the recent, very large red tide event in 2018. During the 2018 red tide event, the City of Sanibel spent over $2 million in cleanup costs from the end of July through the first week of September. Fort Myers also spent over $400,000 in clean-up costs for the same red tide event. Simply removing the marine casualties (mostly fish) and decomposing algae is quite costly to Study Area counties. In fact, cleanup costs range from $7.23 per linear foot of beach to $22.50 per linear foot of beach depending on where the impacts are most severe.

[14] 2022 Revised Recapitulation of the Ad Valorem Assessment Rolls Value Data. Charlotte County. Available here.
[15] Lee County 2022 At-A-Glance. Available here.
[16] Collier County Property Appraiser. Available here.

Table 3-11: Known Cleanup Costs for Red Tide Events (in 2023 dollars)

Area of Expenditure	Reason for Expenditure	Cost of Expenditure
Lee County	Two Surf Rakes	$74,800[17]
Fort Myers, Lee County	Cleanup for 2004 red tide event	$407,300[18]
City of Sanibel, Lee County	Clean up for 2018 red tide event from July 30th to Sept. 9th	$2,084,000[19]
Collier County	Cleanup for 2005 red tide event	$394,000[20]
Naples, Collier County	Remove dead fish from red tide event 2023	$100,000[21]
United States	Average annual monitoring and maintenance cost of harmful algal blooms	$5 million[22]
Pinellas, Sarasota, Lee, Collier, Longboat Key, and Naples	Harmful algal bloom cleanup activities from 2004 to 2007	$971,000 total; $16,500 to $371,000 per event [23]
Sarasota County	Cleanup for six red tide events in fiscal year 2006-2007 (labor, equipment, vendor)	$76,000[24]
Seven cities in Pinellas County	Cleanup costs related to red tide events in 2005	$123,100 total, $22.50 per linear foot of beach[25]
Sarasota County	Dead fish removal from red tide event that occurred from Oct. 2006 to Feb. 2007	$7.23 per linear foot of beach[26]

After Lee County was forced to remove 2,000 tons of material from beaches and shoreline due to the 2018 red tide event, it was clearer than ever that long-term red tide events have serious impacts. To help cover these expensive cleanup costs, Lee County was awarded $3 million in total grant money for red tide cleanup by the FDEP, and $77,500 from VISIT Florida to bring tourists back to the county.[27] The county was further authorized to spend up to $1 million in tourist development tax expenditures for a marketing campaign to spur tourism once water and beach conditions improved.[28]

[17] Florida Fish and Wildlife Conservation Commission. 2018. Lee County Recovery Efforts Fact Sheet. October. Available here.
[18] Morgan, K., et al. 2008. Public Costs of Florida Red Tides, 2007. University of Florida. Available here.
[19] Walton, C. 2018. In the Wake of Red Tide. Florida Weekly Correspondent. November. Available here.
[20] Morgan, K., et al. 2008. Public Costs of Florida Red Tides, 2007. University of Florida. Available here.
[21] Alvarez, M. 2023. Naples Spending up to $100,000 to Remove Fish Kill from Red Tide. March. Available here.
[22] Hoagland, P., Anderson, D., Kaoru, Y., White, A. 2002. The Economic Effects of Harmful Algal Blooms in the United States: Estimates, Assessment Issues, and Information Needs. Estuaries and Coasts 25:819-837. August. Available here.
[23] Morgan, K., et al. 2008. Public Costs of Florida Red Tides, 2007. University of Florida. Available here.
[24] Ibid
[25] Ibid
[26] Ibid
[27] Florida Fish and Wildlife Conservation Commission. 2018. Lee County Recovery Efforts Fact Sheet. October. Available here.
[28] 2021. Meeting of the Lee Board of County Commissioners. August 21st.

Since the early 2000s, most funds for red tide-related cleanups have been generated by tourism tax dollars. Only two counties relied strictly on their county taxes and/or fee revenues, perhaps due to the lack of public beaches in these areas (e.g., none were reported in Franklin County and only one in Charlotte County). As of 2008, only two cities, Longboat Key and Naples, had placed red tide cleaning costs as a line-item in the annual budget, in the amounts of $100,000 and $50,000, respectively.[29]

Blue-green algae blooms in freshwater also invoke cleanup costs. The largest cleanup costs associated with blue-green algae are the removal and disposal of the algae itself. Some blue-green algae blooms result in the death of aquatic species, depending on the size, duration, intensity, and toxicity of the bloom, but not all. The removal of the algae itself is expensive and necessary to prevent the death of aquatic species through eutrophication. Blooms are common in standing or slow flowing water, and therefore cannot be carried away by a current, thus requiring human intervention. Though all three counties are impacted by blue-green algae blooms, Lee County is especially impacted. Home to the Caloosahatchee River, several canals and other freshwater systems, blue-green algae removal is a regular expenditure.

The county has a grant agreement with the FDEP of $700,000 to assist in blue-green algae removal and processing.[30] Blue-green algae blooms are often the result of excess nutrients released into the water via septic tanks or stormwater run-off carrying fertilizer, sewage, or agricultural-related waste. To help prevent future algal blooms, millions of dollars have been spent on water quality improvement projects throughout Lee County. From 2008 to 2018, over $25 million was spent on water quality improvement projects across the county, and an additional $12.2 million was allocated for future projects. From 2013 to 2018, $96 million was spent on stormwater management improvement projects as well.[31] Ultimately, blue-green algae blooms are costly to clean up, and though millions have been spent on water quality improvements, more needs to be done to reduce their occurrence and in turn reduce their cleanup costs.

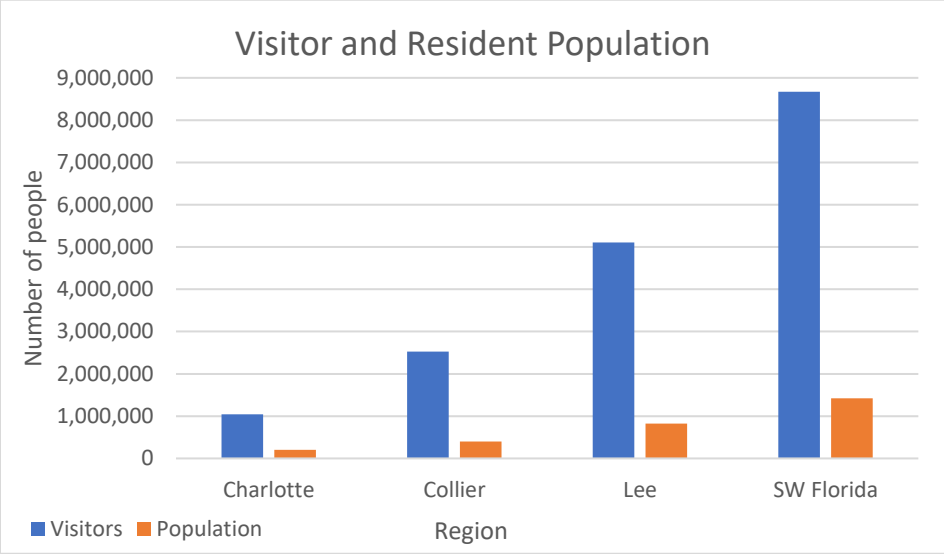
3.5. Quality of Life

"Short term memory is certainly a problem. People forget about these large events or how the ecosystem used to flourish and this allows people to ignore water quality and climate change related problems."

Scientist

The people of southwest Florida care about quality of life, which is why so many people live in and visit this region (Figure 3-17). From recreational fishing to bird watching to water skiing to relaxing on the beach to playing golf, there are outdoor activities for everyone to enjoy. These outdoor activities are a huge draw to the area, especially for tourists who rank outdoor activities, particularly beach activities as one of the main reasons they travel to southwest Florida. In 2023, the region will receive an estimated 9 million visitors. Over 5 million of these visitors travel to Lee County, which also has the largest resident population of just over 800,000. Collier County is the next largest in terms of population (400,000 residents), followed by Charlotte County (200,000 residents). In total, the region was home to over 1.4 million residents in 2022 and is growing quickly. The region also hosts over six times as many visitors as it does full-time residents. The majority of these individuals visit southwest Florida due to the high-quality opportunities to engage in recreational activities.

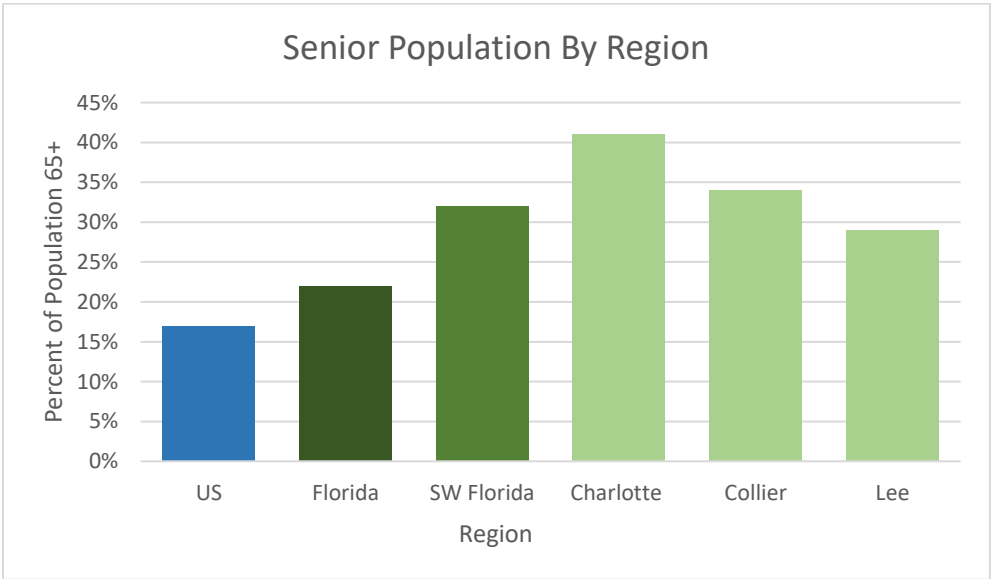
[29] Morgan, K., et al. 2008. Public Costs of Florida Red Tides, 2007. University of Florida. Available here.
[30] 2021. Meeting of the Lee Board of County Commissioners. August 21st.
[31] Florida Fish and Wildlife Conservation Commission. 2018. Lee County Recovery Efforts Fact Sheet. October. Available here.



Sources: US Census Bureau. American Community Survey 2022 1-year. County Visitor and Convention Bureaus.

Figure 3-17: Visitor and Resident Population in Southwest Florida

Within the southwest Florida resident population, there are a striking number of people aged 65 and older (Figure 3-18). In southwest Florida 32 percent of the population is over 64, which is 10 percent greater than the percentage of over 64 within the entire Florida population, and 15 percent higher than that of the US. Within southwest Florida, Charlotte County has the highest percentage of seniors in their population, followed by Collier, then Lee. All three counties have a greater percentage of senior residents than the state. Whilst one could argue that the older population may not enjoy the outdoors due to limitations in mobility and health, most people choose to retire here to enjoy the recreation and quality of life southwest Florida has to offer. Over 85 percent of the senior population is not in the workforce, also giving them more time to take advantage of and appreciate the high quality of life offered here.



Source: US Census Bureau. American Community Survey 2022 1-year.

Figure 3-18: Senior Population by Region in Southwest Florida

The natural assets of southwest Florida are worth more than the amount of money people spend recreating, relaxing, or utilizing these resources in one way or another. Residents and tourists alike value the aesthetics and recreation opportunities water-related resources in southwest Florida have to offer. Our interview with local stakeholders supported this claim with many of them calling the region a "water community." Related literature further supports this claim with various monetary values people are willing to pay to engage in certain activities or are willing to pay via travel to reach these water resources.

The net economic value of a beach visit, or other outdoor activity is made up of its market and non-market values, minus the cost to society of providing the amenities. While estimating market values is relatively straightforward, the non-market value estimation is a more complex process and requires using specific valuation methods. For example, one measure of non-market value is consumer surplus, which, in case of beach visitation, reflects the benefits received by visitors above and beyond the money they spend to be able to enjoy the beach.

A number of studies have looked into and estimated the non-market value of visiting beaches and other outdoor activities. A Recreation Use Value Database (RVUM) developed by Dr. Randall Rosenberger currently contains 421 documents of economic valuation studies that estimated the use value of recreation activities in the U.S. and Canada from 1958 to 2015, totaling 3,192 estimates in per person per activity day units, adjusted to 2016 dollar values.[32] Twenty-one primary activity types are provided, with several more available if segregated by activity mode, resource type, primary species sought, or little studied activities. These recreation use value estimates are measures of net willingness-to-pay or consumer surplus (i.e., the consumer surplus, or the value to visitors above the actual expenditure incurred for the recreation) for recreational access to specific sites, or for certain activities at broader geographic scales (e.g., state or province, national) in per person per activity day units (the RUVD does not contain information on marginal values for changes in site quality or condition).

Non-Market Value of Water-Related Recreation

The recreational opportunities supported by Florida's natural resources are worth something to those who choose to participate in water-related recreational activities like beach going and bird watching. To determine the annual value of these activities, the team calculated total participants by recreational activity, using values from the 2019 Florida SCORP.[33] It should be noted that resident participation data is missing for multiple activities in Collier County (freshwater boat ramp use, saltwater boat ramp use, and water skiing/wakeboarding), so the annual non-market value is likely undervalued for this county as the values used only account for visitors.

The number of days each participant spent per year participating in each activity was estimated from sources identified via the literature review process. The US Fish and Wildlife National Survey of Fishing, Hunting and Wildlife-Associated Recreation report contained values for all fishing and wildlife related activities (saltwater fishing, freshwater fishing, nature study, and wildlife viewing). Houston's (2013) Value of Florida Beaches presentation included both beach days visits and number of tourists that visits Florida beaches annually.[34] From these values we calculated that visitors spend 9.2 days per year on average at

[32] Rosenberger, R., S. 2016. Recreation Use Values Database – Summary. November. Available here.
[33] Florida Department of Environmental Protection. 2019. Outdoor Recreation in Florida 2019: Florida's Statewide Comprehensive Outdoor Recreation Plan. Division of Parks and Recreation. Available here.
[34] Jim Houston. 2013. The Value of Florida Beaches. Available here.

the beach. Hiking and picnicking likely had similar activity participation days per year, so this value was used for saltwater beach activities, freshwater beach activities, hiking, and picnicking. The 2011 National Recreational Boating Survey included average number of days spent on paddling boats (canoes, kayaks, other row boats) and average number of days spent across all boat types for the Southern region of the United States.[35] The values in this report were for freshwater boat ramp use, saltwater boat ramp use, and paddling activities. Finally, the average number of days people spend water skiing/wakeboarding came from the 2020 National Recreational Boating Safety Survey.[36]

To calculate the total annual non-market value for each recreational activity, we multiplied the number of participants by the number of days the average participant spends participating in each activity annually by the non-market or consumer surplus per day value. The per day values were provided by Rosenberger et al.'s Recreation Use Value Database,[37] which were updated from their 2016-dollar value to 2023 dollars using an inflation calculator (see Table 3-12).[38] Additional information about the non-market value of recreation is available in Appendix I.

[35] United States Coast Guard. 2011. 2011 National Recreational Boating Survey. Available here.
[36] RTI International. 2020. National Recreational Boating Safety Survey Participation Survey Final Report. Prepared for the United States Coast Guard Boating Safety Division. October. Available here.
[37] Rosenberger, R., S. 2016. Recreation Use Values Database – Summary. November. Available here.
[38] US Inflation Calculator. Available here.

Table 3-12: Values Used to Calculate the Value of Water-related Recreational Activities in Southwest Florida

Activity		Total Participants		Days per Person/year	Per Day Value (2023 dollars)
	Charlotte	**Lee**	**Collier**		
Saltwater Beach Activities	243,593	2,378,579	1,587,364	9.2	$97.71
Saltwater Fishing	118,417	737,637	1,067,974	8.8	$162.82
Nature Study	142,377	938,207	265,761	16	$81.38
Freshwater Beach	131,396	1,187,410	247,631	9.2	$97.71
Freshwater Boat Ramp	110,351	284,987	160,770	17.5	$89.20
Hiking	84,806	2,105,615	1,067,983	9.2	$138.57
Wildlife Viewing	236,922	3,351,775	374,784	16	$74.83
Picnicking	86,087	1,799,664	776,306	9.2	$88.31
Paddling Activities	102,833	1,253,441	430,026	12.9	$89.20
Saltwater Boat Ramp Use	44,216	472,234	33,496	17.5	$89.20
Water Skiing/ Wakeboarding	27,292	341,441	330,184	18	$34.14
Freshwater Fishing	87,731	151,778	407,132	12.8	$80.43
TOTAL	**1,416,021**	**15,002,768**	**6,621,433**		

Across all three counties, recreational activities are worth over $25 billion per year (Table 3-13). The vast majority of the recreational value comes from Lee County, which has a value of over $16.5 billion. Collier is worth over $7 billion and Charlotte is worth around $1 billion, though Collier County is likely undervalued due to lack of data. Wildlife viewing, saltwater beach activities, saltwater fishing, and hiking are valuable activities across the Study Area.

In Charlotte County wildlife viewing provides the greatest value followed by saltwater beach activities, nature study and saltwater fishing. These activities also have the greatest number of participants. Even water skiing/wakeboarding, which has the fewest participants, is worth over $16 million. Altogether, the recreational activities are worth over $1.6 billion.

In Collier County, saltwater fishing provides the greatest value to the county followed by saltwater beach activities, paddling activities, and hiking. Similar to Charlotte County, these activities also have the greatest number of participants. Altogether, the recreational activities are worth over the $7 billion estimation included in the table below, but this total needs to be understood in the context of missing data on ramp use and water sports.

In Lee County, wildlife viewing provides the greatest value to the county followed by hiking and saltwater beach activities. Like the other two counties, these activities also have the greatest number of

participants. Altogether, the recreational activities are worth a staggering $16.6 billion, which is more than twice the total non-market value of these activities in Collier County, the next highest in the study area.

Table 3-13: Total Annual Value for Water Related Recreational Activities in Southwest Florida (in 2023 dollars)

Activity	Charlotte County	Collier County	Lee County	Study Area
Saltwater Beach Activities	$218,973,310	$1,426,931,990	$2,138,180,372	$3,784,085,672
Saltwater Fishing	$169,669,307	$1,530210079	$1,056,898772	$2,756,778,158
Nature Study	$185,386,810	$346,042,131	$1,221,620,730	$1,753,049,671
Freshwater Beach Activities	$118,116,013	$222,603,219	$1,067,400,451	$1,408,119,683
Freshwater Boat Ramp Use	$172,257,368	250,962,681	$444,865,189	$868,085,238
Hiking	$108,114,508	$1,361,511,550	$2,684,330,137	$4,153,956,195
Wildlife Viewing	$283,661,624	$448,721,298	$4,013,013,340	$4,745,396,164
Picnicking	$69,941,467	$630,711,246	$1,462,140,686	$2,162,793,399
Paddling Activities	$118,327,987	$494,822,181	$1,442,309,490	$2,055,459,658
Saltwater Boat Ramp Use	$69,021,515	$52,287,096	$737,157,559	$858,466,170
Water Skiing/ Wakeboarding	$16,771,713	$124,259,734	$209,822,211	$350,853,658
Freshwater Fishing	$90,319,450	$419,144,161	$156,256,054	$665,719,665
TOTAL	**$1,620,561,074**	**$7,308,207,366**	**$ 16,633,994,992**	**$25,562,763,433**

A Word About Golf

The golf industry is a significant component of the southwest Florida economy, with over 150 golf communities in the area. [39] A 2022 study commissioned by the Florida Sports Foundation estimated that the direct economic impact of golf was just over $21 million, and that the golf sector contributed nearly $4 million to state and local tax revenue. [40] While an important component of the regional economy, and a major outdoor recreational activity, non-market values for golf are not typically estimated. This is primarily because golf is not dependent on the existence, or health of a naturally occurring habitat or

[39] Golf Community Trends in Southwest Florida. 2021. Available here.
[40] The Florida Sports Economy. Economic Impacts. FY 19/20-20/21. Tourism Economics for the Florida Sports Foundation. Pg. 20. Available here.

geographic feature. Golf courses are artificial manmade venues and all aspects of the economic impacts of the golf industry can be captured directly in the marketplace.

3.6. Summary

This analysis has shown that there are many ways in which water is connected to the southwest Florida economy. The baseline estimates of value for each of the economic subcategories represent the economic assets that are at risk of a large detrimental water quality event, and/or continued degradation of the water quality in the Study Area. Some of these categories overlap but each has been described above to establish the baseline economic assets that are affected by HABs and that are placed at risk of future losses. In Chapter 4, losses for one HAB will be developed based on these asset values, and in Chapter 5, future losses will be considered.

The final categories used in this analysis are inter-related and show up in different asset classes. The fisheries relate to the economy in several ways. Commercial fishing generates employment and income for local fishermen. As such, the commercial fishing revenues are reported in this study as a separate category for emphasis. But the revenues and employment are also imbedded in the Coastal Economy category. Recreational fishing is analyzed in three ways. First, recreational fishers spend money in the economy on bait, equipment, guiding services and other types of expenditures, and these expenditures stimulate the economy. So in the same way that commercial fishing is part of the Coastal Economy asset category, recreational fishing expenditures make up a portion of the Coastal Economy jobs and output. This is the second way this value is reported. The third way is that recreational fishing is addressed is in the Quality of Life section, which covers the non-market value of all outdoor recreational activities – including recreational fishing values. Property values and tax revenues do not overlap with the other categories of measurement. The table below clarifies how each of the measures discussed in this chapter are inter-related.

Table 3-14: Summary of Similarities and Differences between Economic Asset Measurement Approaches

Type of Economic Asset	Measurement Approach	Economic Importance	Relationship to Other Economic Asset Classes
Fishing – Commercial	Revenues from Landings in Study Area	Provides employment and local economic output	Portion of Coastal Economy jobs and output
Fishing – Recreational	Numbers of trips by visitors and residents, and expenditures for these trips	Provides local economic employment and output	Portion of Coastal Economy jobs and output AND Trips used as portion of Quality of Life, Outdoor Recreation
Coastal Economy – Jobs	Includes jobs from six coastal sectors including marine transportation, mineral and resource extraction, ship and boat-building, and coastal tourism and recreation	This is a sweeping assessment of the ocean-related employment in the Study Area. It includes the employment from tourism and recreation, as well as commercial fishing and the other sectors. This is a conservative assessment of how the water affects the local economies	Includes commercial fishing employment as well as recreational fishing employment but also includes employment from all other recreation and tourism as well as the other marine-based industries.
Coastal Economy – Output	Same as above, but for output instead of employment	Same as above with output (GDP) instead of employment	Same as above, showing output instead of employment
Property Value	Taxable value of property within proximity of the coast	Value of homes (personal wealth)	Source of property tax impact assessment
Property Tax Revenue	Revenue generated from taxing properties within proximity of the coast	Funding for local governments	Generated from property values
Quality of Life Value of Outdoor Recreation	Non-market value of recreational visits by tourists and residents	Estimates the benefits of the natural environment to visitors and residents	Benefit is derived from recreational fishing trips plus other outdoor recreational trips. Widely recognized to stimulate the growth and popularity of the region which generates jobs and output and property values

Baseline estimates of each of the asset classes is shown below in Table 3-15. The commercial and recreational fisheries together are responsible for over $1.4 billion in expenditures within the three counties. The economy that is attributed to the six coastal sectors (living resources, ocean mineral extraction, marine transportation, marine construction, ship and boat building, and tourism and recreation) directly dependent on the water account for 21 percent of employment in the region, and 15 percent of the output. Property values within one mile of a waterway total $57.2 billion in taxable property value, representing 22 percent of the Study Area taxable property values and generating an estimated $336 million in tax revenue. Finally, the measure of value of having access to outdoor recreation is estimated at $25.6 billion in the region. Together these represent the economic assets at risk from continued degradation of water quality.

Table 3-15: Summary of Water Quality Connected Economic Assets in Study Area

Type of Economic Asset	Total
Fishing – Commercial	$30.8 million
Fishing – Recreational	$1.4 billion
Coastal Economy – Jobs	151,280 (21 Percent of Study Area)
Coastal Economy – Output	$18.8 billion (15 percent of Study Area)
Property Value (w/in 1 mile of water)	$57.2 billion
Property Tax Revenue	$336.4 million
Quality of Life Non-market Recreation	$25.6 billion

4. Results: Impacts of a Harmful Algal Bloom

"Florida is a homogenous term for most people. People hear 'red tide' on the news and change their plans… the 2018 red tide had impacts all the way up and over to Jacksonville on the East coast."

SCCF

Red tides can last anywhere from a few weeks to over a year (see Appendix A for an overview). Extended red tide events are less common in southwest Florida. Since the beginning of 2005 there have only been four red tides that have lasted a minimum of three months; these events are included in the table below (Table 4-1). Blooms of shorter duration are more frequent, occurring almost every year in the Gulf, especially during the late summer months.[41] Blue-green algal blooms occur during the same season, late summer to early fall. They are considered a chronic problem and occur every year. They are especially prolific in Lake Okeechobee and all waterways that carry water from the lake to the Gulf, alongside areas with extensive stormwater runoff or leaky septic tanks. Though chronic, some blue-green algae blooms last longer and are larger in size than others. In 2018, the blue-green algae bloom in Lake Okeechobee covered 90 percent of the lake during its peak.[42] The bloom occurred in nearby waterways and estuaries as well, causing problems in counties that were already suffering from the concurrent red tide event along the coast, which was likely exacerbated by the blue-green algae bloom.

Table 4-1: Major Red Tide Events from 2005 through 2018

Year of Occurrence	Duration	Impacted Region
2005	3 months (Jan-Mar)	St. Petersburg to Naples (All of SW Florida)
2005	4 months (Aug-Nov)	St. Petersburg to Naples (All of SW Florida)
2006	4 months (Aug-Nov)	SW Florida, Sarasota County hit hardest
2018	6 months + (Jun-Nov)	Entirety of SW Florida

Source: Bechard, Andrew. 2020. Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida. The Review of Regional Studies (50): 170-188. Available here.

Based on data collected, literature reviewed, and discussions with affected parties, the following analysis estimates the potential impact of another HAB like the one southwest Florida experienced in 2018 in terms of duration and impact to the Study Area. Chapter 4 establishes a baseline for each economic asset – fishing, economy, property, and quality of life. In this chapter we estimate how a longer-term HAB would negatively impact the baseline value determined in the previous chapter, essentially the annual economic loss caused by a yearlong HAB. Losses are estimated using the best available information for the impact of a HAB on the region on each asset.

[41] NOAA. Gulf of Mexico/Florida: Harmful Algal Blooms. Available here.
[42] Court, Christa, at al. 2021. Quantifying the Socio-Economic Impacts of Harmful Algal Blooms in Southwest Florida in 2018. July. Available here.

4.1. Fish

To measure the potential impact of a long-term HAB event on commercial fishing, we referenced Andrew Bechard's 2020 report on the losses to fisheries and seafood businesses during HAB events. He found that fisheries and seafood businesses generate 14.8 percent less in monthly taxable sales during red tide events in nearby Pinellas County.[43] We used this value to measure the economic losses from a yearlong HAB event to the commercial fishing industry in Charlotte, Collier, and Lee County.

Larkin and Adam (2007) considered the impact of HABs on coastal businesses in Florida, particularly those related to tourism. In northwest Florida, tourism sectors decline 29 to 35 percent in average monthly revenues during months with red tides.[44] As recreational fishing is heavily reliant on tourism, we believe this sector is likely to experience similar losses in revenue. Therefore, we took the average of this range, 32 percent, and used this value to measure the economic losses from a yearlong HAB event on recreational fishing.

As demonstrated in each county, commercial and recreational fishing are economically important assets to the three southwest Florida counties with a combined baseline value of almost $1.5 billion. Annual losses from a yearlong HAB total $4.6 million for commercial fishing and $460 million for recreational fishing (Table 4-2). These estimates are conservative. They do not consider the long-term effects of a red tide on the fishing industry. Perception and lack of awareness regarding improved water quality could elongate the period of loss beyond that of the actual HAB.

Table 4-2: Economic Impact of HAB on Fishing in Tri-County Region

(2023 dollars)

	Baseline Value in 2022	Annual Loss from HAB
Fishing – Commercial	$30.8 million	$4.6 million
Fishing – Recreational	$1.44 billion	$459.7 million

4.2. Economy

As established in Chapter 3, our conservative approach to evaluating the coastal economy includes only sectors directly related to water rather than the geographic coastal region. These sectors include living resources, ocean mineral extraction, marine transportation, marine construction, ship and boat building, and tourism and recreation. Rather than apply a single percentage to represent HAB related losses to all the sectors, we applied tailored percentages to each industry as they are impacted to different degrees by HAB events.

- **Living Resources**: This industry essentially concerns commercial fishing among a few other natural resource-based marine industries. For consistency, we used Bechard's (2020) estimated

[43] Bechard, Andrew. 2020. Economic Losses to Fishery and Seafood Related Businesses During Harmful Algal Blooms. Fisheries Research 230. Available here. (HAB-4)
[44] Larkin, S., Adams, C. 2007. Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida. Society and Natural Resources 20:849-859. Available here. (HAB-11)

loss in monthly taxable sales for seafood-related industries during a HAB, 14.8 percent.[45] This was also the value we used to measure the impact of a long-term HAB on commercial fishing.

- **Ocean Mineral Extraction**: Ocean mineral extraction is not a large contributor to the larger coastal economy, nor is there literature on the degree of impact a HAB has on this industry. To be conservative the team used 2 percent to measure the impact of HABs on this sector as this level of impact fell on the smallest end of the spectrum of the values found in the literature.
- **Marine Transportation**: This sector contributes the least to all three counties out of the six coastal sectors in terms of jobs and output. Like ocean mineral extraction, it is not clear how impacted this sector would be from a HAB. Though heavily reliant on tourism and recreators, marine transportation could be boosted by algae and dead fish removal needs. To accommodate for this uncertainty, the team used a conservative tourism related impact estimate from Bechard's (2020) HAB and tourism report.[46] In this study they found affected counties produce 5 to 7 percent less in tourism related sectors. As marine transport is heavily reliant on tourism, we utilized the lower end of this range, 5 percent, to measure the economic impacts of a HAB event on marine transportation.
- **Ship and Boat Building/Marine Construction**: Ship and boat building and marine construction are very similar industries, so the team believed both would be similarly impacted by a HAB. Court et al. (2021) used an online survey to gauge business owners' loss in revenue during the 2018 HAB event. According to the owners of marine based businesses focused on marina and boat maintenance, revenue changed by anywhere from 10 percent to 75 percent. Across all water-based business sectors, the average loss was 36 percent.[47] We used this value, 36 percent, to estimate the economic impact of a HAB on both ship and boat building and marine construction.
- **Tourism and Recreation**: To determine the economic impact of a HAB on tourism and recreation, we again referred to Larkin and Adam (2007). They determined that tourism sectors decline 29 to 35 percent in average monthly revenues during months with red tides.[48] We averaged this range and used a 32 percent decline for the tourism and recreation sector.

Across the Study Area, the coastal economy provides 151,000 jobs and generates $18.8 billion in output during a typical year. A HAB results in the loss of 43,000 jobs and $5 billion in output (Table 4-3). Again, this loss could have harmful impacts not only on the southwest Florida economy, but also on the thousands of people who rely on coastal resources for their livelihoods.

[45] Bechard, Andrew. 2020. Economic Losses to Fishery and Seafood Related Businesses During Harmful Algal Blooms. Fisheries Research 230. Available here. (HAB-4)
[46] Bechard, Andrew. 2020. Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida. The Review of Regional Studies (50): 170-188. Available here. (HAB-1)
[47] Court, Christa, at al. 2021. Quantifying the Socio-Economic Impacts of Harmful Algal Blooms in Southwest Florida in 2018. July. Available here. (HAB-7)
[48] Larkin, S., Adams, C. 2007. Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida. Society and Natural Resources 20:849-859. Available here. (HAB-11)

Table 4-3: Economic Impact of HAB on Study Area Coastal Economy
(2023 dollars)

	Baseline Value in 2022	Annual Loss from HAB
Jobs	151,280	43,094
Output	$18.8 billion	$5.2 billion

4.3. Property

Measuring the economic impact of a HAB on property was more complex than the other economic assets because we considered the potential loss of taxable value and property tax revenue. When considering taxable value lost, Bechard's (2020) study on declines in property value as HABs blow to shore provided valuable information on the economic impact of HABs on property values in southwest Florida. Bechard found that during a bloom event, properties within a mile of an affected area sold for 20 percent less than those in an unaffected area. When he focused on residential properties that percentage decrease rose to 25 percent.[49] Those results held as distance from the coast increased, with price drops remaining in the 15-20 percent range.[50] For our analysis, we assumed a 20 percent loss for properties within one mile of the coast, and a conservative 15 percent loss for properties one to five miles from the coast.

We also considered the potential property tax revenue losses from a HAB. The tax revenues at risk for each county are the sum of the estimated tax revenues within one mile from shoreline and those within one to five miles from the shoreline for each county. The expected loss due to HABs is the same as expected loss to property value, 20 percent for properties within one mile of the coast and 15 percent for properties one to five miles from the coast. We applied these percentages to the respective 2022 taxable values for each of the three counties. Then to estimate the property tax revenue losses, we multiplied the average millage rates for each county to the value loss in taxable values. Summing the estimated property tax losses within one mile from the shoreline and those within one to five miles from the shoreline for each county resulted in the total expected property tax loss for each county.

Across the Study Area, property values within five miles of the coast are worth approximately $100 billion and property tax revenue amounts to $336 million. In essence, coastal properties are very valuable economic assets in southwest Florida. A HAB event results in $18 billion in property related losses, impacting property owners and county staff and elected officials that rely on property tax revenue for budgeting (Table 4-4).

[49] For condominiums the impact was not as great, with condominium sale prices only dropping 16 percent during a bloom event.
[50] Bechard, Andrew. 2020. Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Towards the Shore. Journal of Real Estate Finance 62:242-257. Page 248. Available here. (HAB-3)

Table 4-4: Economic Impact of HAB on Property in the Study Area

(In 2023 dollars)

	Baseline Value in 2022	Annual Loss from HAB
Property Value (w/in 1 miles of water)	$57.2 billion	$11.5 billion
Property Value (1 to 5 miles from water)	$42.7 billion	$6.4 billion
Property Tax Revenue	$336.3 million	$60.3 million

4.4. Quality of Life

To be consistent, we used Larkin and Adam's (2007) HAB impact value (32 percent decrease) for all quality-of-life considerations.[51] As quality of life encompasses the worth of recreational opportunities related to water and outdoor assets, we believe quality of life is likely to experience similar losses in revenue to that of tourism related sectors. Therefore, we used this value to measure the economic losses from a yearlong HAB event on quality-of-life non-market recreation.

For the entire Study Area, the quality-of-life recreational non-market value comes out to $25.6 billion. A long-term HAB event like that of 2018 would result in a loss of $8.1 billion, which is greater than the loss from coastal economy output by over $1 billion (See Table 4-5). A HAB undoubtedly will have a serious impact on quality of life in southwest Florida.

Table 4-5: Economic Impact of HAB on Quality of Life in Study Area

(2023 dollars)

	Baseline Value in 2022	Annual Loss from HAB
Non-Market Value of Recreation	$25.6 billion	$8.1 billion

[51] Larkin, S., Adams, C. 2007. Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida. Society and Natural Resources 20:849-859. Available here. (HAB-11)

4.5. Summary

> *"A hurricane is something you can plan for and insure against, but even that's getting more expensive, algal blooms, releases, other water quality events, there is no insurance policy to help recover from those things"*
>
> *Long-Term Study Area Resident*

Each of the counties has a forecasted estimate of economic losses associated with a HAB, and a summary of the Study Area provides the complete picture (see Table 4-6). A long-term HAB like the one of 2018 will have serious economic consequences. Including all economic assets, Charlotte County stands to lose nearly half a billion in the Coastal Economy output and 4,353 jobs. Due to its popularity with tourists and its larger population, Lee County will lose the most out of the three-county region in the sum of $3.0 billion in losses to the Coastal Economy, and 24,808 lost jobs. A HAB will also invoke grim consequences for Collier County in the sum of $9.4 billion in property value losses, almost 14,000 jobs, and a loss of $1.7 billion in the Coastal Economy. The largest of the economic asset class losses comes from decreases in coastal property value ($17.8 billion). Losses to quality-of-life non-market recreation and coastal economy output are also substantial across all three counties (see Figure 4-1). It should be noted that these impacts do not capture increased healthcare costs incurred from those who are impacted by the toxins released by red tide into the air due to lack of available data. As such, the total impact is an underestimation of the cost incurred by those in the study area.

Table 4-6: Summary of Annual Economic Losses from HAB Event

Type of Economic Asset	Charlotte	Lee	Collier	Study Area
Fishing – Commercial	$276,000	$2.59 million	$1.68 million	**$4.6 million**
Fishing – Recreational	$23.8 million	$192.2 million	$243.8 million	**$459.7 million**
Coastal Economy – Jobs	*4,353*	*24,808*	*13,933*	***43,094***
Coastal Economy – Output	$466 million	$3.0 billion	$1.7 billion	**$5.2 billion**
Property Value (w/in 1 mile of shore)	$847.2 million	$3.8 billion	$6.8 billion	**$11.5 billion**
Property Value 1-5 miles from shore	$868.2 million	$2.9 billion	$2.6 billion	**$6.4 billion**
Property Tax Revenue	$3.2 million	$21.4 million	$35.7 million	**$60.3 million**
Quality of Life Non-market Recreation	$518.6 million	$5.3 billion	$2.3 billion	**$8.1 billion**

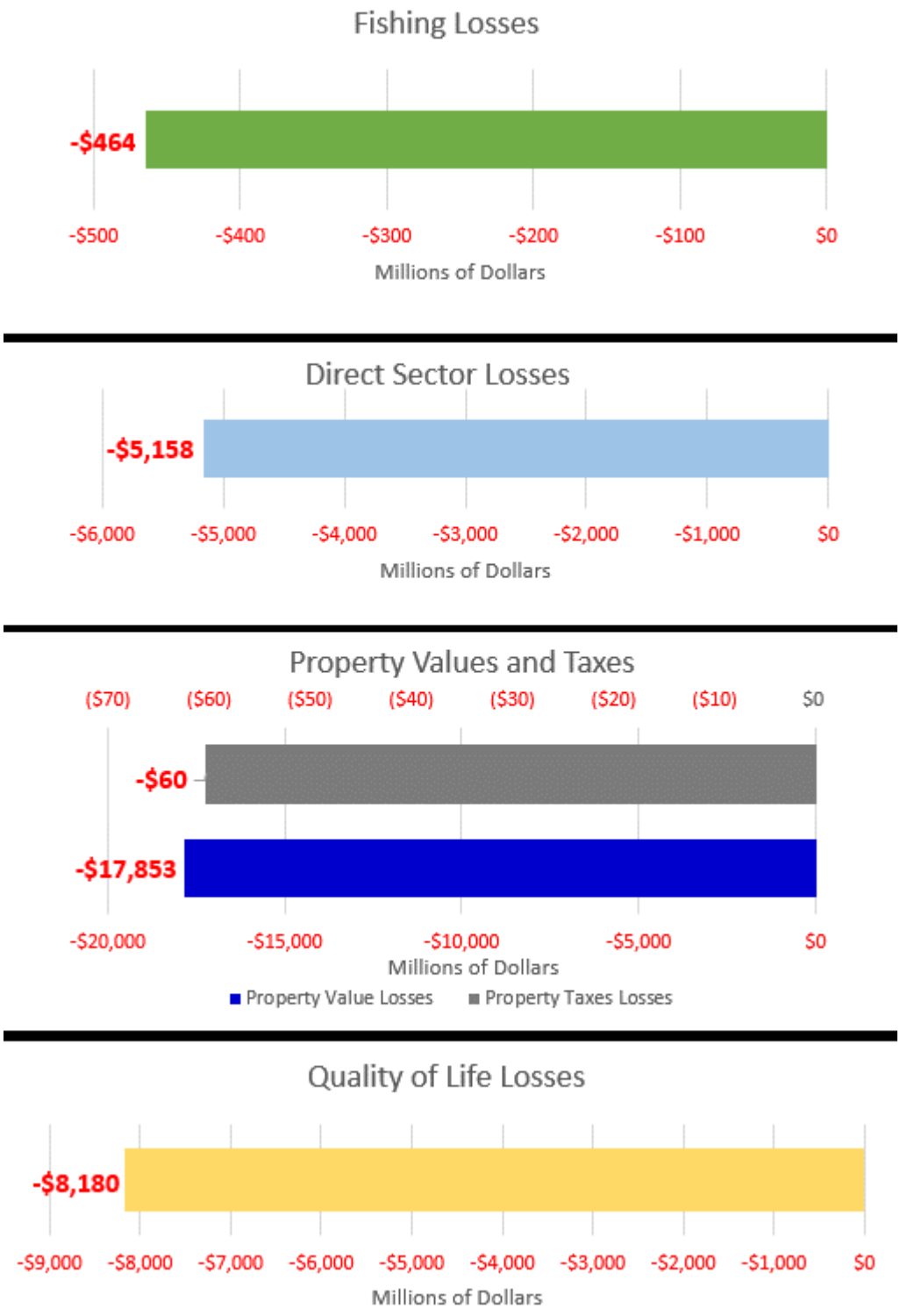


Figure 4-1: Potential Losses from a HAB in Study Area

5. Future Impacts and Chronic Water Degradation

The impacts reported in Chapter 4 are static, or rather deal with a one-time HAB event. But there are many factors compounding the water quality issue and there are risks when forces work in tandem. For example, during the stakeholder interviews, many people commented that the more frequent the HAB events, the more frequent the blue green algae events, and the less time there is between events to recover. Less recovery time for the ecosystem is directly reflected in the economy. This chapter addresses the concerns related to the compounding factor of the ongoing degradation of the natural systems in southwest Florida, and how this could play out in the economy based on the analysis and information collected so far. A background on the chronic water conditions is addressed first, followed by a discussion of how ecosystems can hit 'tipping points' and not recover. The main body of this section discusses how the uncertainty of ecological events could play out in the economy over time, and a final segment addresses how to use the information in this report to make decisions about investing in clean water. Several related Appendices describe some of these issues in greater detail.

5.1. The Role of Chronic Water Quality Issues

The state of Florida classifies waters, designates uses and tracks criteria pollutants.[52] Temperature, salinity, pH, dissolved oxygen, nitrogen (total and organic), chlorophyll, phosphorus, turbidity, heavy metal concentration, and fecal indicator bacteria are typically parameters of interest. In our study the six parameters in Table 5-1 below are of particular interest, both because of their role in illustrating estuary and water body health, and because most of the listed waterbodies (the waterbodies that fail to meet water quality standards), in our study area are listed because the thresholds for one or more of these criteria have been exceeded.

Table 5-1. Indicator Variables for Assessing Ambient Water Quality

Indicator Variable	Cause for Concern
Temperature	Fish and aquatic species require certain temperature ranges to survive; temperature imbalances also encourage growth of harmful organisms (algae)
Dissolved Oxygen	Species require oxygen to survive, low levels of dissolved oxygen can also be an indicator of increased harmful plant growth and algal blooms
Nitrogen/Phosphorus	High levels of nutrients fuel growth of algal blooms
Chlorophyll	Measure of the presence of microscopic photosynthetic organisms (aka algae)
Turbidity	Measure of water clarity- indicates the presence of suspended materials (living or dead), increased sediment loads can smother habitat and interfere with fishing and swimming
Fecal Indicator Bacteria	Waterborne pathogens threaten human health

[52] Surface Water Quality Standards, Classes Uses, Criteria. Florida Department of Environmental Protection. Available here.

In the study area, Collier County has a robust program to track and report water quality data and materials are easily located on the county website.[53] Lee County has some data on their website, but the information is general, and most is outdated.[54] Charlotte County did not hire a water quality coordinator until 2021 or launch an ambient water quality monitoring program until June 2022.[55]

According to the FDEP verified list for the 2020-2022 Biennial Assessment there are four listed estuaries in Charlotte County (three for nitrogen and one for enterococci). There are 10 streams that are co-located in Charlotte and Lee Counties that are listed for e-coli. There are nine bodies (estuaries and streams) in Collier County that are listed for dissolved oxygen, E. coli, nitrogen/phosphorus, and two bodies that span Lee/Collier County are listed for E.coli and enterococci.[56]

> *"Engineering is important, but we can't engineer our way out of this… when talking about water we focus on 'quantity' but we should be focused on 'quality' … we are trying to use a shotgun when a rifle is what's needed"*
>
> *Captain*

There are an additional 12 reaches in the Caloosahatchee Estuary in Lee County and three that span Lee and Collier County that are being evaluated for listing. There are nine reaches that are under consideration in Charlotte County and seven in Charlotte Harbor.[57]

Key drivers of increased contamination and continued degradation in the Study Area are population growth, lack of growth management, and antiquated regulations. Population growth is rapid across Florida. According to the US Census Bureau, the Punta Gorda Metropolitan Statistical Area, which includes all of Charlotte County is the 5th largest area for population growth in the United States[58], followed by Lee County (9th), and Collier (12th).[59] Growth and development have the potential to impact water quality through changes in density and changes in ratios of pervious to impervious surfaces, which impacts not only the amount of contamination entering the ecosystem, but also the concentration of contaminants. Growth and development also can result in increased demand for and pressure on water, sewer, and wastewater treatment and management. The way that lawns are managed impacts runoff and nutrient concentrations in runoff. Increased traffic and use of automobiles and other forms of transportation increases brake dust (which contains heavy metals) and particulate matter which make their way into waterbodies through stormwater runoff.

In addition to the clear and tangible impacts of human population growth and resulting anthropogenic impacts on water quality, climate change is another human-related driver of chronic poor water quality. The ocean is the largest carbon sink on the planet. As carbon dioxide continues to accumulate in the atmosphere, more carbon is dissolved in the ocean, causing the water to become more acidic.[60] These conditions hinder calcification, impeding mollusks' and crustaceans' ability to grow strong shells. In

[53] Collier County Pollution Control Water Quality Reports and Maps. Available here.
[54] Lee County's Current Water Quality Status. Available here.
[55] Charlotte County Project Plan for Ambient Surface Water Monitoring Program. Available here.
[56] Florida Department of Environmental Protection. Comprehensive Verified List. Available here.
[57] Florida Department of Environmental Protection. Comprehensive Study List. Available here.
[58] Semon, Nancy. Gulfshore Business. November 4, 2023. Charlotte County Ranked Fifth-Fasted Growing Region in the Nation. Available here.
[59] Regan, Adam. Gulfshore Business. March 25, 2022. Lee Among 10 Fastest Growing Counties in the U.S. Available here.
[60] National Oceanic and Atmospheric Administration. Ocean Acidification. Available here.

addition, the acidification paired with increasing temperatures lead to coral reef bleaching events, which can kill the coral and destroy a critical habitat for countless aquatic species.[61] As waterbodies continue to fall outside their typical ranges for pH and temperature, the impacts on aquatic life will compound and result in serious habitat alterations and loss of life.

There are two issues at play when assessing the anthropogenic impact on water quality. One is the question of whether existing regulations are adequate to regulate and manage things like stormwater runoff, wastewater treatment, etc. The second is whether or not existing regulations, regardless of their stringency, are being correctly applied and enforced. Additional information on these two topics are available in Appendix J.

In summary, baseline water quality in the three-county study area is significantly degraded and that degradation continues and is accelerating. This means that when a single negative water quality event occurs (hurricane, flood, red tide, or blue green bloom) the system is already weakened and stressed. We know that if a human body is weakened through sequential shocks to the system or when an acute event occurs to a body weakened by chronic illness or disease, the body is less able, and less likely to fend off or survive an additional acute event. The same is true for species and ecosystem health. This is illustrated by Stevens et al. who examined the ability of Snook to rebound after an extreme freeze event in 2010 and found that for Snook in the Northern Indian River lagoon area, where the cold event was immediately followed by an algal bloom event, the species could not recover. While there was initial ability to resist the cold event, in subsequent years the Snook population failed to recover and four years later was still 65 percent below pre cold event levels.[62] While one study is not definitive, this example does illustrate the vulnerability of populations to multiple acute events. During our engagement with stakeholders in the three-county study area we heard multiple anecdotes (based on firsthand experience with fisheries) detailing loss of fish populations over time and observed increases in required recovery time following multiple, sequential negative water quality events, suggesting the need for further empirical investigation to better document these relationships. Several stakeholders suggested that the ecosystem in the Study Area may already have exceeded a tipping point, beyond which it may not be possible to recover. Additional information surrounding the tipping point concept is available in Appendix K.

[61] Florida Oceans and Coastal Council. 2009. The Effects of Climate change on Florida's Ocean and Coastal Resources: A Special Report to the Florida energy and Climate Commission and People of Florida. June. Available here.
[62] Ibid. Pg. 8. Available here.

5.2. Using the Research for Investment Decisions

Of utmost importance in understanding these impacts is to realize that there are different ways to quantify value in economics. For example, fishing expenditures and commercial fishing are important components of a regional economy that represent businesses and jobs. Consequently, potential losses in these areas signify that the economies in these counties may weaken with fewer jobs, income, and output than they would have otherwise. Similarly, the direct economic sector losses include fishing, recreation and tourism, ship building, and other water-based economic activities that suffer losses when water quality declines. Hence both metrics are of a similar type – they represent regional economic activity.

"Talking about these issues is not enough. It's like a run on the bank. Everyone tries to save their little piece without thinking about the big picture."
architect, developer, fisher

But if tourists did not come to southwest Florida because of poor water quality or HABs, those same tourists might well go elsewhere, and so those dollars are not likely lost to a global economy. And for these reasons (for example) expenditures like those used in the measures of fishing expenditures and direct sector economies are not typically used in metrics such as benefit cost analysis. In benefit cost analysis, the gains and losses are intended to focus on benefits or costs that would not otherwise occur absent a particular investment. But the property value losses, and the quality of life (non-market) losses are usually included in benefit cost analyses because they are gains and losses that would not occur in the absence of the investment, or the change that is the subject of the analysis.

Essentially it is most important to remember that these types of economic results are different kinds of economic metrics, each of which have different purposes. But if one were to add them up together, that would not be an appropriate economic metric because many of these measures have overlapping and interdependent features.

Finally, the losses that were tallied using the different metrics (fisheries, economy, property, and quality of life) are all quantified using an example of one HAB similar to the one that the Study Area experienced in 2018. But the purpose of developing this information is to better understand what is at risk from poor water quality so that communities can better assess the appropriate effort that is warranted to invest in water quality improvement projects. To do this, economists think about the future stream of benefits and compare those to the future stream of costs to be able to think about making long term decisions.

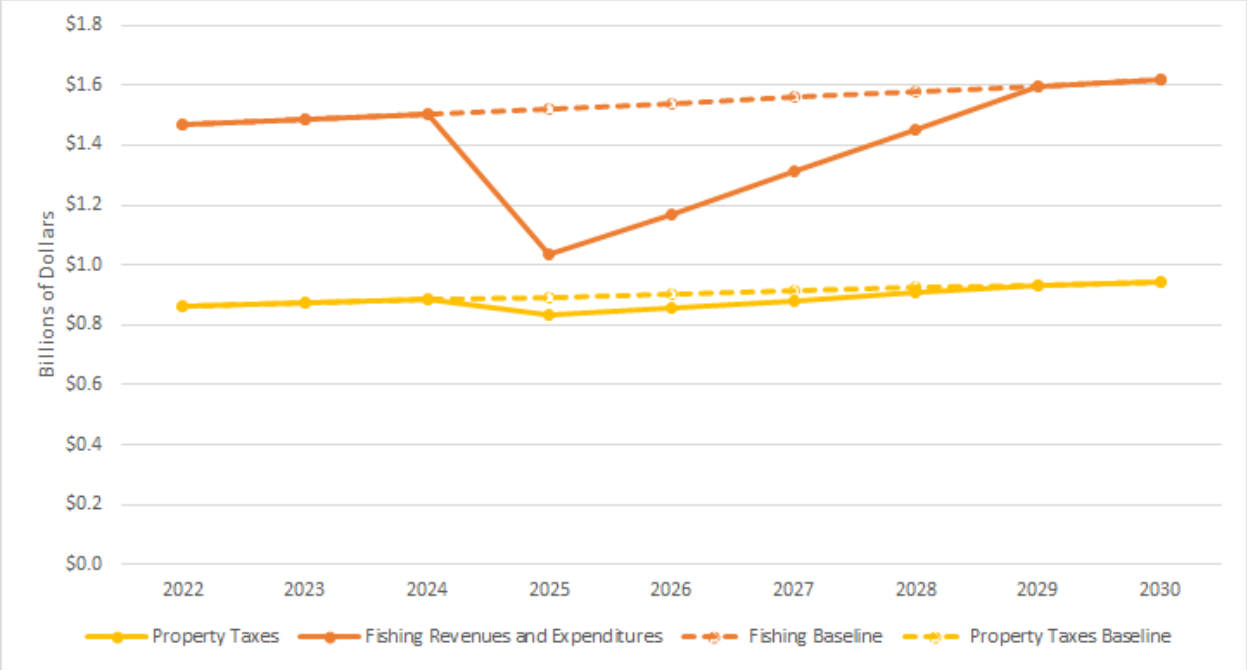
There is a great deal of uncertainty surrounding this. For example, we need to think about the future of HABs – how frequently will these occur? And how long will they last? When will the next one come? And will the economy and/or the ecosystem be able to recover from these losses if they come more frequently in the future? For this project, Greene Economics has developed some simple tools to help decision makers use the information about HAB economic losses as well as chronic water quality issues in southwest Florida to evaluate the investment in improved water quality. An example of some of the outputs is shown below. In the first scenario, the baseline metrics are all in place, and assumed to be increasing as the local economies grow. Then, a HAB arrives in 2025, and the losses are shown on the graph. In the following year it is assumed that the economy recovers after the bloom. The graph has two components because the magnitude of the dollar values is different for the different types of economic impact. For example, the starting point in 2022 is about $1.5 billion for total fishing values (in orange) and about $860 million for property taxes (in yellow), and both lines can be shown on the same chart.

Meanwhile, the starting values for economic activity (in blue) and for quality of life (in green) are $19.1 billion and $25.6 billion respectively, and those are shown in the second chart, with values that go up to $30 billion on the axis. This convention has been adopted so that the reader can view all four impact types on one visual. Figure 5-1 captures Scenario 1 impacts in 2023 dollars. The baseline values shown in dotted lines represent the value that would have occurred absent the HAB loss. Baseline economic growth estimates follow population projections for the three counties developed by the University of Florida.[63]

Figure 5-1: Scenario 1 – HAB in 2025 Assuming One Year Recovery Period

But given that poor water quality comes from many sources, it is also plausible that the ecosystem might take four years to fully recover, and in this case, the economic losses would persist for the additional three years. This is portrayed graphically in Figure 5-2 below showing Scenario 2.

[63] Florida Demographic Estimating Conference and the University of Florida, Bureau of Economic and Business Research, 2021. Florida Population Studies, Volume 54, Bulletin 189, April.



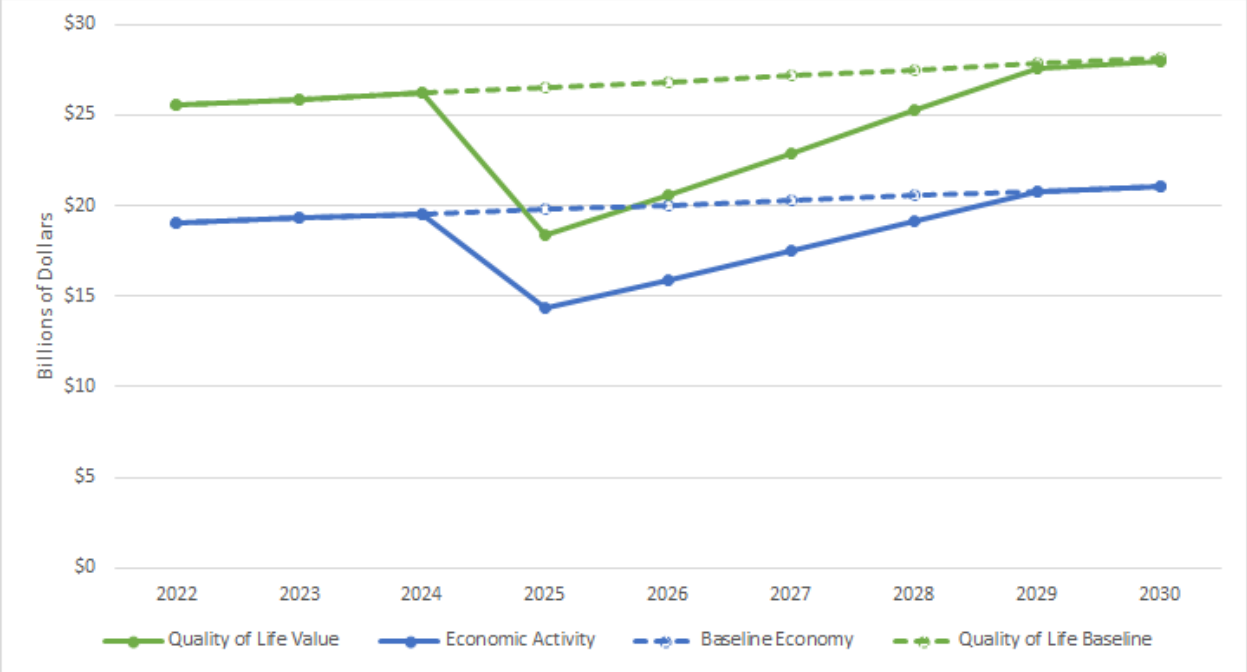


Figure 5-2: Scenario 2 – HAB in 2025 Assuming Four Year Recovery Period

Finally, another scenario shows how a second HAB on the heels of the first one could further delay the ecologic recovery and in doing so further aggravate the economic losses. For Scenario 3, a HAB is assumed to occur in 2025 with the assumed three-year recovery period. But then in 2027, before the economy has recovered fully, a second HAB occurs, further delaying, and calling into question the economic recovery at all.

Figure 5-3: Scenario 3 – HAB in 2025 Assuming Four Year Recovery Period, Followed by Another HAB in 2027 with Four Year Recovery Period

As demonstrated in the three scenarios, the long-term health of these ecosystems will be jeopardized if the southwest Florida region continues to be bombarded by HABs and other chronic water quality degrading events. Pollution prevention/reduction and restorative action can reduce the frequency and severity of harmful water quality events and make these ecosystems more resilient to the negative impacts HABs and other events have on ecosystems health. Investment, strategic growth and city planning, and public education regarding local water quality issues will also greatly impact the future of

these critical ecosystems and lessen the economic impact of water quality events. For example, a recent study found that those provided with information explaining the health and safety of certain commercially caught seafood during a HAB are 34 percent more likely to say they are willing to consume certain fish during a bloom compared to those who were not presented the seafood safety information.[64] While lack of action could lead to irreversible damage, and serious economic impacts, considerate investment and quick action could help restore southwest Florida into the ecological haven it once was and bring economic prosperity to the region.

[64] Bechard, A., and Lang, C. 2023. Seafood Consumption During Harmful Algal Blooms: The Impact of Information Regarding Safety and Health. Harmful Algae 123, 102387. March. Available here.

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Appendix A: Brief Introduction to Harmful Algal Blooms in Florida

In recent years, Harmful Algal Blooms (HABs) have become an increasingly relevant threat to the health and prosperity of coastal communities worldwide. An algal bloom is an event where local algae (microscopic or macroscopic plant-like organisms that exist within the uppermost layers of the ocean) populations explode over a short period of time, usually just a matter of a few days. Blooms are often a natural process, but can become harmful when their effects begin to negatively impact humans and wildlife. Among other issues, HABs have been linked to large coastal fish kills, and can produce toxins that contaminate beaches and lead to poisoning in humans. Over the past several decades, reports of HABs and their impacts have increased in frequency (Van Dolah, 2000), coinciding with growing concerns over climate change, and giving researchers reason to suspect that human activity is to blame.

In Florida and the Gulf of Mexico, an organism by the name of *Karenia brevis* is best known for being the culprit behind the reddish-brown waters which periodically wash up along the shores of the region's sub-tropical beaches. These waters, dubbed 'red tides' by locals, signify that a HAB has formed offshore. The development of a HAB can be triggered by a wide range of specific conditions, related to both human and natural processes (Sellner et al., 2003). Most often, algae exploit temporary circumstances involving high nutrient levels and ample sunlight to produce rapid growth. Elements such as nitrogen and phosphorus are essential for the development of most organic life, and while they are relatively common in nature, runoff water from human communities is made extremely nutrient rich through the use of fertilizers, automobiles, and sewage systems. These nutrients can build up over time before being carried away by heavy rainfall, flowing down through the watershed and into coastal waters. During seasons of low sunlight, growth can still be limited by a lack of light energy, which is required for photosynthesis, but in the spring and summer months a strong storm can often provide the perfect set of conditions to promote the formation of a HAB.

As climate change continues to modify and intensify natural phenomena, concerns about the increasing frequency of hurricanes and tropical storms have caused researchers to examine the potential effects this change might have on coastal communities. In 2020, Philips et al. looked at the relationship between hurricanes and HAB formation. They reasoned that heavy rainfall and high wind speeds would erode the soil and vegetation of the natural landscape and produce large amounts of nutrient-rich runoff water, which would in turn stimulate HAB growth. Florida was hit by a series of five hurricanes in 2004 and 2005 (Charley, Francis, Jeanne, Dennis and Wilma) and the HABs that followed these storms were shown to be intensified by the influx of nutrients added to the studied areas of the St. Lucie Estuary and the Indian River Lagoon by mandated water releases from Lake Okeechobee (Philips et al., 2020). Philips et al. also identified other factors that play a role in the timing of HABs, such as the impacts of the 2004 hurricanes being delayed until 2005 because of suspended sediments blocking sunlight and therefore primary production, as well as the long residence time (the average length of time it takes for a particle to move through a body of water) of the Indian River Lagoon producing a HAB that lasted for months.

Philips, Edward J., Susan Badylak, Natalie G. Nelson and Karl E. Havens. "Hurricanes, El Niño and harmful algal blooms in two sub-tropical Florida estuaries: Direct and indirect impacts." Scientific Reports 10, no. 1 (2020): 1910. https://doi.org/10.1038/s41598-020-58771-4.

Sellner, Kevin G., Gregory J. Doucette, and Gary J. Kirkpatrick. "Harmful algal blooms: causes, impacts and detection." Journal of Industrial Microbiology and Biotechnology 30 (2003): 383-406. https://doi.org/10.1007/s10295-003-0074-9.

Van Dolah, Frances M. "Marine algal toxins: origins, health effects, and their increased occurrence." Environmental Health Perspectives 108, no. suppl 1 (2000): 133-141. https://doi.org/10.1289/ehp.00108s1133.

Appendix B-1: Previous Research and Information Gathered

The research team premised this study on the idea that correctly interpreting the multiple types of economic benefits stemming from water quality changes (in terms of recreation, tourism, cleanup costs, fisheries, and overall quality of life) would be fundamental to the accuracy of the results. Two strategies were adopted to meet this goal. First, existing research on the economic impacts of water quality, coastal economies in general, water quality in general and other themes was reviewed, compiled, and summarized into a bibliographic database. Second, the researchers spent three days in southwest Florida to discuss this question with stakeholders and experts, and to learn about the background of water quality in Charlotte, Lee, and Collier Counties. The results of these activities are summarized in this chapter to set the stage for the subsequent analyses.

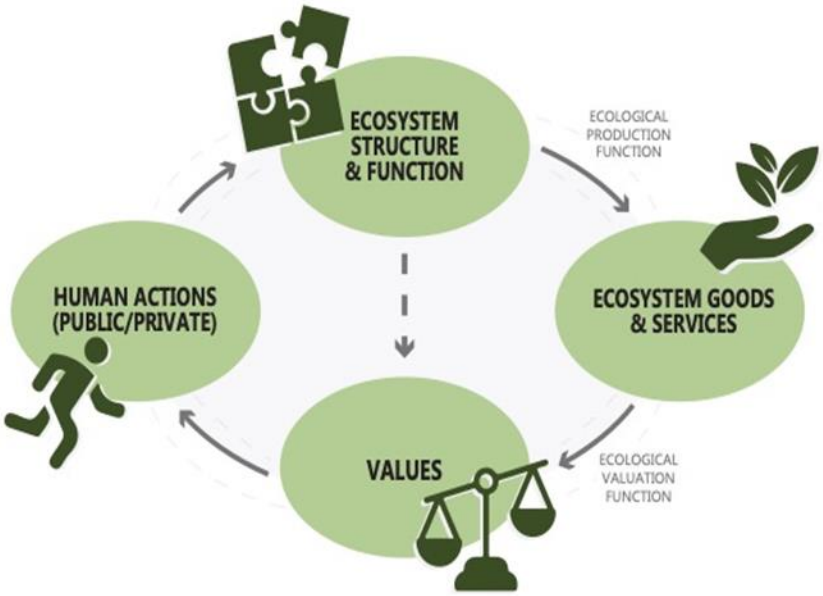


Figure B-1: Relationship between Ecosystem Services, Values, and Human Actions[65]

The figure above illustrates the relationship between policies, decisions, unexpected human actions and their influence the structure and function of ecosystems. The goods and services that we receive from the ecosystem can be affected (both positively and negatively) by actions and choices, and in turn the economic value of those ecosystem goods and services will change. Understanding those values more accurately helps communities make better decisions about how to manage the natural environment.

Bibliographic Database and Themes

The research team reviewed over one hundred sources related to the impacts of water quality on the southwest Florida economy. An annotated bibliographic database was developed to organize and summarize these documents, and is provided here as Appendix B. A summary of the economic values found in many of these documents is also provided with each of the monetary estimates updated to 2023

[65] Based on a figure from "Valuing Ecosystem Services: Toward Better Environmental Decision Making" National Research Council, published by the National Academies of Science, Engineering, and Medicine, 2005. This volume is available here.

dollar values. This summary table is provided in Appendix C. Each reference was assigned a unique number and letter combination within the database, which corresponds with when the resource was reviewed and the theme with which the research best fits. Sources were further classified by bibliographic citation. Each source offers unique insights into one of the many facets of the study, and when reviewed collectively these sources began to illuminate larger themes within the research. The following core themes and subthemes have been used to categorize the references contained in the database:

- Harmful Algal Blooms (HABs)
- Blue Economy (B)
- Tourism (T)
- Climate Change (C)
  - Failing Wastewater Infrastructure (WW)
  - Saltwater Intrusion (S)
  - Hurricanes (Hurr)
- Hypoxia (Hyp)
- Water Quality and Water Management (W)
- Fishing Industry (F)

For easy visual reference, the team developed a color-coding system within the Resource Database to categorize the references under their respective themes. Cells in Column A of the database are color coded according to the key below. Where more than one theme is present, the reference is coded to the primary theme.

	Harmful Algal Blooms		Saltwater Intrusion
	Blue Economy		Hurricanes
	Tourism		Hypoxia
	Climate Change		Water Quality/Management
	Failing Wastewater Infrastructure		

Harmful Algal Blooms

The team gathered and reviewed twenty-three references regarding harmful algal blooms (HABs), many of which include estimates of the economic impact HAB events have on coastal economies, particularly in Florida. Included in this list are Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida (HAB-1),[66] Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Toward Shore (HAB-3),[67] Assessing the Economic Consequences of Harmful Algal Blooms (HAB-

[66] Bechard, Andrew. 2020. Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida. The Review of Regional Studies (50): 170-188. Available here.
[67] Bechard, Andrew. 2020. Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Towards the Shore. Journal of Real Estate Finance 62:242-257. Available here.

5),[68] Quantifying the Socioeconomic Impacts of Harmful Algal Blooms in Southwest Florida (HAB-7),[69] Florida Department of Environmental Protection (FDEP) algal bloom sampling results (HAB-19),[70] and Florida Fish and Wildlife Conservation Commission (FWC) HAB events and water quality data sets (HAB-22).[71]

There are several resources available to monitor HAB events. The FWC provides an interactive map with daily water sampling data and red tide events along with weekly reports of red tide events in southwest Florida (HAB -13).[72] The FWC also provides annual datasets from 2017 through 2022 that include water quality information in the HAB monitoring database (HAB-21).[73] The data can be narrowed down by specific sampling locations. The FDEP provides a similar weekly report to that of the FWC, but for blue-green algae blooms, which occur in fresh water like Lake Okeechobee (HAB-15).[74] The Watershed Information Network (WIN) is available through the FDEP as well. This source allows the user to access water quality data by county in the state of Florida. Due to the frequency of HAB events and the potential harm they pose, the state and other organizations have created several data repositories dedicated to water quality and HAB tracking.

Red tides are the most well-known HAB events that occur along the southwest Florida coast. Though these events generally occur every few years, *Karena brevis*, the algae that red tides are composed of, can have serious, long lasting environmental, economic, and public health impacts. While some red tides run their course within a few days, other blooms can last multiple months, leaving behind copious amounts of dead sea life and posing a public health concern for an extended period of time (HAB-1).[75] According to a study released in 2022 titled Nitrogen-Enriched Discharges from a Highly Managed Watershed Intensify Red Tide Blooms in Southwest Florida, nitrogen-enriched discharges from the Caloosahatchee River have consistently intensified red tide blooms to varying degrees over time, particularly those released during the earliest stages of blooms. During the earliest stages of a bloom, the algae go through growth and maintenance stages, which is when they require the most nutrients (HAB-14).[76] The correlation is not consistently precise between algae blooms and the release of excess nitrogen because other conditions must be met to support a large algal bloom. However, anthropogenic impacts have clearly led to the increased severity and frequency of these events both along the coast and in bodies of freshwater like Lake Okeechobee.

[68] Adams, C., et al. 2018. Assessing the Economic Consequences of Harmful Algal Blooms: A Summary of Existing Literature, Research Methods, Data, and Information Gaps. Harmful Algal Blooms: A Compendium Desk Reference. Available here.
[69] Court, Christa, at al. 2021. Quantifying the Socio-Economic Impacts of Harmful Algal Blooms in Southwest Florida in 2018. July. Available here.
[70] Florida Department of Environmental Protection. Algal Bloom Sampling Results. Available here.
[71] Florida Fish and Wildlife Conservation Commission. Harmful Algal Bloom Events. Three Datasets accessed: 2000 to 2006, 2007 to 2014, 2015 to present. Available here.
[72] Florida Fish and Wildlife Conservation Commission. Red Tide Current Status. Available at: https://myfwc.com/research/redtide/statewide/.
[73] Florida Fish and Wildlife Conservation Commission. HAB Monitoring Database. Available here.
[74] Florida Department of Environmental Protection. 2019. Blue-Green Algae Bloom Weekly Update. Available here.
[75] Bechard, Andrew. 2020. Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida. The Review of Regional Studies (50): 170-188. Available here.
[76] Medina, M., et al. 2022. Nitrogen-Enriched Discharges From a Highly Managed Watershed Intensify Red Tide (Karenia brevis) Blooms in Southwest Florida. Science of the Total Environment. Available here.

HABs and the toxins they release can cause coughing and eye irritation along with other harsher medical conditions (HAB-14).[77] In addition, the presence of these blooms has a negative impact on many sectors of the local economy. Lodging, restaurant, fishing, and seafood industries were found to suffer noticeable losses during months with red tide events across the sources reviewed, dropping up to 35 percent below their average monthly revenues during the months of red tide incidence (HAB-11).[78] In addition, red tide events have a notable impact on property value. In a 2020 report in the Journal of Real Estate Finance, it noted that homes within a mile of the coast in counties affected by a red tide event sell for up to 30 percent less than homes in the same range in unaffected counties during the same month (HAB-3).[79] Ultimately, most coastal sectors are impacted in some way by red tide events. The fishing and seafood industry suffer losses through reduced harvests and declines in tourism. Lodging, restaurants, and other tourism-based sectors suffer losses in revenue due to the smell of decaying algae and dead fish, toxins affecting human health, and unappealing aesthetic left by mountains of algae on the beach that keep tourists away (HAB-1).[80] Even the housing market suffers (HAB-3).[81] Below are some of the economic impact estimates provided within the reviewed sources including individual sectors, total impact across the state and references to specific red tide events.

- After considering beach clean-up and impacted commercial oyster harvests, the estimated direct impact of a red tide event in Galveston Texas in 2000 was between $9.9 and $11.5 million, and the total impact was closer to $16 to $18.5 million. The event impacted between 367 and 426 jobs. (HAB-2)[82]
- At Lake Erie, a 2014 HAB event cost around $65 million ($18 million for property value, $20 million for tourism, $23 million for recreation, and $4 million for water treatment). (HAB-16)[83]
- The Florida Department of Health estimates that the state loses $22 million annually during HAB events, most of which is lost from commercial fishing and tourism. (HAB-17)[84]
- The estimated costs of physical and economic damages from the 2018 red tide were approximately $130.6 million. The industries most impacted by the red tide were vacation home rentals, charter boat rentals, hotels, and restaurants, which led to a loss in employment and personal income. (B-1)[85]

[77] Ibid.
[78] Larkin, S., Adams, C. 2007. Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida. Society and Natural Resources 20:849-859. Available here.
[79] Bechard, Andrew. 2020. Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Towards the Shore. Journal of Real Estate Finance 62:242-257. Available here.
[80] Bechard, Andrew. 2020. Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida. The Review of Regional Studies (50): 170-188. Available here.
[81] Bechard, Andrew. 2020. Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Towards the Shore. Journal of Real Estate Finance 62:242-257. Available here.
[82] Evans, Garen and Jones, Lonnie. 2001. Economic Impacts of the 2000 red Tide on Galveston County, Texas A Case Study. Prepared for Texas Parks and Wildlife State of Texas. Available here.
[83] Veritas Economic Consulting and Environmental Consulting & Technology, Inc. 2015. Economic Benefits of Reducing Harmful Algal Blooms in Lake Erie. Submitted to the International Joint Commission. September. Available here.
[84] Florida Department of Health. Harmful Algal Blooms - Economic Impacts. Available here.
[85] Florida Ocean Alliance. 2020. Securing Florida's Blue Economy: Strategic Plan for Florida's Oceans and Coasts. June. Available here.

Blue Economy

The Blue Economy refers to "businesses and jobs in industries with direct ties and connections to the ocean" (B-3).[86] As Florida is almost entirely surrounded by ocean, its coastal and ocean related industries are highly important to the state's economy as a whole. The team reviewed six sources that focus solely on the blue economy of Florida. Securing Florida's Blue Economy (B-1),[87] Florida: From Ocean Economy to Blue Economy (B-2),[88] Developing the blue Economy of Florida's Gulf Coast (B-3),[89] Phase 1: Florida's Ocean and Coastal Economies Report (B-4),[90] A Global Synthesis of the Economic Multiplier Effects of Marine Sectors (B-5)[91] and Coastal and Heartland National Estuary Partnership Economic Valuation (B-6).[92]

Important Findings and Values

The blue economy is booming and is valued at over 75 percent of the state's economy (B-1). Industries reliant on the ocean and coast provide over a million jobs across the states (B-1).[93] These industries include recreation, fishing, lodging, restaurants, and other tourism-related sectors. Without ocean and coastal resources like sea grass, mangroves, oysters, crab, fish, and wildlife, the marine economy would cease to exist. Coastal ecosystems and the flora and fauna within these ecosystems also provide other services that are only just beginning to be considered or monetized. The report written by Charles Cogan titled Florida: From Ocean Economy to Blue Economy notes that ecosystem services provided by Florida's coastline like carbon sequestration and storm surge protection should be considered when valuing these resources and their importance to the state (B-2).[94] The coastline also provides aspects like national defense, education and research opportunities, and natural capital. Essentially, the coastline and its resources are critical to the state's economy and therefore the health of these resources should also be highly valued. For the Coastal and Heartland National Estuary region, investments in restoration have resulted in returns that are 3.4 times the amount spent on the restoration projects (B-6).[95] Below are more values highlighting just how important the Blue Economy is to the state and southwest Florida.

[86] Gulf Coast Community Foundation. 2015. Developing the Blue Economy of Florida's Gulf Coast: A Strategic Roadmap for Innovation and Growth in the Marine Sciences Cluster. Available here.
[87] Florida Ocean Alliance. 2020. Securing Florida's Blue Economy: Strategic Plan for Florida's Oceans and Coasts. June. Available here.
[88] Colgan, Charles. Florida: From Ocean Economy to Blue Economy. Center for the Blue Economy, Middlebury Institute of International Studies at Monterey.
[89] Gulf Coast Community Foundation. 2015. Developing the Blue Economy of Florida's Gulf Coast: A Strategic Roadmap for Innovation and Growth in the Marine Sciences Cluster. Available here.
[90] Kildow, J. 2006. Phase 1: Florida's Ocean and Coastal Economics Report. NOEP. June. Available here.
[91] Jacobsen, I, et al. 2014. A Global Synthesis of the Economic Multiplier Effects of Marine Sectors. Marine Policy, 44: 273-278. February. Available here.
[92] The Balmoral Group. 2020. Coastal and Heartland National Estuary Partnership (CHNEP) Economic Valuation. September. Available here.
[93] Florida Ocean Alliance. 2020. Securing Florida's Blue Economy: Strategic Plan for Florida's Oceans and Coasts. June. Available here..
[94] Colgan, Charles. Florida: From Ocean Economy to Blue Economy. Center for the Blue Economy, Middlebury Institute of International Studies at Monterey.
[95] The Balmoral Group. 2020. Coastal and Heartland National Estuary Partnership (CHNEP) Economic Valuation. September. Available here.

- Florida's coastal counties generated more than $797 billion in economic value or 77% of the state's more than $1 trillion economy. (B-1).[96]
  - Direct and indirect use of ocean and coastal resources contributed $73.9 billion to the state's economy.
  - More than one million jobs in Florida were directly and indirectly created by activities that used ocean and coastal resources.
- In 2003, Florida's Direct Ocean Economy (GSP) was an estimated $13 billion, and Florida's total Ocean Economy that same year (including multipliers) was an estimated $23.2 billion (B-4).[97]
- Overall economic multiplier effect for global marine industries is 1.82. (B-5).[98]
- Natural resources in the Coastal and Heartland National Estuary Partnership region generate more than $13.6 billion in total output, $3.8 billion in regional income, $146 million in local and state tax revenues and support more than 148,000 jobs annually. Proximity premiums associated with natural resources contribute an additional $381 million in annual benefits. (B-6).[99]
  - Returns from natural resource-related spending have outweighed costs by 3.4:1, meaning that for every dollar spent on restoration, they have received $3.40 in returns.

Tourism

Tourism plays a huge role in Florida's economy. People travel from far and wide to enjoy the beaches, wildlife, and other attractions Florida has to offer. From snowbirds that stay for months in the winter to weekend vacationers, there are activities that everyone can enjoy. The team reviewed three reports centered around tourism in Florida and its impact on the economy: Estimating the Economic Impact of Natural Hazards on Shared Accommodation in Coastal Tourism Destination (T-1),[100] How Hurricanes Impact Florida's Tourism Economy (T-2),[101] and Florida's Tourism Economy Experiences Another Record Year in 2019 but Shifts to a Lower Gear of Growth (T-3).[102] Many other sources mention the tourism industry as it relates to water quality and the economy. The key values from those sources have been added to the section below.

The Florida economy, particularly the coastal economy, is built upon tourism. Tourism alone accounts for nearly 6 percent of the state's GDP (T-2).[103] Many sectors like lodging, restaurants and certain recreational

[96] Florida Ocean Alliance. 2020. Securing Florida's Blue Economy: Strategic Plan for Florida's Oceans and Coasts. June. Available here.
[97] Kildow, J. 2006. Phase 1: Florida's Ocean and Coastal Economics Report. NOEP. June. Available here.
[98] Jacobsen, I, et al. 2014. A Global Synthesis of the Economic Multiplier Effects of Marine Sectors. Marine Policy, 44: 273-278. February. Available here.
[99] The Balmoral Group. 2020. Coastal and Heartland National Estuary Partnership (CHNEP) Economic Valuation. September. Available here.
[100] Chen, Y., et al. 2021. Estimating the Economic Impact of Natural Hazards on Shared Accommodation in Coastal Tourism Destinations. Journal of Destination Marketing & Management 21. Available here.
[101] Huang, A. 2021. How Hurricanes Impact Florida's Tourism Industry.
[102] Rockport Analytics. 2019. Florida's tourism Economy Experiences Another Record Year in 2019 But Shifts Into a Lower Gear of Growth: 2019 contribution of Travel and Tourism to the Florida Economy. Available here.
[103] Huang, A. 2021. How Hurricanes Impact Florida's Tourism Industry.

activities rely on tourists to generate revenue. The importance of tourism in Florida, particularly southwest Florida is highlighted in the values included below:

- In a case study of the effects of Hurricane Irma on Airbnb properties in Collier County in 2017, the estimated direct combined losses were $22,683,054. (T-1).[104]
- In 2019, before the COVID 19 pandemic, the Florida tourism sector accounted for nearly 6 percent of real state GDP, 14 percent of total employment, and 15 percent of sales tax revenue. (T-2).[105]
- Tourism is another heavily impacted sector. One study titled the Impacts of Red Tide in Peer-to-Peer Accommodations found a red tide event resulted in $317 million in Airbnb sales revenue lost across the state of Florida. (HAB-9).[106]
- Florida's beaches and near shore coastal waters draw more than 33 million tourists to Florida each year, contributing more than $56 billion and more than 900,000 jobs to the economy. (W-3).[107]
- As of 2015, in Lee County tourism generates more than $3 billion annually. (W-15).[108]

Climate Change 

The team reviewed nine resources related to climate change and its current and potential future impact on Florida. Some key reports include Climate Change and Sea Level Rise in Florida (C-2),[109] Economic Impacts of Climate Change on Florida: Estimations from Two Studies (C-4),[110] and Impact of Climate Change on Florida Economy Could be Huge (C-5).[111]

Climate change results in long term chronic issues like sea level rise, change in ocean pH, and increase in temperature. Climate change also increases the frequency and severity of severe, distinguishable events like hurricanes, heat waves, rain events, floods, and king tides. Both types of issues impact Florida's coastline and its blue economy. The world's oceans have become 30 percent more acidic than they were in 1750 due to the rise in temperature and excess carbon absorbed by the water (C-1).[112]

Increased acidity and temperature impact coral reefs found around Florida and the many species that rely on coral reefs for food and habitat. In turn, this impacts the fishing and recreation industries. Sea level rise is another chronic problem. Over 75 percent of Florida's population lives in coastal counties and the

[104] Chen, Y., et al. 2021. Estimating the Economic Impact of Natural Hazards on Shared Accommodation in Coastal Tourism Destinations. Journal of Destination Marketing & Management 21. Available here.
[105] Huang, A. 2021. How Hurricanes Impact Florida's Tourism Industry.
[106] Ferreira, Joao- Pedro, et al. 2022. Impacts of Red Tide in Peer-to-Peer Accommodations: a Multi-Regional Input-Output Model. Tourism Economics 0:1-23. Available here..
[107] Florida Oceans and Coastal Resources Council. Investing in Florida's Coastal and Oceans Future. Available here.
[108] Sanibel Florida. 2016. Caloosahatchee Watershed Regional Water Management Issues. Endorsed by Sanibel Captiva Conservation Foundation. Available here.
[109] Florida Oceans and Coastal Council. 2010. Climate Change and Sea-Level Rise in Florida: an Update of the Effects of Climate Change on Florida's Oceans and Coastal Resources. December. Available here.
[110] Borisova, Tatiana, et al. 2021. Economic Impacts of Climate change on Florida: Estimates from Two Studies. University of Florida. September. Available here.
[111] Trigaux, Robert. 2014. Impact of Climate Change on Florida Economy Could Be Huge. May 7. Available here.
[112] Florida Oceans and Coastal Council. 2009. The Effects of Climate change on Florida's Ocean and Coastal Resources: A Special Report to the Florida energy and Climate Commission and People of Florida. June. Available here.

built environment and infrastructure is projected to reach $3 trillion in value by 2030 (C-2).[113] Sea level rise could force these communities inland and destroy trillions of dollars' worth of built infrastructure. The next three subsections, failing wastewater infrastructure, saltwater intrusion, and hurricanes, are all climate change related threats that impact water quality. More details on those threats will be included in the following sections. Below are general climate change values and the potential future impact they could have in Florida:

- By the year 2100, the sea level could rise between 1-3 feet. One foot of sea level rise could erode 100-200 feet up on beaches. (C-4).[114]
  - By 2050, projected hurricane damages are predicted to be $24 billion and result in 18 deaths annually under a rapid stabilization scenario, and $49 billion and 37 deaths under the business-as-usual scenario.
- The Everglades and Florida Keys stand to lose $9 billion from tourism from 2014 to 2025 thanks to sea level rise and $40 billion by the 2050s. (C-5).[115]

Failing Wastewater Infrastructure

In Florida, failing wastewater infrastructure is exacerbated by climate change, particularly higher sea levels, more storms and flooding and more frequent and intense hurricanes. The team reviewed three reports focused on wastewater infrastructure: Florida Must Move Waterfront Wastewater Treatment Plants at All Costs (WW-1),[116] The Invading Sea: Florida and the Climate Crisis (WW-2),[117] and Phillippi Creek Septic System Replacement Program (WW-2).[118]

Climate change has caused the sea level to rise and increased the severity of rain events, and septic tanks can develop issues with old age. In many places, this combination has pushed the water table higher in the ground, especially near the coast (WW-2). For a state so reliant on septic tanks, this is a problem. Septic tanks cannot function properly if they are right above or submerged in groundwater, as it causes them to leak fecal material into the groundwater. In 2019, 56 percent of septic tanks in Miami malfunctioned for at least part of the year (WW-2).[119] Fecal material, nitrogen and phosphorous can then easily make its way into local waterways and contaminate the environment, contaminate drinking water, and contribute to HABs. With over 2 million septic systems in the state, this is a serious issue that will cost billions to address.

Some wastewater treatment centers pose another water quality threat. During rain events and major floods, wastewater treatment centers do not have the capacity to receive a large influx of stormwater. As

[113] Florida Oceans and Coastal Council. 2010. Climate Change and Sea-Level Rise in Florida: an Update of the Effects of Climate Change on Florida's Oceans and Coastal Resources. December. Available here.
[114] Borisova, Tatiana, et al. 2021. Economic Impacts of Climate change on Florida: Estimates from Two Studies. University of Florida. September. Available here.
[115] Trigaux, Robert. 2014. Impact of Climate Change on Florida Economy Could Be Huge. May 7. Available here.
[116] Killer, Ed. 2020. Florida Must Move Waterfront Wastewater Treatment Plants at all Costs. October. Available here.
[117] The Invading Sea: Florida and the Climate Crisis. 2019. Failing Septic Tanks are Demanding Florida's Environment and Will Cost Billions of Dollars to Replace. May 23. Available here.
[118] Hazen and Sawyer and Ayres Associates. 2000. Phillippi Creek Septic System Replacement Program Final Report Volume 1. Prepared for Sarasota County Environmental Services. September. Available here.
[119] Ibid.

a result, they release millions of gallons of water into local waterways and estuaries (WW-1).[120] Untreated stormwater contains water of very poor quality and often includes pharmaceuticals, bacteria, excess nitrogen, excess phosphorous, and other harmful substances that can wreak havoc on an ecosystem. Even large releases of treated water can disturb salinity levels in estuaries and result in harmful effects on ecosystems (WW-1).[121] Unfortunately, many wastewater treatment centers exist along the coast, making them susceptible to storms and more likely to impact critical habitat if called upon to release great quantities of water, and moving them inland can cost upward of $130 million.

- Florida is home to 2.6 million septic tanks. (WW-2).[122]
  - In 2016, it was estimated that Florida communities would need to spend $18 billion to address the wastewater infrastructure crisis.
  - In 1999, it cost Monroe County $1 billion to convert 33,000 septic tanks to centralized sewer systems.

Saltwater Intrusion 

The team reviewed seven sources touching on saltwater intrusion along the east coast. Some key reports include Saltwater Intrusion, a Slow Poison to East Coast Drinking Water (S-1),[123] Saltwater Intrusion in Coastal Aquifers: the Inland Migration of Saltwater Poses a Threat to Water Supply and Critical Freshwater Habitats (S-3),[124] The Invisible Flood: The Chemistry, Ecology, and Social Implications of Coastal Saltwater Intrusion (S-4),[125] and Assessing the Impacts of Saltwater Intrusion in the Carolinas Under Future Climatic and Sea Level Conditions (S-5).[126]

Groundwater yields 64 percent of Florida's freshwater supply (S-6).[127] This water is contained in aquifers, water bearing rocks or sand below the ground's surface. Where aquifers meet the ocean, there exists the possibility of saltwater moving inland, polluting these water sources. Sea level rise, drought conditions, and increased use of these aquifers due to Florida's expanding population reduce the water pressure exerted against the saltwater interface and slowly allows saltwater to infiltrate these valuable water

[120] Killer, Ed. 2020. Florida Must Move Waterfront Wastewater Treatment Plants at all Costs. October. Available here.
[121] Ibid.
[122] The Invading Sea: Florida and the Climate Crisis. 2019. Failing Septic Tanks are Demanding Florida's Environment and Will Cost Billions of Dollars to Replace. May 23. Available here.
[123] Richter, Hannah. 2022. Saltwater Intrusion, a "Slow Poison" to East Coast Drinking Water. August 2. Available here.
[124] Smith, Karin, and Esterson, Kristopher. 2022. Saltwater Intrusion in Coastal Aquifers: The Inland Migration of Saltwater Poses a Threat to Water Supply and Critical Freshwater Habitats. South Florida Water Management District. August 3. Available here.
[125] Tully, Kate, et al. 2019. The Invisible Flood: The chemistry, Ecology, and Social Implications of Coastal Saltwater Intrusion. BioScience 69: 368-378. May. Available here.
[126] Carolinas Integrated Sciences and Assessments, and South Carolina Sea Grant Consortium. 2012. Assessing the Impacts of Saltwater Intrusion in the Carolinas Under Future Climatic and Sea Level Conditions. December. Available here.
[127] Neeley, Josiah and Carvajal, Tony. 2023. Be Prepared: Water Quality and Climate Change in Florida. Florida TaxWatch. Available here.

resources (S-3).[128] Economic and environmental consequences of saltwater intrusion include degradation of natural ecosystems and the contamination of municipal, industrial, and agricultural water supplies (S-5).[129] This phenomenon has already cost an island community (Hilton Head, South Carolina) over $100 million to address (S-1),[130] and some coastal communities have resorted to purchasing water from nearby towns because their wells have become polluted due to saltwater intrusion (S-2).[131]

The South Florida Water Management District (SFWMD) pulls water samples from coastal wells to monitor the inland movement of saltwater every five years. The data can be accessed in the SFWMD environmental database. The US Geographical Survey (USGS) also collects water level and salinity samples which can be viewed using their Water Level and Salinity Analyses Mapper webtool (S-3).[132]

- The Hilton Head community on the East coast spent $129 million from 1998 to 2022 to construct a pipeline for treated mainland surface water and to build and operate a reverse osmosis water treatment facility and aquifer storage and recovery facility. (S-1)[133]
  - The community will likely spend an additional $80 million on maintenance and upgrades over the next 20 years.
- The community of Port Richey Florida spends $50 to $60 thousand a month to access clean water from another town now that saltwater intrusion has made several of their wells inoperable. (S-2)[134]
- Groundwater provides 64 percent of Florida's freshwater supply but as sea level rises, an increase in hydraulic backpressure could reverse this process, causing saltwater to move inland and contaminate freshwater supplies. (S-6)[135]

Hurricanes

Hurricanes not only leave behind a trail of devastation, but also hurt local economies and seriously reduce local water quality. The team reviewed two sources centered on hurricane impacts: A Supercharged

[128] Smith, Karin, and Esterson, Kristopher. 2022. Saltwater Intrusion in Coastal Aquifers: The Inland Migration of Saltwater Poses a Threat to Water Supply and Critical Freshwater Habitats. South Florida Water Management District. August 3. Available here.
[129] Carolinas Integrated Sciences and Assessments, and South Carolina Sea Grant Consortium. 2012. Assessing the Impacts of Saltwater Intrusion in the Carolinas Under Future Climatic and Sea Level Conditions. December. Available here.
[130] Richter, Hannah. 2022. Saltwater Intrusion, a "Slow Poison" to East Coast Drinking Water. August 2. Available here.
[131] Napper, Robert. 2013. Saltwater Intrusion of Port Richey Wells Could Cost Residents for Years to Come. April 26. Available here.
[132] Smith, Karin, and Esterson, Kristopher. 2022. Saltwater Intrusion in Coastal Aquifers: The Inland Migration of Saltwater Poses a Threat to Water Supply and Critical Freshwater Habitats. South Florida Water Management District. August 3. Available here.
[133] Richter, Hannah. 2022. Saltwater Intrusion, a "Slow Poison" to East Coast Drinking Water. August 2. Available here.
[134] Napper, Robert. 2013. Saltwater Intrusion of Port Richey Wells Could Cost Residents for Years to Come. April 26. Available here.
[135] Neeley, Josiah and Carvajal, Tony. 2023. Be Prepared: Water Quality and Climate Change in Florida. Florida TaxWatch. Available here.

Atlantic Hurricane Season: How Wetter Storms Exacerbate Florida's Sewer Pollution Crisis (Hur-1)[136] and How Hurricane Ian and Other Storms Impact Water Quality (Hur-2).[137] Hurricanes and their impacts were included in sources from other themes as well. Findings from those reports are included below in addition to the findings from the sources under this theme.

Hurricane winds and storm surges destroy more than homes and businesses. They also have the potential to impact wastewater treatment facilities and drinking water utilities. The destruction of these facilities can result in the release of dirty stormwater into natural waterways. Storm surges and floods associated with hurricanes can also carry pollutants from homes, agricultural fields, and industrial facilities into bodies of water. Nitrates in freshwater can lead to baby blue syndrome or cancer. Other diseases like cholera, hepatitis, dysentery, and bacteria can be in the water as well (Hur-2).[138] In the aftermath of Hurricane Ian there were 65 documented cases of flesh-eating bacteria, resulting in the death of 11 people (Hur-1).[139] Due to the disturbance and excess nutrients carried back into the ocean after a hurricane, these events have even been tied with red tide events (W-24).[140] Ultimately, the negative impact hurricanes have on water facilities and water quality poses a significant threat to public health, the environment, and the industries reliant on good water quality.

- Hurricane Ian resulted in 7.2 million gallons of spilled sewage in the Indian River Lagoon. (Hur-1)[141]
- Hurricane Sandy compromised over 690 wastewater and drinking water utilities across 11 states. (Hur-2)[142]
  - Hurricane Katrina compromised over 200 wastewater treatment facilities and 1,220 drinking water systems.
- In a case study of the effects of Hurricane Irma on Airbnb properties in Collier County in 2017, the estimated direct combined losses were $22,683,054 and the indirect losses to rental incomes were as high as $19,120 per day. (T-1)[143]
- Tourism businesses in counties affected directly by hurricanes are associated with lower tax growth rates than those in counties largely unaffected by hurricanes. (T-2)[144]

[136] Haydocy, Emma. 2022. A Supercharged Atlantic Hurricane Season: How Stronger, Wetter Storms Exacerbate Florida's Sewage Pollution Crisis. October 17. Available here.
[137] Kightlinger, Diana. 2022. How Hurricane Ian and Other Storms Impact Water Quality. December 1. Available here.
[138] Kightlinger, Diana. 2022. How Hurricane Ian and Other Storms Impact Water Quality. December 1. Available here.
[139] Haydocy, Emma. 2022. A Supercharged Atlantic Hurricane Season: How Stronger, Wetter Storms Exacerbate Florida's Sewage Pollution Crisis. October 17. Available here.
[140] Bayles, T. 2023. Water Quality Report for Southwest Florida. March 26. Available here.
[141] Haydocy, Emma. 2022. A Supercharged Atlantic Hurricane Season: How Stronger, Wetter Storms Exacerbate Florida's Sewage Pollution Crisis. October 17. Available here.
[142] Kightlinger, Diana. 2022. How Hurricane Ian and Other Storms Impact Water Quality. December 1. Available here.
[143] Chen, Y., et al. 2021. Estimating the Economic Impact of Natural Hazards on Shared Accommodation in Coastal Tourism Destinations. Journal of Destination Marketing & Management 21. Available here.
[144] Huang, A. 2021. How Hurricanes Impact Florida's Tourism Industry.

  - The negative effect was not equal across the state; rural counties seem to bear the brunt of it. Whether or not a county was along the state's coastline mattered too. Coastal counties with hurricanes had lower tourism sales tax rates than coastal counties without hurricanes.

- By 2050, projected hurricane damages are predicted to be $24 billion and result in 18 deaths annually under a rapid stabilization scenario, and $49 billion and 37 deaths under the business-as-usual scenario. (C-4)[145]
- In 2017, Hurricane Harvey caused $125 billion in damages in the first 24 hours and forced 39,000 people out of their homes due to flooding. (W-1)[146]

Hypoxia

The team reviewed two studies and two data sources related to hypoxic events in the Gulf of Mexico. The Ecological and Economic consequences of Hypoxia (Hyp-1)[147] and Seafood Prices Reveal Impacts of a Major Ecological Disturbance (Hyp-2)[148] examine how hypoxic events impact marine species. The Gulf of Mexico Hypoxia Watch (Hyp-3)[149] and Northern Gulf of Mexico Hypoxic Zone (Hyp-4)[150] are two hypoxia data sources produced by NOAA.

The Gulf of Mexico contains a hypoxia zone of varying size every summer where the dissolved oxygen levels are equal to or less than 2mg/L due to a combination of conditions (Hyp-2).[151] NOAA releases a size estimate of the summer hypoxic zone in the Gulf every spring by considering nitrogen loading in the Gulf through four nitrogen-based models (Hyp-4).[152] Fish and benthic marine communities experience varying degrees of community mortality during hypoxic events (Hyp-1).[153] However, due to lack of data, the impact of other environmental stressors, and the fluid nature of fish, it is unclear how these events impact the fishing industry. A more recent study titled Seafood Prices Reveal Impacts of a Major Ecological Disturbance found that hypoxia can skew a population's size distribution toward smaller individuals (Hyp-2).[154] For example, hypoxia results in a decrease in the quantity of large shrimp relative to small shrimp, which increases the price of large shrimp relative to small shrimp (Hyp-2).[155] Again, this study notes that

[145] Borisova, Tatiana, et al. 2021. Economic Impacts of Climate change on Florida: Estimates from Two Studies. University of Florida. September. Available here.
[146] TBD Economics. 2021. The Economic Value of America's Estuaries. Prepared for Restore America's Estuaries. June. Available here.
[147] Diaz, R., and Solow, A. 1999. Ecological and Economic Consequences of Hypoxia: Topic 2 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 16. May. Available here.
[148] Smith, D., Martin, et al. 2017. Seafood Prices Reveal Impacts of a Major Ecological Disturbance. Biological Sciences 114(7) 1512-1517. January 30. Available here.
[149] NOAA. Gulf of Mexico. Available here.
[150] United States Environmental Protection Agency. 2022. Northern Gulf of Mexico Hypoxic Zone. Available here.
[151] Smith, D., Martin, et al. 2017. Seafood Prices Reveal Impacts of a Major Ecological Disturbance. Biological Sciences 114(7) 1512-1517. January 30. Available here.
[152] United States Environmental Protection Agency. 2022. Northern Gulf of Mexico Hypoxic Zone. Available here.
[153] Diaz, R., and Solow, A. 1999. Ecological and Economic Consequences of Hypoxia: Topic 2 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 16. May. Available here.
[154] Smith, D., Martin, et al. 2017. Seafood Prices Reveal Impacts of a Major Ecological Disturbance. Biological Sciences 114(7) 1512-1517. January 30. Available here.
[155] Ibid.

it is challenging to link hypoxic events to fishery losses because fishermen can change where they fish in response to a hypoxic event and there are many other environmental and economic factors at play.

NOAA has created a Gulf of Mexico Hypoxia Watch showing real time dissolved oxygen data, which allows users to monitor for hypoxic conditions (Hyp-3).[156]

Water Quality and Water Management 

The team reviewed over thirty sources centered on water quality, management, and restoration and how these actions impact the economy and/or specific industries. Of these thirty plus reports, some stood out in terms of the analysis conducted, results presented, or geography studied. These reports include The Impacts of Water Quality on Florida's Home Values (W-7),[157] Naples Bay Past and Present: A Chronology of Disturbance to an Estuary (W-13),[158] Caloosahatchee Watershed Regional Water Management Issues (W-15),[159] Benefit and Benefit/Cost Calculations for Two Everglades Restoration Projects (W-18),[160] and Florida's Natural Assets (W-19).[161]

Florida is home to a number of water ecosystems – the ocean, estuaries, marshes, wetlands, and freshwater systems. Each has unique and shared water quality issues that impact these ecosystems and the economies they support. Estuaries for example, are geographically small but economically huge. They provide storm protection through mangrove forests and oyster beds, sequester carbon, support fisheries, increase real estate values, and offer a place for recreation (W-1).[162] However, humans are drastically changing the face of estuaries through dredging, the conversion of mangroves to developments, the addition of canals, and the introduction of excess nutrients (W-13).[163] Anthropogenic impacts are destroying an ecosystem, estuaries, that covers a mere 4 percent of the earth's surface but produces 47 percent of the country's output (W-1).[164] Studies have shown that investments in estuary restoration produce up to $4 for every dollar spent (W-17),[165] but developments and population growth are prominent factors that work against any restoration attempts.

[156] NOAA. Gulf of Mexico. Available here.
[157] Florida Realtors. 2015. The Impact of Water Quality on Florida's Home Values. March. Available here.
[158] Schmid, J., et al. 2006. Naples Bay Past and Present: A Chronology of Disturbance to an Estuary. Final Report to the City of Naples Funded by the South Florida Water Management District. February. Available here.
[159] Sanibel Florida. 2016. Caloosahatchee Watershed Regional Water Management Issues. Endorsed by Sanibel Captiva Conservation Foundation. Available here.
[160] Maloney, M., et al. 2017. Benefit and Benefit/Cost Calculations for Two Everglades Restoration Projects. Available here.
[161] Defenders of Wildlife. 2012. Florida's Natural Assets: Investing in Nature is Key to Our Prosperity. January. Available here.
[162] TBD Economics. 2021. The Economic Value of America's Estuaries. Prepared for Restore America's Estuaries. June. Available here.
[163] Schmid, J., et al. 2006. Naples Bay Past and Present: A Chronology of Disturbance to an Estuary. Final Report to the City of Naples Funded by the South Florida Water Management District. February. Available here.
[164] TBD Economics. 2021. The Economic Value of America's Estuaries. Prepared for Restore America's Estuaries. June. Available here.
[165] USDA, Executive Office of the United States, US Department of the Interior, EPA, US Department of the Army. 2012. Restoring America's Everglades: Progress and Next Steps for Restoring a Treasured Landscape and Sustaining a Way of Life. July. Available here.

Freshwater systems like Lake Okeechobee, the Caloosahatchee River, and St. Lucie River suffer from similar issues including excess nutrient run-offs from human activity (W-15).[166] Lake Okeechobee suffers greatly from said runoff. A cost/benefit calculation study examined the economic benefits of two restoration projects, the South Reservoir, located south of Lake Okeechobee, and the North Reservoir, located north of the lake (W-18).[167] The study determined that restoring the South Reservoir would result in $20 billion in economic benefits and restoring the North Reservoir would result in $1.7 billion in economic benefits thanks to the reduction in nutrient discharge and increase in property value along these waterways. Florida's economy relies on its water and natural resources to attract visitors and generate billions in economic output (W-19)[168] (W-15),[169] and restoring it is projected to produce even more in economic benefits.

The Gulf of Mexico is equally critical to the state's economy. The Florida shoreline is responsible for 2.5 times more of the gross state product compared to its inland economy (W-3).[170] It draws millions of tourists to the region every year and provides countless recreational opportunities. It also provides similar ecosystem services as those of the estuaries when fully functioning.

It is unsurprising that there are many water quality databases available to the public due to its importance to Florida's ecosystems and economy. The Sanibel-Captiva Conservation Foundation (SCCF) houses the River, Estuary and Coastal Observing Network that monitors water quality throughout the Caloosahatchee River and estuary network (W-11).[171] The dashboard allows the user to see different measures of water quality in real time and see how they have changed over time for several sites. The SCCF also produces weekly Caloosahatchee Conditions Reports that summarize the week's water quality data throughout the river and estuary network (W-12).[172] There are other water quality datasets mentioned in the HAB theme section that include water quality data as well.

- In the US estuaries comprise 4 percent of the earth's surface area but produce 47 percent of the output and 39 percent of the employment, population, and housing. (W-1)[173]
- Florida's shoreline gross state product is over $402 billion, 2.5 times the inland economy. Florida's beaches and near shore coastal waters draw more than 33 million tourists to Florida each year, contributing more than $56 billion and more than 900,000 jobs to the economy. (W-3)[174]

[166] Sanibel Florida. 2016. Caloosahatchee Watershed Regional Water Management Issues. Endorsed by Sanibel Captiva Conservation Foundation. Available here.
[167] Maloney, M., et al. 2017. Benefit and Benefit/Cost Calculations for Two Everglades Restoration Projects. Available here.
[168] Defenders of Wildlife. 2012. Florida's Natural Assets: Investing in Nature is Key to Our Prosperity. January. Available here.
[169] Sanibel Florida. 2016. Caloosahatchee Watershed Regional Water Management Issues. Endorsed by Sanibel Captiva Conservation Foundation. Available here.
[170] Florida Oceans and Coastal Resources Council. Investing in Florida's Coastal and Oceans Future. Available here.
[171] SCCF. River, Estuary and Coastal Observing Network (RECON). Available here.
[172] SCCF. Caloosahatchee Conditions Report. Available here.
[173] TBD Economics. 2021. The Economic Value of America's Estuaries. Prepared for Restore America's Estuaries. June. Available here.
[174] Florida Oceans and Coastal Resources Council. Investing in Florida's Coastal and Oceans Future. Available here.

- Lee County's aggregate property values increased by an estimated $541 million as a result of improved water quality and clarity. (W-7)[175]
- Seagrass and oyster habitats within Naples Bay have been reduced 80-90% due to dredging for creation of waterfront property and maintenance of navigational channels. (W-13)[176]
  - Additionally, over 70% of the fringing mangrove shoreline of Naples Bay has been converted to residential developments.
  - The perimeter of the bay has increased 53% and the water surface area 23% due to the construction of canal systems in residential areas.
- Investing in conservation practices in Chesapeake Bay would result in $332 million estimated economic impacts to businesses and workers annually through 2025. (W-14)[177]
- As of 2015, in Lee County tourism generated more than $3 billion annually, real estate values totaled more than $87 billion, and a poll indicated that beaches were the county's most attractive asset. (W-15)[178]
- Restoring the South reservoir below Lake Okeechobee would improve water quality by 45 percent in the Caloosahatchee River and 64 percent in the St. Lucie River. (W-18)[179]
  - This restoration project would increase the property value of homes near or on the waterfront by 18 percent.
  - The total value added by this project through improved recreation and real estate values would be over $20 billion.
  - Restoring the South reservoir would result in improvements valued at $1.7 billion.
- In the Everglades, an investment of $11.5 billion will result in over $46.5 billion in gains to Florida's economy— at least $4 gained for every $1 spent. It will also create more than 440,000 jobs over the next 50 years. (W-19)[180]
- The annual total suspended solids (TSS) loads to Naples Bay were calculated to be approximately 350 tons between 2009 and 2014, more than six times greater than the annual TSS loading to Tampa Bay by volume, which has seen significant resource recovery in recent years. (W-29)[181]

Fishing Industry

The fishing industry is reliant on good water quality and habitat to maintain healthy fish stocks. The fishing industry is also a vital piece of the blue economy. With this in mind, the team reviewed five fishing industry reports and delved into several commercial and fishing data sources, which are mentioned below. Some

[175] Florida Realtors. 2015. The Impact of Water Quality on Florida's Home Values. March. Available here.
[176] Schmid, J., et al. 2006. Naples Bay Past and Present: A Chronology of Disturbance to an Estuary. Final Report to the City of Naples Funded by the South Florida Water Management District. February. Available here.
[177] Key-Log Economics. 2022. Economic Impacts of Implementing the Phase III Watershed Implementation Plans: Agriculture BMPs. Prepared for Chesapeake Bay. July.
[178] Sanibel Florida. 2016. Caloosahatchee Watershed Regional Water Management Issues. Endorsed by Sanibel Captiva Conservation Foundation. Available here.
[179] Maloney, M., et al. 2017. Benefit and Benefit/Cost Calculations for Two Everglades Restoration Projects. Available here.
[180] Defenders of Wildlife. 2012. Florida's Natural Assets: Investing in Nature is Key to Our Prosperity. January. Available here.
[181] Cardno. Shaping the Future. 2016. Status of Naples Bay Water Clarity: 2005-2014 Final Report. Prepared for The City of Naples Streets and Stormwater Department Natural Resources Division. July. Available here.

key reports include the Economic Impacts of Saltwater Fishing (F-1)[182] and The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee River and Charlotte Harbor Region of Florida (F-5).[183]

Two of the fishing industry reports focus on geographies outside of Southwest Florida, the Florida Keys Flats (F-3)[184] and Florida Reefs fishing (F-1).[185] They highlight the importance of recreational fishing to local economies around the state. The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee River and Charlotte Region of Florida was more specific to the southwest Florida region. This study found that the total economic impact of tarpon anglers in the region including taxes, expenditures, business income and local salaries was $108,614,000 per year (F-5).[186] Recreational tarpon fishing alone has a significant impact on the local economy. Commercial fishing is another important industry in the state. The top five species in dockside value for the state of Florida totaled over $130 million in the 2019/2020 fiscal year (F-2).[187] With thousands of active, licensed recreational and commercial anglers, it is clear that both residents and visitors are invested in the fishing industry, and its economic importance is clear from the reported values shared below.

In addition to reviewing the reports on the fishing industry in Florida, the team looked into a number of recreational and commercial fishing data sources used in said reports. The FWC and NOAA both provide access to the Commercial Landings Data. This data is collected dockside by the FCW and then sent to NOAA's larger database that has commercial fishing data for all relevant states. The Commercial Landings data contains species, pounds caught, trips, estimated dockside price per unit, and estimated total value for each harvested species by county and year. The FWC also has commercial and recreational fishing license data. This database contains the number of active saltwater and freshwater fishing licenses with expirations dates for the state. The Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP) also provides some recreational fishing data such as the regional participation rate in fresh and saltwater fishing and spending by county for fresh and saltwater fishing.

- There were 2.4 million active licensed freshwater and saltwater recreational fishing anglers in Florida in 2019/2020, including both residents and non-residents. (F-2)[188]
  - Saltwater recreational fishing has an economic impact of $9.2 billion, and freshwater and saltwater combined have an impact of $13.8 billion.
  - Saltwater fishing supports 88,501 jobs annually and freshwater and saltwater combined support 120,000 jobs.

[182] Wallmo, K., et al. 2021. Economic Impact Analysis of Recreational Fishing on Florida Reefs. NOAA Technical Memorandum CRCP 41. May. Available here.
[183] Fedler, T. 2011. The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee River and Charlotte Harbor Region of Florida. Prepared for The Everglades Foundation. January. Available here.
[184] Fedler, T. 2013. Economic Impact of the Florida Keys Flats Fishery. Prepared for Bonefish and Tarpon Trust. May 29. Available here.
[185] Wallmo, K., et al. 2021. Economic Impact Analysis of Recreational Fishing on Florida Reefs. NOAA Technical Memorandum CRCP 41. May. Available here.
[186] Fedler, T. 2011. The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee river and Charlotte Harbor Region of Florida. Prepared for The Everglades Foundation. January. Available here.
[187] Florida Fish and Wildlife Conservation Commission. The Economic Impacts of Saltwater Fishing in Florida. Available here.
[188] Florida Fish and Wildlife Conservation Commission. The Economic Impacts of Saltwater Fishing in Florida. Available here.

  - Over 12,000 Saltwater Products Licenses were issued in 2019/2020 (of which over 9,700 were for individual commercial saltwater fishers), generating revenue totaling over $1 million.
  - In 2020, the estimated dockside value for the state's commercial food fish sales was $197 million.
  - In 2016, Florida's commercial fisheries generated $3.2 billion in income and supported 76,700 jobs.
  - The top species in dockside value harvested in Florida in 2020 were shrimp ($49 million), stone crab ($31 million), spiny lobster ($25 million), blue crab ($12.7 million), and red snapper ($12.7 million).
- In southwest Florida in 2011, tarpon anglers in the region spend $237 per day and $2,362 annually whilst fishing for tarpon. (F-5)[189]
  - Aggregating expenditures for all tarpon fishing in the region resulted in $63,539,000 in direct expenditures and $45,075,000 in supplemental expenditures.
  - The total impact of tarpon fishing in the region accounts for $33,245,000 in local salaries, wages and business income and supports 1,094 full-time jobs.
  - Tarpon angler spending contributed $8,032,000 in federal tax revenue and $6,598,000 in state and local tax revenue.
- In 2020, Charlotte County annual commercial fishing production direct output was $1,458,000, total output was $1,693,000, total value added was $1,586,000, labor income was $448,000 and employment was 55 full-time jobs. In Lee County, annual commercial fishing production direct output was $20,376,000, total output was $24,908,000, total value added was $23,026,000, labor income was $9,202,000, and total employment was 136 full-time jobs. (B-6)[190]

Stakeholder Interviews

In addition to the extensive literature review, the team conducted several interviews, both in person during their visit to southwest Florida and virtually, with local stakeholders impacted by water quality. The team spoke with real estate agents/developers, wildlife biologists, local business owners, representatives from various water quality focused organizations, and established fishing guides and fishermen in an effort to understand the impacts of discrete and chronic water quality events on the regional economy and environment. Though each interviewee offered a slightly different perspective on water quality and the coastal economy in southwest Florida, many points and topics were reiterated by multiple stakeholders. The common themes are summarized below under four major categories: water-based economy, water quality events, water quality trends, and takehome messages.

[189] Fedler, T. 2011. The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee river and Charlotte Harbor Region of Florida. Prepared for The Everglades Foundation. January. Available here.
[190] The Balmoral Group. 2020. Coastal and Heartland National Estuary Partnership (CHNEP) Economic Valuation. September. Available here.

Water-Based Economy

- Up to 90 percent of guided recreation participants are tourists on Sanibel Island.
  - One in five jobs is reliant on the tourism industry.
- Over the past decade there has been a decline in the number of guides and licensed captains.
- For the coastal property market water quality is a predominant factor (hurricanes, storm surges, red tides).
  - In general, potential homebuyers are more likely to be concerned about hurricanes and flooding history of a house than HAB frequency and impacts.
- Fish populations have declined over the past few decades.
  - There has been a general decline in commercial fishing and a change in the class of fish caught recreationally.
- For many folks, their house is their biggest asset - property value is important to them.
  - Poor water quality and increased events decrease property value.

Water Quality Events

- In 2013, 2016, and 2018 there were massive discharges from Lake Okeechobee. These discharges carry nitrates, phosphates, and other nutrients, 65 percent of which make it all the way to the Gulf.
  - Discharges hurt fishing guides and hospitality industries.
  - The seagrass and oysters were lost due to changes in salinity and algal blooms from the excess nutrients.
  - Ultimately these discharges act as a major blow to ecosystems and businesses related to these species.
- Red tide events (less common but tend to have a larger impact if large) – four major events in the past two decades that each lasted several months to a year.
  - Red tides seriously impact local fishing stocks and ecosystems.
- Blue-green algae (chronic) – common in the Caloosahatchee watershed and in freshwater throughout southwest Florida.
  - Eutrophication is a major issue with these events. Algae is replacing other aquatic vegetation.
- Saltwater intrusion (chronic) – occurring mostly along the coast where it impacts drinking water and causes habitat migration.
- Sewers/wastewater/stormwater, agricultural runoff, and development all contribute to poor water quality and events.

Water Quality Trends

- Red tide events are rare, or at least they used to be rare. Today they occur more frequently and are larger as more nutrients enter waterways and warmer temperatures also support the blooms.

- The 2016/17 hurricane and 2018 red tide event increased downward spiral in regard to ecosystem health – not enough time between events for ecosystems to recover.
- Water quality is negatively impacted during periods of big growth or housing industry booms.
- There has been an increase in algae blooms over the past few decades, blue-green and red.
- Red tide events create a negative feedback loop – red tides kill fish, which release more nutrients into the water, which in turn feed the algal bloom, leading to more fish mortalities and so on.
  - Blue-green algae blooms also tie into this loop because their release into saltwater fuels red tide events as well.

Take Home Messages

- SW Florida is a water community.
- Tourism drives the local economy.
- Poor water quality decreases business.
  - Unless action is taken to restore ecosystems in SW Florida, these ecosystems will collapse. The golden goose won't stay golden forever.
- The region needs to invest in storytelling to highlight how poor water quality has negative environmental impacts on quality of life, economy, and the environment. People are not grasping how bad the situation is or do not know about the problem (especially true for Lake Okeechobee discharges).
  - Get people engaged – people often need a personal impact before they consider action.
- Essentially, the region has a changing baseline and changing ecosystems. The new normal is less robust and diverse than the baseline years previous.
- Ecosystems aren't getting enough time in between negative water quality events to recover. If an ecosystem requires ten years to recover from an event and it is hit again 3 years into that recovery, this timeline gets extended. At some point it will not be able to recover if it doesn't get the time to do so without enduring another shock to the system.
  - Now seeing longer and faster declines in ecosystem health.

Ultimately, Lake Okeechobee discharges, HABs, and climate change related events (sea level rise, saltwater intrusion, increased hurricane and storm frequency) were major concerns for local stakeholders. These events, chronic and discrete, have a serious impact on water quality and in turn impact the local economy, quality of life, and the environment. Many felt that increased development and larger populations are signifcant contributors to poor water quality in the region as well. Today there are fewer fish, fewer mangroves, fewer seagrass beds and fewer oyster beds than there were in decades past. This is a large concern for those whose livelihoods depend on these resources.

In addition, the stakeholders felt that the many visitors and newcomers to the Florida communities do not understand or care about ongoing water quality issues. New residents may not realize that the current ecosystems are not the baseline but are performing far below where they were historically because good water quality and water-based recreation are advertised so heavily. Across the board interviewees called for more education, more coverage, and more action to restore southwest Florida's degraded ecosystems and address poor water quality.

Appendix B-2: Bibliographic Database

See separate Excel spreadsheet.

Appendix C: Summary of Economic Values from Previous Research

Table C-1: Literature Review Summary of Economic Values

Harmful Algal Blooms (HABS)

Source	Description	Geography	Original Estimate	2023-dollar Update
Securing Florida's Blue Economy (B-1)	Estimated costs of physical and economic damages from 2018 red tide event	Florida	$130.6 million	$159.7 million
Harmful Algal Blooms and Tourism (HAB-1)	Lodging industry income during a month with red tide event	SW Florida	$28.4 million	$48.5 million
Harmful Algal Blooms and Tourism (HAB-1)	Lost lodging income during a month with red tide event	SW Florida	$2.0 million	$3.5 million
Harmful Algal Blooms and Tourism (HAB-1)	Restaurant industry income during month with red tide event	SW Florida	$53.3 million	$91.0 million
Harmful Algal Blooms and Tourism (HAB-1)	Lost restaurant income during a month with red tide event	SW Florida	$1.2 million	$2.1 million
Economic Impact of the 2000 Red Tide (HAB-2)	Estimated direct economic impact of red tide event on county	Galveston County, TX	$9.93 - $11.5 million	$17.7 - $20.5 million
Economic Impact of the 2000 Red Tide (HAB-2)	Estimated total economic impact of red tide event on county	Galveston County, TX	$15.98 - $18.45 million	$28.5 - $32.9 million
Economic Losses During HABs (HAB-4)	Fishing and seafood sales average losses during red tide events	Pinellas County, FL	$20,000	$23,700
Economic Losses During HABs (HAB-4)	Revenue lost in county due to red tide event in marine related industries	Galveston County, TX	$10 million	$18 million
Economic Losses During HABs (HAB-4)	Revenue lost in county due to red tide event in recreational fishing	Galveston County, TX	$2 million	$3.25 million
Economic Losses During HABs (HAB-4)	Average monthly generation in seafood related sales in county	Pinellas County, FL	$137,800	$163,500
Economic Losses During HABs (HAB-4)	Monthly loss in generation of seafood related sales in county due to HAB event	Pinellas County, FL	$20,394	$24,200
Economic Losses During HABs (HAB-4)	Oysterman harvesters' revenue lost per boat during 2011 HAB event	Calhoun County, TX	$8,000	$9,500
Economic Consequences of HABs (HAB-5)	Economic impact of 1971 HAB event on tourism; commercial fishing	Florida	$117 million	$152 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Consequences of HABs (HAB-5)	Economic impact of 1974 HAB event on tourism; sports fishing; condo sales	Florida	$72 million	$94 million
Economic Consequences of HABs (HAB-5)	Economic impact of 1992 HAB event on CFP morbidities in humans	Florida	$1 million	$1.3 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 2007 HAB event on the restaurant and hotel sectors	Florida	$51 million	$66 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1972 HAB event on shellfish closures	Maine	$5 million	$5.6 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1980 HAB event on shellfish closures	Maine	$7 million	$9 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1987 HAB event on hotel and restaurant businesses	North Carolina	$40 million	$52 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1987 HAB event on oyster bed closures	Texas	$8 million	$10.4 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1988 HAB event on bay scallop mortalities	New York	$4 million	$5.2 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1988 HAB event on shellfish closures	North Carolina	$11 million	$14.3 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1990 HAB event on salmon net pen mortalities	Washington	$4 million	$5.2 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1992 HAB event on untapped Bering Sea surf clam fishery	Alaska	$13 million	$17 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1992 HAB event on commercial sales of sportfish	Hawaii	$4 million	$5.2 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1996 HAB event on closed geoduck commercial beds	Alaska	$3 million	$3.9 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 1997 HAB event on seafood sales	Maryland	$66 million	$85.7 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 2000 HAB event on tourism industry; oyster landings	Texas	$15 million	$19.5 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 2001 HAB event on sports fishing	Texas	$3 million	$3.9 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Consequences of HABs (HAB-5)	Economic impact of a 2005 HAB event on shellfish closures	Maine	$2 million	$2.6 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 2005 HAB event on shellfish closures	Massach-usetts	$22 million	$28.6 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 2009 HAB event on recreational shellfish closures	Washington	$12 million	$15.6 million
Economic Consequences of HABs (HAB-5)	Economic impact of a 2014 HAB event on drinking water decontamination	Ohio	$3 million	$3.9 million
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Direct economic impact of 2017-2019 HAB events	SW Florida	$184 million	$221 million
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Total economic impacts of lost tourism due to HAB-induced Airbnb market decline	SW Florida	$317 million	$387.6 million
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Loss in value added due to HAB events	SW Florida	$195 million	$225 million
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Loss in labor income due to HAB events	SW Florida	$120 million	$146.7 million
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Loss in tax revenue due to HAB events	SW Florida	$45 million	$55 million
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Sales revenue lost in Airbnb sales due to HAB events	Florida	$317 million	$333 million
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Average daily Airbnb rate price drop during red tide event	Florida	$0.45	$0.47
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Airbnb revenue lost during month with worst HAB impacts	Lee County, FL	$4.0 million	$4.2 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Airbnb revenue lost during month with worst HAB impacts	Collier County, FL	$857,000	$899,000
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Airbnb revenue lost during month with worst HAB impacts	Charlotte County, FL	$151,000	$158,000
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Economic impact of tourism reduction due to Airbnb market decline: output	Florida	$258.5 million	$271.2 million
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Economic impact of tourism reduction due to Airbnb market decline: gross value added	Florida	$160.7 million	$168.6 million
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Economic impact of tourism reduction due to Airbnb market decline: labor income	Florida	$99.9 million	$104.8 million
Impacts of Red Tide in Peer-to-Peer Accommodations (HAB-9)	Economic impact of tourism reduction due to Airbnb market decline: tax revenue	Florida	$37.1 million	$38.9 million
Economic Effects of HABs in the US (HAB-10)	Red tide and shellfish poisoning (SP) impacts: cost per reported SP	United States	$1400	$3,500
Economic Effects of HABs in the US (HAB-10)	Red tide and shellfish poisoning impacts: cost per unreported SP illness	United States	$1,100	$2,700
Economic Effects of HABs in the US (HAB-10)	Red tide and SP impacts: annual avg. public health cost for SP	United States	$400,000	$900,000
Economic Effects of HABs in the US (HAB-10)	Red tide and shellfish poisoning impacts: per reported Ciguatera fish poisoning	United States	$1,000	$2,500
Economic Effects of HABs in the US (HAB-10)	Red tide and shellfish poisoning impacts: per unreported Ciguatera fish poisoning	United States	$700	$1,700
Economic Effects of HABs in the US (HAB-10)	Red tide and Ciguatera fish poisoning impacts: annual public health cost	United States	$19 million	$47 million
Economic Effects of HABs in the US (HAB-10)	Annual HAB impact on commercial fisheries	United States	$12 million	$29.7 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Effects of HABs in the US (HAB-10)	Average annual economic impact on recreation and tourism due to HABs	United States	$7 million	$17.3 million
Economic Effects of HABs in the US (HAB-10)	Economic damage to tourism industry from 1971 red tide event	Florida	$68 million	$515 million
Economic Effects of HABs in the US (HAB-10)	Annual average monitoring and management cost for HABs	United States	$2 million	$5 million
Economic Effects of HABs in the US (HAB-10)	Average annual HAB economic impact	United States	$50 million	$124 million
HABs and Coastal Business (HAB-11)	Monthly restaurant industry lost revenue due to HAB event	NW Florida	$2.8 million	$5.4 million
HABs and Coastal Business (HAB-11)	Monthly lodging industry lost revenue due to HAB event	NW Florida	$3.7 million	$7.0 million
HABs and Coastal Business (HAB-11)	HAB event results in tourism related revenue loss (restaurant/lodging)	NW Florida	$6.5 million	$12.4 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in commercial fishing	Fort Myers, FL	$3.2 million	$3.8 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in recreational fishing	Fort Myers, FL	$28.1 million	$33.4 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in restaurant and catering services	Fort Myers, FL	$274 million	$325 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in Property transaction fees	Fort Myers, FL	$123 million	$146 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in property sales due to poor water quality	Fort Myers, FL	$711 million	$844 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in boat sales	Fort Myers, FL	$62 million	$73.6 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in marine animal mortalities	Fort Myers, FL	$135 million	$160 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in labor income	Fort Myers, FL	$189 million	$224 million
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in value added	Fort Myers, FL	$300 million	$356 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Impacts of Water Quality (HAB-12)	Predicted loss from HAB event in output	Fort Myers, FL	$374 million	$444 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: total	Lake Erie	$71 million	$92 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: property value	Lake Erie	$16 million	$21 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: tourism	Lake Erie	$20 million	$26 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: recreation	Lake Erie	$31 million	$40 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: recreation beach-going	Lake Erie	$14 million	$18 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: recreational fishing	Lake Erie	$10 million	$13 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: recreational boating	Lake Erie	$7 million	$9 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2011 HAB: water treatment	Lake Erie	$4 million	$5 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2014 HAB: property value	Lake Erie	$18 million	$23 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2014 HAB: recreation beach going	Lake Erie	$11 million	$14 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2014 HAB: recreation fishing	Lake Erie	$7 million	$9 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2014 HAB: recreation boating	Lake Erie	$5 million	$6.5 million
Economic Benefits of Reducing HABs (HAB-16)	Impact of ecosystem service interruptions due to 2014 HAB: recreation	Lake Erie	$23 million	$30 million

Blue Economy (B)

Source	Description	Geography	Original Estimate	2023-dollar Update
Securing Florida's Blue Economy (B-1)	Florida's coastal counties generate 77% of the state's economy	Florida	$797 billion	$974.5 billion
Securing Florida's Blue Economy (B-1)	Coastal resources' direct and indirect contribution to the state's economy	Florida	$73.9 billion	$90.4 billion
Securing Florida's Blue Economy (B-1)	Living resources' contribution to the state's economy	Florida	$0.6 billion	$0.73 billion
Securing Florida's Blue Economy (B-1)	Ocean recreation's contribution to the state's economy	Florida	$2.0 billion	$2.5 billion
Securing Florida's Blue Economy (B-1)	Marine industries contribution to the state's economy	Florida	$4.6 billion	$5.6 billion
Securing Florida's Blue Economy (B-1)	Ocean tourism's contribution to the state's economy	Florida	$424.6 billion	$30.1 billion
From Ocean Economy to Blue Economy (B-2)	Florida Ocean Economy value added by transportation sector	Florida	$8.67 billion	$10.42 billion
Harmful Algal Blooms and tourism (HAB-1)	Florida Ocean Economy value added by living resources sector	Florida	$785 million	$943 million
Harmful Algal Blooms and tourism (HAB-1)	Florida Ocean Economy value added by minerals sector	Florida	$377 million	$453 million
Harmful Algal Blooms and tourism (HAB-1)	Florida Ocean Economy value added by ship and boat building sector	Florida	$1.12 billion	$1.34 billion
Harmful Algal Blooms and tourism (HAB-1)	State estimated natural infrastructure and blue carbon benefits	Florida	$909.7 - $2,749.3 million	$1.09 - $3.30 billion
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Economic output of regional economy	SW Florida	$452 billion	$542.8 billion
Quantifying the Socio-Economic Impact of HABs (HAB-7)	Value added by regional economy (GSP)	SW Florida	$255 billion	$306.2 billion
Developing the Blue Economy of Florida (B-3)	GSP tied to economic activity in Florida's Gulf	FL Gulf Coast	$17.5 billion	$24.6 billion

Source	Description	Geography	Original Estimate	2023-dollar Update
Developing the Blue Economy of Florida (B-3)	Florida Gulf Coast economy wages generated	FL Gulf Coast	$612 million	$818 million
Developing the Blue Economy of Florida (B-3)	Florida Gulf coast gross regional product generated	FL Gulf Coast	$1.2 billion	$1.6 billion
Developing the Blue Economy of Florida (B-3)	Annual recreational boat sales	Florida	$1.9 billion	$2.5 billion
Florida's Ocean and Coastal Economies Report (B-4)	Florida's Direct Ocean Economy (GSP)	Florida	$13 billion	$23 billion
Florida's Ocean and Coastal Economies Report (B-4)	Total Ocean Economy (with multipliers)	Florida	$23.2 billion	$41.4 billion
Florida's Ocean and Coastal Economies Report (B-4)	Florida's coastal economy's contribution to state economy	Florida	$402 billion	$717 billion
Florida's Ocean and Coastal Economies Report (B-4)	Non-market value of beaches	Florida	$3.5 - $17.7 billion	$5.5 - $27.8 billion
Florida's Ocean and Coastal Economies Report (B-4)	Non-market value of recreational fishing	Florida	$3.4 - $5.6 billion	$5.4 - $8.8 billion
Investing in FL's Coastal and Oceans Future (W-3)	Florida's shoreline gross state product	Florida	$402 billion	$566 billion

Tourism (T)

Source	Description	Geography	Original Estimate	2023-dollar Update
Harmful Algal Blooms and tourism (HAB-1)	Florida ocean economy value added by tourism and recreation	Florida	$18.6 billion	$22.3 billion
Natural Hazards and Coastal Tourism (T-1)	Direct losses from storm gusts and flooding per day	Collier County, FL	$22.7 million	$28.4 million
Natural Hazards and Coastal Tourism (T-1)	Indirect losses from loss in rental income due to storm per day	Collier County, FL	$19,000	$23,800
Investing in FL's Coastal and Oceans Future (W-3)	Tourists' contribution to Florida state economy annually	Florida	$56 billion	$79 billion
Florida's Tourism Economy (T-3)	Visitor spending	Florida	$98.8 billion	$118.7 billion

Source	Description	Geography	Original Estimate	2023-dollar Update
Florida's Tourism Economy (T-3)	Initiated taxes	Florida	$27.6 billion	$33.2 billion
Florida's Tourism Economy (T-3)	Total wages and salaries paid	Florida	$57.2 billion	$68.7 billion
Florida's Tourism Economy (T-3)	Value added by tourists	Florida	$96.5 billion	$115.9 billion
Florida's Tourism Economy (T-3)	Average visitor spending/trip	Florida	$679	$817
Florida's Tourism Economy (T-3)	Domestic visitor spending/trip	Florida	$623	$750
Florida's Tourism Economy (T-3)	International visitor spending/trip	Florida	$1,188	$1,430
Florida's Tourism Economy (T-3)	Total Visitor spending	SW Florida	$11.7 billion	$14.1 billion
Florida's Tourism Economy (T-3)	Value added by tourism	SW Florida	$8.9 billion	$10.7 billion
Florida's Tourism Economy (T-3)	Taxes generated by tourism	SW Florida	$5.4 billion	$54.5 billion
Florida's Tourism Economy (T-3)	Total wages and salaries paid	Lee County, FL	$1.9 billion	$2.31 billion
Florida's Tourism Economy (T-3)	Value added by tourism	Lee County, FL	$3.2 billion	$3.38 billion
Florida's Tourism Economy (T-3)	Taxes generated by tourism	Lee County, FL	$895 million	$1.07 billion
Florida's Tourism Economy (T-3)	Total wages and salaries paid	Collier County, FL	$1.27 billion	$1.53 billion
Florida's Tourism Economy (T-3)	Value added by tourism	Collier County, FL	$2.05 billion	$2.46 billion
Florida's Tourism Economy (T-3)	Taxes generated by tourism	Collier County, FL	$549 million	$659 million
Securing Florida's Blue Economy (B-1)	Ocean tourism's contribution to the state's economy	Florida	$424.6 billion	$30.1 billion

Climate Change (C)

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Impacts of Climate Change (C-4)	Estimated climate change economic damages by the end of the 21st century	Florida	$345 billion	$525 billion
Climate Change and Florida Economy (C-5)	Amount lost due to sea level rise, top tourist attractions state to lose from tourism by 2025	Florida	$9 billion	$11.7 billion
Climate Change and Florida Economy (C-5)	Amount lost due to sea level rise, top tourist attractions state to lose from tourism by 2050s	Florida	$40 billion	$52 billion
Climate Change and Florida Economy (C-5)	Cost to respond to 4 feet of sea level rise	Florida	$130 billion	$169 billion

Failing Wastewater Infrastructure (WW)

Source	Description	Geography	Original Estimate	2023-dollar Update
Developing the Blue Economy of Florida (B-3)	Future water and wastewater infrastructure needs from 2013 to 2033	Florida	$32 billion	$42 billion

Saltwater Intrusion (S)

Source	Description	Geography	Original Estimate	2023-dollar Update
Saltwater Intrusion (S-1)	Installation cost of whole household reverse osmosis system	East Coast	$20,000	$20,982
Saltwater Intrusion (S-1)	Installation of under-the-sink reverse household reverse osmosis system	East Coast	$250-$1,500	$260 - $1,575
The Spread & Cost of Saltwater Intrusion (S-8)	Economic loss from farmland (corn) within 200m buffer around salt patches annually: low estimate	Mid-Atlantic	$39.4 million	$39.4 million
The Spread & Cost of Saltwater Intrusion (S-8)	Economic loss from farmland (corn) within 200m buffer around salt patches annually: high estimate	Mid-Atlantic	$107.5 million	$107.5 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmland (corn/soybean) within 200m buffer around salt patches annually: low est.	Mid-Atlantic	$101,642	$101,642
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmland (corn/soybean) within 200m buffer around salt patches annually: high est.	Mid-Atlantic	$325,419	$325,419
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmland (corn share) within 200m buffer around salt patches annually: low est.	Mid-Atlantic	$67,202	$67,202

Source	Description	Geography	Original Estimate	2023-dollar Update
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmland (corn share) within 200m buffer around salt patches annually: high est.	Mid-Atlantic	$234,017	$234,017
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from all farmlands within 50m buffer around salt patches annually: low est.	Mid-Atlantic	$5.8 million	$5.8 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from all farmlands within 50m buffer around salt patches annually: high est.	Mid-Atlantic	$11.9 million	$11.9 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from all farmlands within 50m buffer around salt patches annually: low est.	Mid-Atlantic	$14.9 million	$14.9 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from all farmlands within 100m buffer around salt patches annually: high est.	Mid-Atlantic	$29 million	$29 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmlands within 50m buffer around salt patches annually: low estimate	Sussex County, DE	$39.3 million	$39.3 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmlands within 50m buffer around salt patches annually: high estimate	Sussex County, DE	$70.7 million	$70.7 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmlands within 50m buffer around salt patches annually	Sussex County, DE	$3.1 million	$3.1 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmlands within 100m buffer around salt patches annually	Sussex County, DE	$7.4 million	$7.4 million
The Spread & Cost of Saltwater Intrusion (S-8)	Profit loss from farmlands within 200m buffer around salt patches annually	Sussex County, DE	$18.5 million	$18.5 million
The Spread & Cost of Saltwater Intrusion (S-8)	Potential annual losses assuming zero profits on visible salt patches over a 10-year average	Mid-Atlantic	$169,963	$169,963

Hurricanes (Hurr)

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Impacts of Climate Change (C-4)	Year 2050, projected annual hurricane damages (low estimate, rapid stabilization)	Florida	$24 billion	$37 billion
Economic Impacts of Climate Change (C-4)	Year 2050, projected annual hurricane damages (high estimate, business as usual)	Florida	$49 billion	$75 billion
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – loss in total visitor spending	Florida	$1.5 billion	$1.9 billion

Source	Description	Geography	Original Estimate	2023-dollar Update
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – loss in domestic visitor spending	Florida	$1.1 billion	$1.4 billion
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – losses in international visitor spending	Florida	$400 million	$501 million
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – total economic loss	Florida	$2.5 billion	$3.1 billion
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – business sales loss (direct)	Florida	$1.47 billion	$1.84 billion
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – business sales loss (indirect and induced)	Florida	$1.02 billion	$1.28 billion
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – personal income loss (direct)	Florida	$368 million	$461 million
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – personal income loss (indirect and induced)	Florida	$329 million	$412 million
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – state tax revenue loss (direct)	Florida	$55.1 million	$69 million
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – state tax revenue loss (indirect and induced)	Florida	$27.5 million	$34.5 million
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – local tax revenue loss (direct)	Florida	$48 million	$60 million
Hurricane Irma and Florida Tourism (T-2)	Due to Irma damages – local tax revenue loss (indirect and induced)	Florida	$22.6 million	$28.3 million
Saltwater Intrusion After Hurricane Katrina (Hurr-3)	Loss due to destroyed timber products	Mississippi	$1.3 billion	$1.8 billion
Saltwater Intrusion After Hurricane Katrina (Hurr-3)	Loss due to damage to urban trees	Mississippi	$1.1 billion	$1.6 billion
Saltwater Intrusion After Hurricane Katrina (Hurr-3)	Economic impacts to agriculture	Louisiana	$1 billion	$1.4 billion
Saltwater Intrusion After Hurricane Katrina (Hurr-3)	Economic impacts to forestry	Louisiana	$612.9 million	$865.1 million
Saltwater Intrusion After Hurricane Katrina (Hurr-3)	Economic impacts to agronomic crops	Louisiana	$156.1 million	$220.3 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Saltwater Intrusion After Hurricane Katrina (Hurr-3)	Economic impacts to fisheries	Louisiana	$142.2 million	$200.7 million
Natural Hazards and Coastal Tourism (T-1)	Direct losses from storm gusts and flooding per day	Collier County, FL	$22.7 million	$28.4 million
Natural Hazards and Coastal Tourism (T-1)	Indirect losses from loss in rental income due to storm per day	Collier County, FL	$19,000	$23,800

Hypoxia (Hyp)

Source	Description	Geography	Original Estimate	2023-dollar Update
Hypoxia and Brown Shrimp (Hyp-5)	Decrease in avg. Neuse River revenue over 7-yr period (1999-2005) due to hypoxia	Neuse River, NC	$32,000	$59,000
Hypoxia and Brown Shrimp (Hyp-5)	Decrease in avg. Pamlico Sound revenue over 7-yr period (1999-2005) due to hypoxia	Pamlico Sound, NC	$1.24 million	$2.29 million
Hypoxia and Brown Shrimp (Hyp-5)	Increase in blue crab fishery due to reduction in nutrient loading (30%) – low estimate	Neuse River, NC	$700,000	$1.29 million
Hypoxia and Brown Shrimp (Hyp-5)	Increase in blue crab fishery due to reduction in nutrient loading (30%) – high estimate	Neuse River, NC	$6.4 million	$11.8 million

Water Quality/Management (W)

Source	Description	Geography	Original Estimate	2023-dollar Update
Declines in Property Values (HAB-3)	The increase in property sales due to clean water quality	SW Florida, Gulf coast	$7,000	$9,226
Value of America's Estuaries (W-1)	Natural infrastructure value: Low estimate	Tampa Bay	$902 million	$1.1 billion
Value of America's Estuaries (W-1)	Natural infrastructure value: high estimate	Tampa Bay	$2.7 billion	$3.3 billion
Value of America's Estuaries (W-1)	Blue carbon value: low estimate	Tampa Bay	$8 million	$9.8 million
Value of America's Estuaries (W-1)	Blue carbon value: high value	Tampa Bay	$44 million	$53.8 million
Water Quality and Florida Home Values (W-7)	Increase in aggregate property values due to improved water quality	Lee County, FL	$541 million	$701 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Water Quality and Florida Home Values (W-7)	Increase in aggregate property values due to improved water quality	Martin County, FL	$428 million	$554 million
Water Quality and Florida Home Values (W-7)	Reduction in aggregate property values from May-Sept due to bad water quality	Martin County, FL	$488 million	$632 million
Clean Water and Climate-Smart Investment (W-14)	Economic returns expected annually through 2025 with investment in conservation practices	Chesapeake Bay	$655.2 million	$744.2 million
Clean Water and Climate-Smart Investment (W-14)	Earning returns expected annually through 2025 with investment in conservation practices	Chesapeake Bay	$268.9 million	$304.7 million
CNEP Economic Valuation (W-8)	Output generated by natural resources in the CHNEP region	Central & SW Florida	$13.6 billion	$16.1 billion
CNEP Economic Valuation (W-8)	Regional income generated by natural resources in the CHNEP region	Central & SW Florida	$3.8 billion	$4.5 billion
CNEP Economic Valuation (W-8)	Local and state tax revenues generated by natural resources in the CHNEP region	Central & SW Florida	$146 million	$173 million
CNEP Economic Valuation (W-8)	Proximity premiums associated with natural resources in the CHNEP region	Central & SW Florida	$381 million	$452 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP via recreation spending	Charlotte County	$1.07 billion	$1.3 billion
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP commercial fishing	Charlotte County	$1.5 million	$1.7 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP agricultural production	Charlotte County	$174 million	$207 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP property values	Charlotte County	$863 million	$1 billion
CNEP Economic Valuation (W-8)	Economic impact of recreation spending: labor income	Charlotte County	$378 million	$449 million
CNEP Economic Valuation (W-8)	Economic impact of recreation spending: value added	Charlotte County	$597 million	$708 million
CNEP Economic Valuation (W-8)	Economic impact of recreation spending: output	Charlotte County	$1.3 billion	$1.5 billion
CNEP Economic Valuation (W-8)	Economic impact of commercial fishing production: labor income	Charlotte County	$448,000	$532,000

Source	Description	Geography	Original Estimate	2023-dollar Update
CNEP Economic Valuation (W-8)	Economic impact of commercial fishing production: value added	Charlotte County	$1.6 million	$1.9 million
CNEP Economic Valuation (W-8)	Economic impact of commercial fishing production: output	Charlotte County	$1.7 million	$2 million
CNEP Economic Valuation (W-8)	Economic impact of ecological restoration activities: labor income	Charlotte County	$3 million	$3.6 million
CNEP Economic Valuation (W-8)	Economic impact of ecological restoration activities: value added	Charlotte County	$3.9 million	$4.6 million
CNEP Economic Valuation (W-8)	Economic impact of ecological restoration activities: output	Charlotte County	$7.5 million	$9 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP via recreation spending	Lee County	$5.1 billion	$6.1 billion
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP commercial fishing	Lee County	$20.3 million	$24.2 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP agricultural production	Lee County	$49.3 million	$58.5 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP property values	Lee County	$5 billion	$6 billion
CNEP Economic Valuation (W-8)	Economic impact of recreation spending: labor income	Lee County	$2.5 billion	$3 billion
CNEP Economic Valuation (W-8)	Economic impact of recreation spending: value added	Lee County	$3.9 billion	$4.6 billion
CNEP Economic Valuation (W-8)	Economic impact of recreation spending: output	Lee County	$7 billion	$8.4 billion
CNEP Economic Valuation (W-8)	Economic impact of commercial fishing production: labor income	Lee County	$9.2 million	$10.9 million
CNEP Economic Valuation (W-8)	Economic impact of commercial fishing production: value added	Lee County	$23 million	$27.3 million
CNEP Economic Valuation (W-8)	Economic impact of commercial fishing production: output	Lee County	$25 million	$29.5 million
CNEP Economic Valuation (W-8)	Economic impact of ecological restoration activities: labor income	Lee County	$291,000	$344,800

Source	Description	Geography	Original Estimate	2023-dollar Update
CNEP Economic Valuation (W-8)	Economic impact of ecological restoration activities: value added	Lee County	$391,000	$464,400
CNEP Economic Valuation (W-8)	Economic impact of ecological restoration activities: output	Lee County	$745,000	$883,300

Fishing Industry (F)

Source	Description	Geography	Original Estimate	2023-dollar Update
Recreational Fishing on Florida Reefs (F-1)	Economic output of recreational fishing	SE Florida	$384 million	$435 million
Recreational Fishing on Florida Reefs (F-1)	Economic output of recreational fishing	Monroe county, FL	$173 million	$196 million
Economic Impacts of Saltwater Fishing (F-2)	Revenue from recreational saltwater license	Florida	$37.8 million	$44.8 million
Economic Impacts of Saltwater Fishing (F-2)	Saltwater recreational fishing economic impact	Florida	$9.2 billion	$10.9 billion
Economic Impacts of Saltwater Fishing (F-2)	Saltwater and freshwater recreational fishing economic impact	Florida	$13.8 billion	$16.4 billion
Economic Impacts of Saltwater Fishing (F-2)	Revenue from saltwater products licenses	Florida	$1 million	$1.19 million
Economic Impacts of Saltwater Fishing (F-2)	Revenue from wholesale dealer licenses	Florida	$940,000	$1.12 million
Economic Impacts of Saltwater Fishing (F-2)	Revenue from retail dealer licenses	Florida	$375,000	$445,000
Economic Impacts of Saltwater Fishing (F-2)	Commercial fishing food sales (estimated dockside value)	Florida	$197 million	$234 million
Economic Impacts of Saltwater Fishing (F-2)	Income generated by commercial fisheries	Florida	$3.2 billion	$3.8 billion
Economic Impacts of Saltwater Fishing (F-2)	Annual dockside value harvested of shrimp	Florida	$49 million	$58 million
Economic Impacts of Saltwater Fishing (F-2)	Annual dockside value harvested of stone crab	Florida	$31 million	$37 million

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Impacts of Saltwater Fishing (F-2)	Annual dockside value harvested of spiny lobster	Florida	$25 million	$30 million
Economic Impacts of Saltwater Fishing (F-2)	Annual dockside value harvested of blue crab	Florida	$12.7 million	$15.1 million
Economic Impacts of Saltwater Fishing (F-2)	Annual dockside value harvested of red snapper	Florida	$12.7 million	$15.1 million
Economic Impact of FL Keys Flats Fishery (F-3)	Average annual expenditures for all saltwater fishing by Keys Flats anglers	Florida Keys Flats	$6,473	$8,656
Economic Impact of FL Keys Flats Fishery (F-3)	Average annual expenditures per day for all saltwater fishing by Keys Flats anglers	Florida Keys Flats	$288	$385
Economic Impact of FL Keys Flats Fishery (F-3)	Total direct expenditures for Florida Keys fishing by Keys Flats anglers	Florida Keys Flats	$272,509,000	$364 million
Economic Impact of FL Keys Flats Fishery (F-3)	Total economic impact (including multipliers) for Keys Flats fishing expenditures	Florida Keys Flats	$465,834,000	$623 million
Economic Impact of FL Keys Flats Fishery (F-3)	Salary, wages and owner income associated with Keys Flats fishing	Florida Keys Flats	$143,930,000	$192 million
Economic Impact of FL Keys Flats Fishery (F-3)	Federal tax revenues generated from Keys Flats fishing	Florida Keys Flats	$34,447,000	$46 million
Economic Impact of FL Keys Flats Fishery (F-3)	State and local tax revenues generated from Keys Flats fishing	Florida Keys Flats	$28,298,000	$37.8 million
Economic Impact of FL Keys Flats Fishery (F-3)	Total direct expenditures for Keys Flats fishing by guided Keys Flats fishing	Florida Keys Flats	$62,651,000	$83.8 million
Economic Impact of FL Keys Flats Fishery (F-3)	Total economic impact (including multipliers) for guided Keys Flats fishing	Florida Keys Flats	$107,097,000	$143 million
Economic Impact of FL Keys Flats Fishery (F-3)	Average annual expenditures for all saltwater fishing by Keys anglers	Florida Keys	$6,241	$8,346
Economic Impact of FL Keys Flats Fishery (F-3)	Average annual expenditures per day for all saltwater fishing by Keys Flats anglers	Florida Keys	$315	$421
Economic Impact of FL Keys Flats Fishery (F-3)	Total direct expenditures for Florida Keys fishing by Keys anglers	Florida Keys	$473,962,000	$634 million
Economic Impact of FL Keys Flats Fishery (F-3)	Total economic impact (including multipliers) for Keys fishing expenditures	Florida Keys	$810,201,000	$1.08 billion

Source	Description	Geography	Original Estimate	2023-dollar Update
Economic Impact of FL Keys Flats Fishery (F-3)	Salary, wages, and owner income associated with Keys fishing	Florida Keys	$229,120,000	$306 million
Economic Impact of FL Keys Flats Fishery (F-3)	Federal tax revenues generated from Keys fishing	Florida Keys	$59,912,000	$80.1 million
Economic Impact of FL Keys Flats Fishery (F-3)	State and local tax revenues generated from Keys fishing	Florida Keys	$49,217,000	$65.8 million
Economic Impact of FL Keys Flats Fishery (F-3)	Total direct expenditures for Keys fishing by guided anglers	Florida Keys	$64,988,000	$86.9 million
Economic Impact of FL Keys Flats Fishery (F-3)	Total economic impact (including multipliers) for guided, fishing	Florida Keys	$111,093,000	$148.6 million
Economic Impact of Tarpon Fishing (F-5)	Tarpon angler spending per day	SW Florida	$237	$333
Economic Impact of Tarpon Fishing (F-5)	Tarpon angler spending annually	SW Florida	$2,362	$3,326
Economic Impact of Tarpon Fishing (F-5)	Direct expenditures for tarpon fishing annually	SW Florida	$63.5 million	$89.5 million
Economic Impact of Tarpon Fishing (F-5)	Indirect expenditures related to tarpon fishing annually	SW Florida	$45.1 million	$63.5 million
Economic Impact of Tarpon Fishing (F-5)	Total economic impact of tarpon fishing annually	SW Florida	$108.6 million	$152.9 million
Economic Impact of Tarpon Fishing (F-5)	Local salaries/wages/business owner income generated from annual tarpon fishing	SW Florida	$33.2 million	$46.8 million
Economic Impact of Tarpon Fishing (F-5)	Tarpon fishing contribution to federal tax revenue annually	SW Florida	$8.0 million	$11.3 million
Economic Impact of Tarpon Fishing (F-5)	Tarpon fishing contribution to state and local revenue annually	SW Florida	$6.6 million	$9.3 million
Economic Impact of Tarpon Fishing (F-5)	Tarpon fishing direct expenditures in Caloosahatchee River	SW Florida	$9.6 million	$13.6 million
Economic Impact of Tarpon Fishing (F-5)	Total economic effect of tarpon fishing expenditures in Caloosahatchee River	SW Florida	$16.5 million	$23.2 million

Property Values

Source	Description	Geography	Original Estimate	2023-dollar Update
Declines in Property Values (HAB-3)	The increase in property sales due to clean water quality	SW Florida, Gulf coast	$7,000	$9,226
Water Quality and Florida Home Values (W-7)	Increase in aggregate property values due to improved water quality	Lee County, FL	$541 million	$701 million
Water Quality and Florida Home Values (W-7)	Increase in aggregate property values due to improved water quality	Martin County, FL	$428 million	$554 million
Water Quality and Florida Home Values (W-7)	Reduction in aggregate property values from May-Sept due to bad water quality	Martin County, FL	$488 million	$632 million
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP property values	Charlotte County	$863 million	$1 billion
CNEP Economic Valuation (W-8)	Annual economic impacts generated by natural resources in CHNEP property values	Lee County	$5 billion	$6 billion

Appendix D: Supplemental Study Area Information

Charlotte County

Charlotte County is the northernmost county in southwest Florida. The most prominent coastal water resource in Charlotte County is the upper half of Charlotte Harbor. The Peace and Myakka rivers, both significant in size, run through the county and empty into Charlotte Harbor before reaching the Gulf. Charlotte's shoreline includes inlets, a mangrove-lined aquatic preserve, and 28 miles of beach. The coastline is protected by a row of barrier islands. North to south, Charlotte County is home to the southern portion of Manasota Key, Knight Island, Pedro Island, and the northern portion of Gasparilla Island. Don Pedro Island has a 230-acre State Park that is only accessible via private boat. The bay side of the park is lined with mangroves and the Gulf side with a mile of white sand beach. Stump Pass State Park on southern Manasota Key supports many native species and offers 1.7 miles of beach, and mangrove swamps that encompass the park's three smaller islands (Peterson, Whidden and Little Whidden Key). These islands sit in the Lemon Bay Aquatic Preserve, which is in both Sarasota and Charlotte County. There are nine coastal public access points in Charlotte County, all of which are on the barrier islands.

Table D-1: Charlotte County Coastal Resource Information

Coastal Resource	Description
Sandy Beaches	12 miles
Public Access Points	9
Coastal-Based State Parks and Lands	
In Charlotte County alone	Don Pedro Island State Park (230 acres), Stump Pass Beach State Park (227 acres)
In Charlotte and Sarasota County	Lemon Bay Aquatic Preserve (7,200 acres)
In Charlotte and Lee County	Cape Haze Aquatic Preserve (12,700 acres), Gasparilla Sound-Charlotte Harbor Aquatic Preserve (84,500 acres), Charlotte Harbor Preserve State Park (43,388 acres)
Bays and Inlets	Charlotte Harbor, Lemon Bay, Charlotte Bay
Rivers	Myakka River, Peace River, Trout Creek, Shell Creek

Table Source: Florida Department of Environmental Protection, Available here.

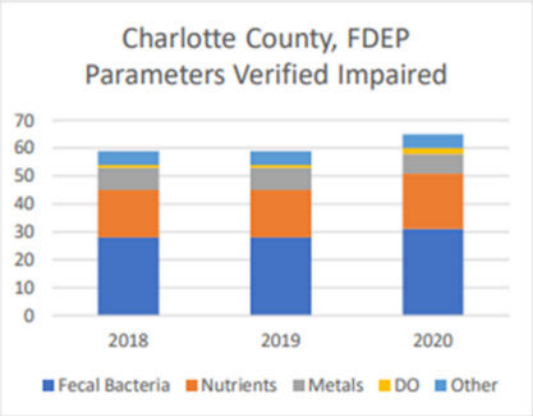
Good water quality is necessary to support diverse biota and local economies. While we know what coastal resources exist in Charlotte County, understanding their status and recent upward or downward trends in water and habitat quality is essential as it allows us to better predict the future status of these resources and understand what events (chronic or independent) impact these resources.

The Florida Department of Environmental Protection (FDEP) tracks the number of water bodies or segments, referred to as waterbody ID units (WBID) that do not meet standard water quality standards for all counties in Florida. The majority of these bodies of water are considered Class III, which means the WBID is used for fish consumption, recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Calusa Waterkeeper collected and compared the number and types of water impairments, or failure to meet water quality standards, from 2018 through 2020 in nine Florida counties in their Water Quality Impairment report.[191] We supplemented the findings from the Calusa

[191] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.

Waterkeeper report with the data from the most recent Comprehensive Verified Impairment List released by the FDEP in November of 2022.[192] We determined the number of WBID that fell within each county and divided this number by the total number of WBID in each county (calculated from the Calusa Waterkeeper report).

From 2018 to 2019, the number of impairments remained consistent in Charlotte County as seen in the chart and table below. The types of impairments (fecal bacteria, excess nutrients, metals, dissolved oxygen, and others) also remain fairly consistent across the two years. In 2020, however, there is a slight spike, 3.3 percent, in the percentage of the county's impaired WBID. The spike is due to an increase in WBID that failed to meet fecal bacteria standards, nutrient level standards and dissolved oxygen levels. In 2020, around 65 water bodies failed to meet water quality standards, meaning that at least 65 water bodies, 36 percent of the county's WBIDs, do not have water considered sufficiently clean to support both human and wildlife needs. This downward trend continued through 2022, when 40 percent of the county's WBIDs were considered impaired.



Year	Percentage of WBID Impaired
2018	32.6%
2019	32.6%
2020	35.9%
2022	40.3%

Figure D-1: Number and Percentage of Impaired WBID in Charlotte County by Year 2018-2020[193,194]

Lee County

Lee County sits between Charlotte County and Collier County. Its coastline provides 47 miles of sandy beaches with over 100 access points. Lee County's entire coastline is protected by barrier islands. From north to south, Lee County is home to Gasparilla Island, Cayo Costa, North Captiva, Captiva Island, Sanibel Island, Fort Myers Beach, Estero Island, Big Hickory Island, and hundreds of smaller islands dispersed in-between. Gasparilla Island can only be reached by boat via the Gasparilla Sound-Charlotte Harbor Aquatic Preserve and Charlotte Harbor State Park, but the island is home to the Gasparilla Island State Park and seven miles of white beaches, making it both a wildlife and tourist destination. Sanibel Island is home to

[192] Florida Department of Environmental Protection. 2022. Comprehensive Verified List. November 14. Available here.
[193] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.
[194] The percentage for 2022 was derived from the Comprehensive Verified Impairment list released by FDEP.

the J.N. "Ding" Darling National Wildlife Refuge. This refuge provides vital habitat for hundreds of bird species and has miles of mangrove forests that support an abundance of wildlife as well. Fort Myers Beach is a popular tourist destination and just southeast of Fort Myers Beach is Estero Bay. The Bay includes several important coastal ecosystems including seagrass beds, mangrove forests and oyster reefs. Pine Island Sound Aquatic Preserve to the north is another important estuarine habitat home to seagrass beds, salt marshes and tidal flats.

Another critical water resource is the Caloosahatchee River, which connects to Lake Okeechobee in the center of the state and flows into the Gulf. This river plays an important role in the county for recreation and habitat for several important aquatic species such as snook, seatrout, crevalle jack and other economically important species including shellfish. The Caloosahatchee River and Gulf are greatly impacted by discharges from Lake Okeechobee. When the lake becomes too full, large discharges of water are released into the river. Large amounts of nutrients accompany the water and result in algae blooms in the Caloosahatchee River. The discharges also impact the salinity of the river and estuaries, which can be helpful in maintaining optimal salinity in the dry season.

Table D-2: Lee County Coastal Resource Information

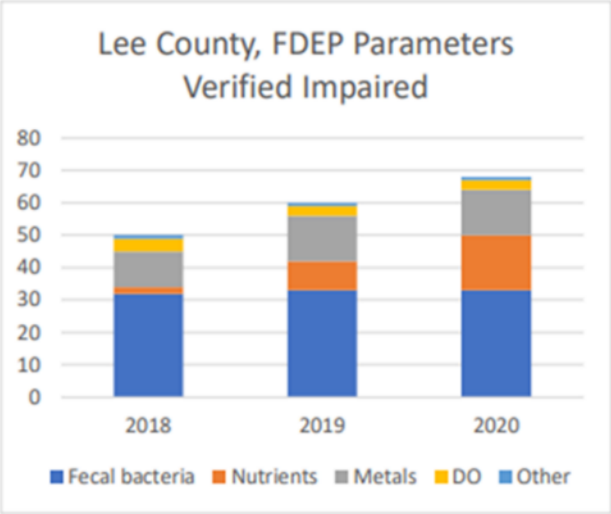
Coastal Resource	Description
Sandy Beaches	47 miles
Public Access Points	101
Coastal-Based State Parks and Lands	
In Lee County alone	Cayo Costa State Park (2,461 acres), Estero Bay Aquatic Preserve (13,800), Estero Bay Preserve State Park (11,381 acres), Gasparilla Island State Park (127 acres), Koreshan State Park (305 acres), Matlacha Pass Aquatic Preserve (14,600 acres), Pine Island Sound Aquatic Preserve (58,500 acres), J.N. "Ding" National Wildlife Refuge (7,600 acres), Lovers Key State Park (712 acres)
In Lee and Charlotte County	Cape Haze Aquatic Preserve (11,000 acres), Charlotte Harbor Preserve State Park (45,387 acres), Gasparilla Sound-Charlotte Harbor Aquatic Preserve (84,501 acres)
Bays and Inlets	Charlotte Bay, Estero Bay, San Carlos Bay
Rivers	Caloosahatchee River, Estero River, Hendry Creek

Table Source: Florida Department of Environmental Protection, Available here

As reported by the Calusa Waterkeeper Water Impairment report, Lee County had the greatest number of impaired water bodies/segments in 2019 and 2020 out of all three counties.[195] This is not surprising, as the county has many well-known culprits for leaking both fecal bacteria and excess nutrients like phosphorous and nitrogen into local waterways. Lake Okeechobee discharges carry nutrients that have accumulated in the lake over time (mostly from agricultural and development runoff), contributing to freshwater algal blooms.[196] The county is also home to an estimated 100,000 septic tanks that are contributing to the large number of impairments related to fecal bacteria. Elevated fecal bacteria levels are responsible for approximately 31 impairments annually from 2018 to 2020, and account for the largest percentage of impairments from 2018 through 2022. If this trend continues, over half of all WBID in Lee County will not meet basic water quality standards, posing a serious threat to both wildlife and human use of these water resources.

"Slow chronic conditions are compounded by one time surge events…all the inland ponds on Sanibel used to be freshwater, provided habitat for migrating birds, now they are all salty and staying salty…"

Scientist



Year	Percentage of WBID Impaired
2018	31.8%
2019	38.2%
2020	43.3%
2022	49.7%

Figure D-2: Number and Percentage of Impaired WBID in Lee County by Year 2018-2020[197, 198]

[195] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.
[196] Missimer, T., et al. 2020. Legacy Phosphorous in Lake Okeechobee (Florida, USA) Sediments: A Review and New Perspective. Water 2021, 13(1), 39. December. Available here.
[197] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.
[198] The percentage for 2022 was derived from the Comprehensive Verified Impairment list released by FDEP.

Lee County Septic System Problem

There are around 40,000 known septic systems in Lee County and an additional 57,000 that "likely" exist, though their location is unknown. This means that there are around 100,000 septic systems in Lee County alone and the county does not know where up to 60 percent of these septic tanks are located. Septic systems must be two feet above the water table, but due to sea level rise and extreme rain events, the water table has risen in some areas of the region permanently or temporarily. Septic systems need the two feet of soil above the water table to remove contaminants, otherwise they leach into the ground water. Today, many septic systems are leaking directly into the water table. Most of the "likely" septic systems are presumed to be very old, and potentially installed before this regulation was in place, meaning they could be even closer to the water table. It is very likely that these septic systems are leaking into Lee County's waterways, but without knowing their location, it is challenging to pinpoint the source of the increased pollution levels. The pollution, particularly the nitrogen, phosphorous and other bacteria associated with waste, are contributing to freshwater green-blue algae blooms in local canals and rivers. The pollution is carried to the Gulf where it contributes to red tide events. This compounding problem poses a significant water quality and public health issue.

Sources: Galoustian. 2022. Water Quality in Southwest Florida Linked to Seeping Septic Systems. Florida Atlantic University. August. Available here. AND Bayles. 2022. Leaky Septic Systems in Lee County Polluting Region's Soil and Water. WGCU PBS and NPR for Southwest Florida. Available here.

Collier County

Collier County is the southernmost county in the Study Area. The county boasts 48 miles of sandy beaches and has over 50 public access points. The southern half of the coast is protected by barrier islands. The major Collier County islands are Keewaydin Island, Lely Barefoot Beach, and Marco Island. Ten-Thousand Islands National Wildlife Refuge and Everglades National Park include thousands of small mangrove islands that are publicly owned and protected for conservation. These public islands along with Delnor-Wiggins State Park in the northern area of Collier County provide habitat for many native wildlife species and provide coastal recreational opportunities for local residents and tourists alike. In addition, the Big Cypress National Preserve is also located in Collier County.

Table D-3: Collier County Coastal Resource Information

Coastal Resource	Description
Sandy Beaches	48 miles
Public Access Points	53
Coastal-Based State/Federal Parks and Lands	
In Collier County alone	Rookery Bay National Estuarine Research Reserve (110,559 acres), Ten Thousand Islands National Wildlife Refuge (26,605), Delnor-Wiggins Pass State Park (166 acres), Collier-Seminole State Park (7,271 acres), Fakahatchee Strand Preserve State Park (77,116 acres)
In Collier, Miami-Dade, and Monroe County	Everglades National Park (1,542,562 acres), Big Cypress National Preserve (729,000 acres)
Bays and Inlets	Addison Bay, Barfield Bay, Chokoloskee Bay, Clam Bay, Fakahatchee Bay, Goodland Bay, Gullivan Bay, Johnson Bay, Little Hickory Bay, Moorings Bay, Naples Bay, Pelican Bay, Rookery Bay, Tarpon Bay, Water Turkey Bay, Venetian Bay
Rivers	Barron River, Blackwater River, Cocohatchee River

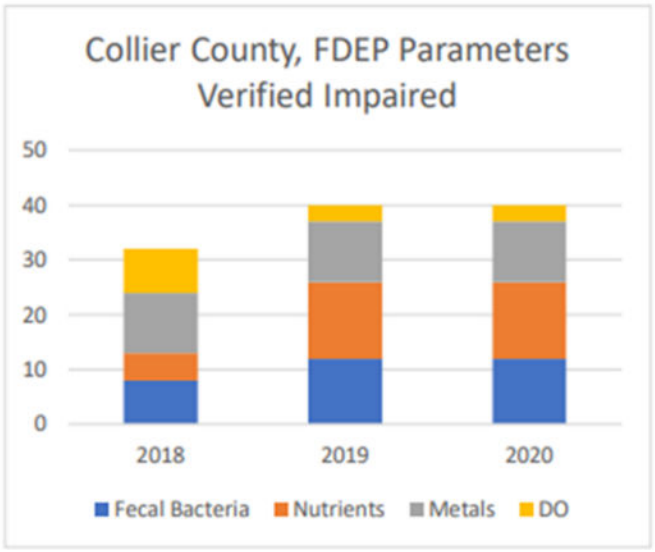
Table Source: Florida Department of Environmental Protection, Available here.

As mentioned previously, the FDEP evaluates water quality with respect to the state water quality standards. In 2007, the Cocohatchee River and Estuary was determined to be impaired by fecal coliform bacteria and iron.[199] This problem has persisted throughout the county due to the large quantity of septic systems. Though fecal coliform concentrations declined between 2003 and 2014, the levels still exceed water quality standards established for these waters.[200] Even in 2022, nitrogen levels exceeded standards in 82 percent of samples taken from the river compared to only 65 percent in 2021.[201]

Other reports noted trends of increased salinity and conductivity, likely caused by reduced rainfall and saltwater intrusion, and the river was decreasing in turbidity.[202] Today, reduced dissolved oxygen levels pose another problem, particularly in the wet season when the water is warmer and darker.[203] In Water Turkey Bay, dredging from canals and urban run-off have increased the ammonia and iron concentration in the water.[204] Though there have been some improvements to water quality over the past few decades, nutrient levels and low levels of dissolved oxygen are consistent problems in Collier County waterways. According to the Calusa Waterkeeper Water Impairment report, dissolved oxygen levels, metal concentrations and fecal bacteria were the main impairments for water bodies in Collier County.[205] As seen in the graphic below, this changed in 2019 when excess nutrients became the most common impairment. This is particularly concerning because excess nutrients have been linked to harmful algal

[199] O'Donnell, K., and Bailey, N. 2008. TMDL Report Fecal Coliform TMDL for the Cocohatchee River Estuary, WBID 3259A. August. Available here.
[200] Hatcher, M. 2014. Water Quality Report of the Cocohatchee Estuary – 2014. November. Available here.
[201] Collier County Pollution Control. FY22 Collier County Surface Water Report. April. Available here.
[202] Janicki Environmental, Inc. 2010. Surface Water Quality Annual Assessment and Trend Report for Collier County Pollution Control Department. Prepared for Collier County Pollution Control Department. November. Available here.
[203] Collier County Pollution Control. FY22 Collier County Surface Water Report. April. Available here.
[204] Hatcher, M. 2014. Water Quality Report of the Cocohatchee Estuary – 2014. November. Available here.
[205] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.

blooms and often are the result of increased human activity. 2019 and 2020 also have a greater number of impaired water bodies (40) compared to 2018 (32). Though there are a number of water bodies classified as impaired, Collier County has the fewest number of impaired bodies across all three years and the lowest percentage of impaired WBIDs by over 10 percent in 2022.



Year	Percentage of WBID Impaired
2018	19.6%
2019	24.6%
2020	24.6%
2022	28.8%

Figure D-3: Number and Percentage of Impaired WBID in Collier County by Year 2018-2020[206, 207]

[206] Calusa Waterkeeper. 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. March. Available here.
[207] The percentage for 2022 was derived from the Comprehensive Verified Impairment list released by FDEP.

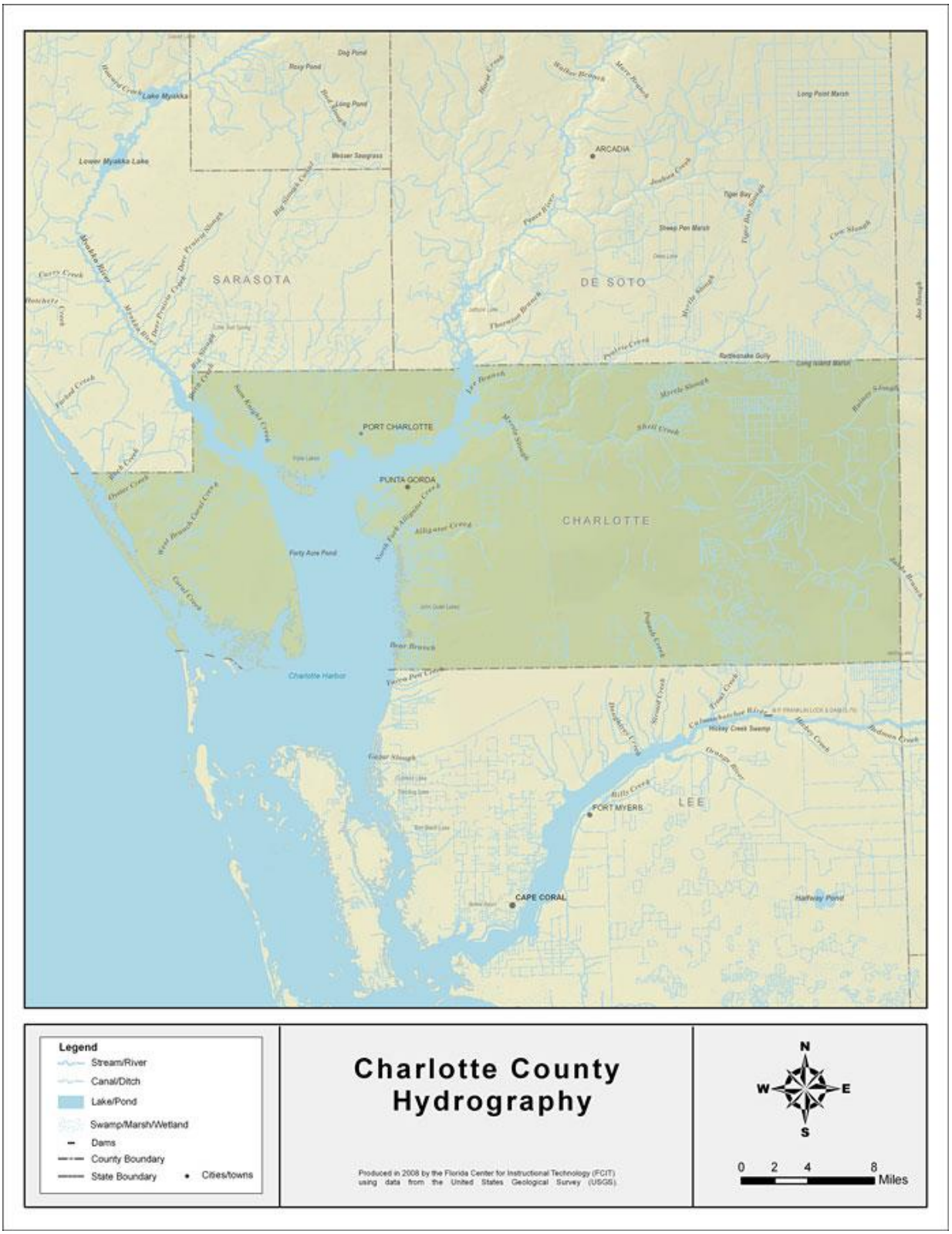


Figure D-4: Charlotte County Hydrography[208]

Figure D-5: Lee County Hydrography[209]

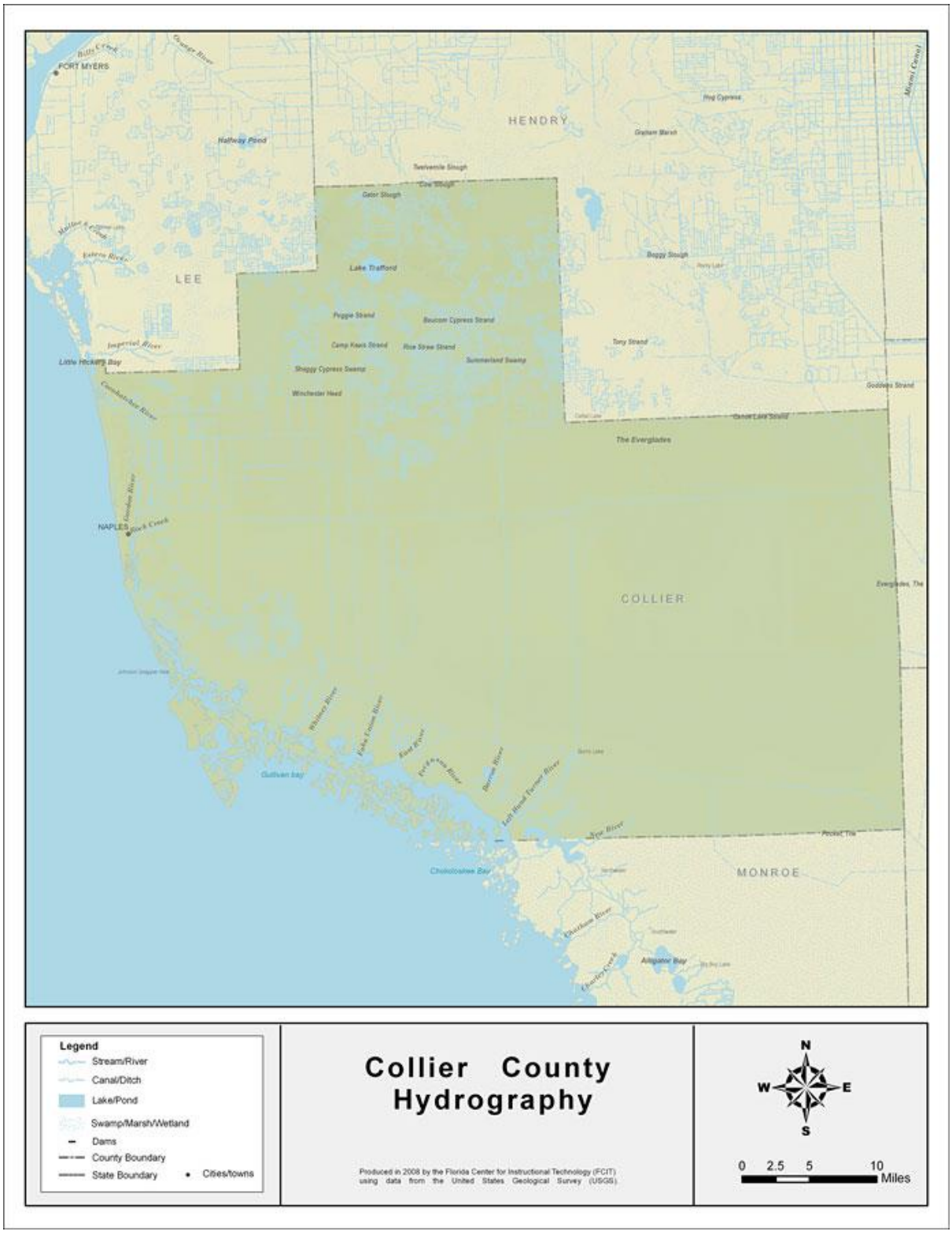


Figure D-6: Collier County Hydrography[210]

[210] Florida Center for Instructional Technology. 2008. Data from USGS. Available here.

Appendix E: Supplemental Information on Commercial Fishing

Charlotte County

Figures E-1 and E-2 pertain only to Charlotte County, the most northern county in our Study Area. As established before, Charlotte County does not bring in nearly as much commercially caught fish as Lee County, though it is comparable to Collier County. Figure E-1 includes the estimated dockside value of the ten species with the greatest value in the year 2000 for both the year 2000 and 2022 in Charlotte County. The FWCC determined the estimated value by multiplying the total pounds caught annually by the estimated dockside value. Over the past 22 years all the species caught have declined in real value of the catch, including black mullet, blue crab, stone crab (large and medium claws), pink shrimp, red grouper, and clams have declined in estimated value due to a decline in pounds landed. Black mullet, blue crab, and stone crab (ungraded claws) also had fewer pounds landed in 2022 compared to 2000. Only mojarra has increased in the value of the haul over the 22 years. However, the dockside prices have increased over the past 22 years for some of the species and so some species have lower pounds landed today than they did in the past. Only the mojarra and crevalle jack increased in pounds landed over the 22-year span.

Figure E-2 includes eight species that experienced the greatest declines in weight landed from 2000 to 2022. Species that were no longer caught in 2022, meaning commercial anglers landed zero pounds of said species, species with years of missing data, and species that did not experience a consistent decline in weight landed were excluded from the analysis. The species shown in Figure E-1 are representatives with some of the highest percentages (over 91 percent) in overall decline that did not, for the most part, have a year with greater pounds landed than that in 2000 across the 22-year time span. In Charlotte County, these species include the Pompano, grey snapper, porgies, grunts, blue runner, permit, flounders, and spotted seatrout. In the graph, it is very clear that the species experience nearly identical declines and increases in weight landed between 2000 and 2022. Though seatrout continually had the greatest weight landed, and pompano continually had the lowest, both species experienced significant increases in tons landed in 2003, 2005, 2008, and 2013. In fact, every species included in this figure experienced those same spikes in weight during the same years. They also experienced similar dips in weight landed during 2001, 2004, 2007, 2011, 2015 and 2019. It is possible that some event (HAB or storm) or disruption contributed to these significant dips in pounds caught since it affected these catch weights so uniformly.

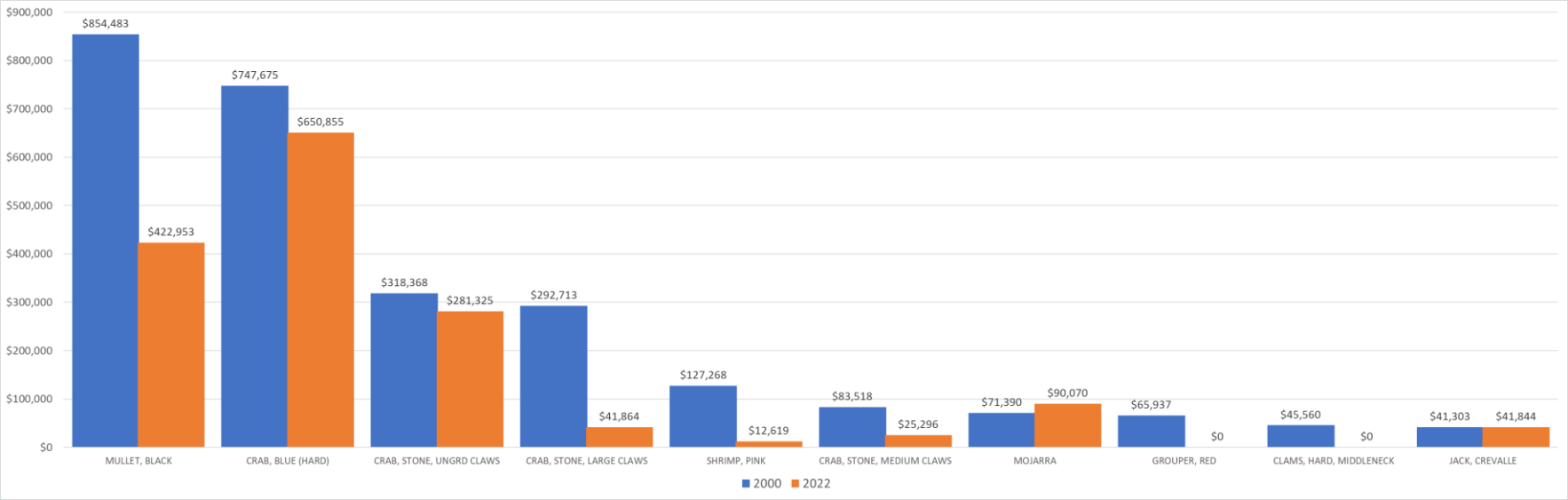


Figure E-1: Charlotte County Top 10 Species By Value (All Values in 2023 dollars)

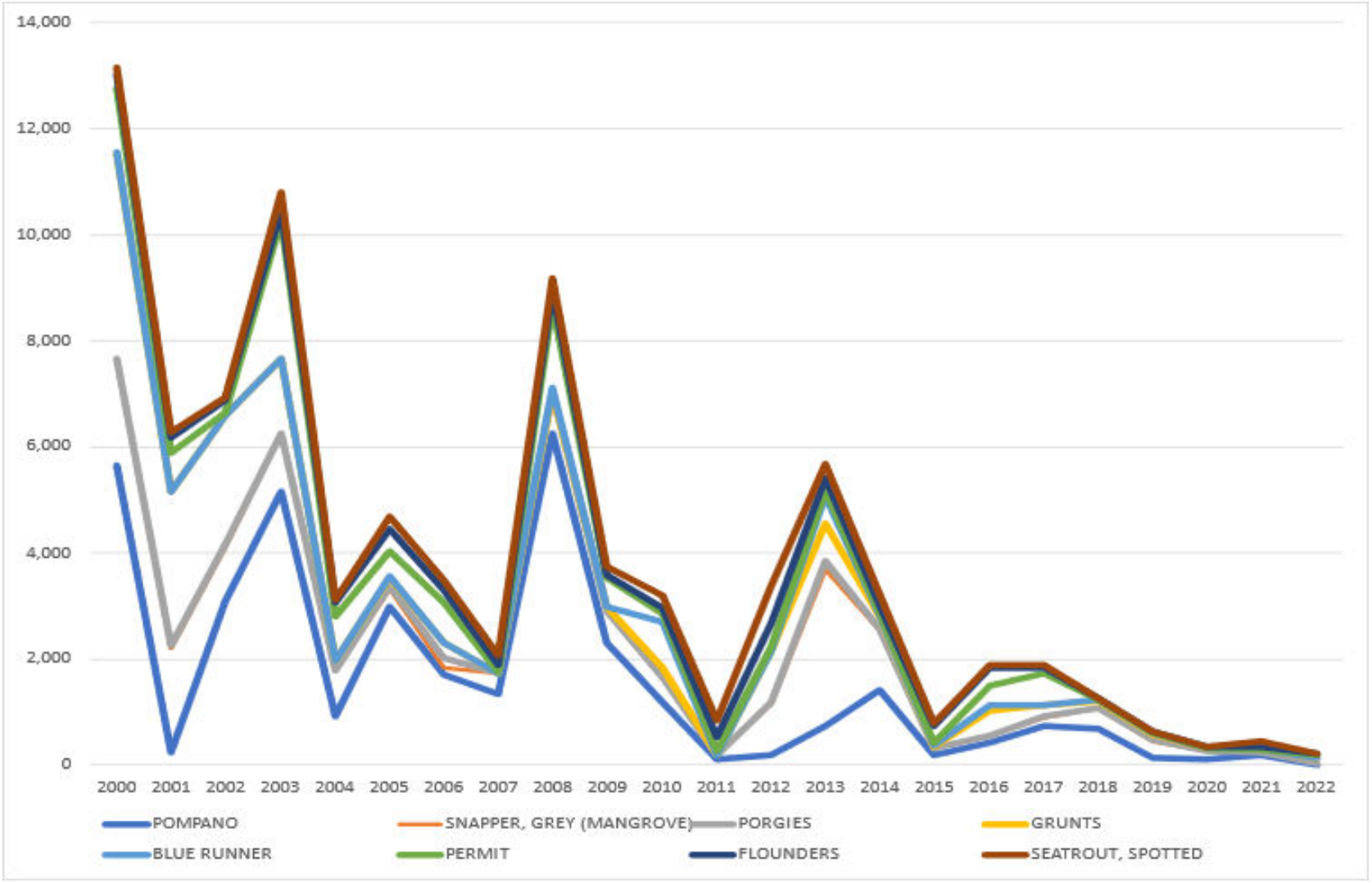


Figure E-2: Charlotte County Top Declining Species by Weight (Pounds)

Lee County

Figures E-3 and E-4 pertain to Lee County, which lands significantly more commercial fishing weight than the other two counties in southwest Florida. Figure E-3 includes the estimated dockside value of the ten species with the greatest value in the year 2000 for both the year 2000 and 2022 in Lee County. Black mullet, red grouper, pompano, brown shrimp, large stone crab claws, bait shrimp, and gag grouper all have lower estimated value in 2022 than in 2000. For these seven species, commercial fishermen are landing fewer pounds, resulting in reduced value (between 25 and 96 percent of the 2000 value). Medium stone crab claws and blue crab also experienced a decrease in weight landed from 2000 to 2022, but due to increased dockside value, they have a greater estimated value in 2022 despite having a greater landing weight in 2000. In Lee County, pink shrimp are the only species that experienced an increase in pounds landed, although the price in constant 2023 dollars has decreased. That is, when the 2000 price is adjusted for inflation it is lower than the 2023 price.

The species shown in Figure E-4 are representatives with some of the highest percentages (over 90 percent) in overall decline that did not, for the most part, have a year with greater pounds landed than that in 2000 across the 22-year time span. In Lee County, these species include spot, spotted seatrout, kingfish, Spanish lobster, grunts, Spanish mackerel, silver seatrout, bluefish, flounders, and pompano. While the top declining species in Lee County show the same general decline in weight landed from 2000 to 2022, the weight landed has more fluctuations compared to the other two counties. It seems like every one to two years the species experience a decrease in weight landed followed by a rise in weight landed that is often lower than the previous peak. The largest decline for all the species seems to have occurred in the early 2000s around 2003 to 2005, followed by smaller declines and increases in weight landed over the following years. These fluctuations could hint at annual or semiannual disturbances that impact the fish stocks and therefore the weight landed by commercial fishermen.

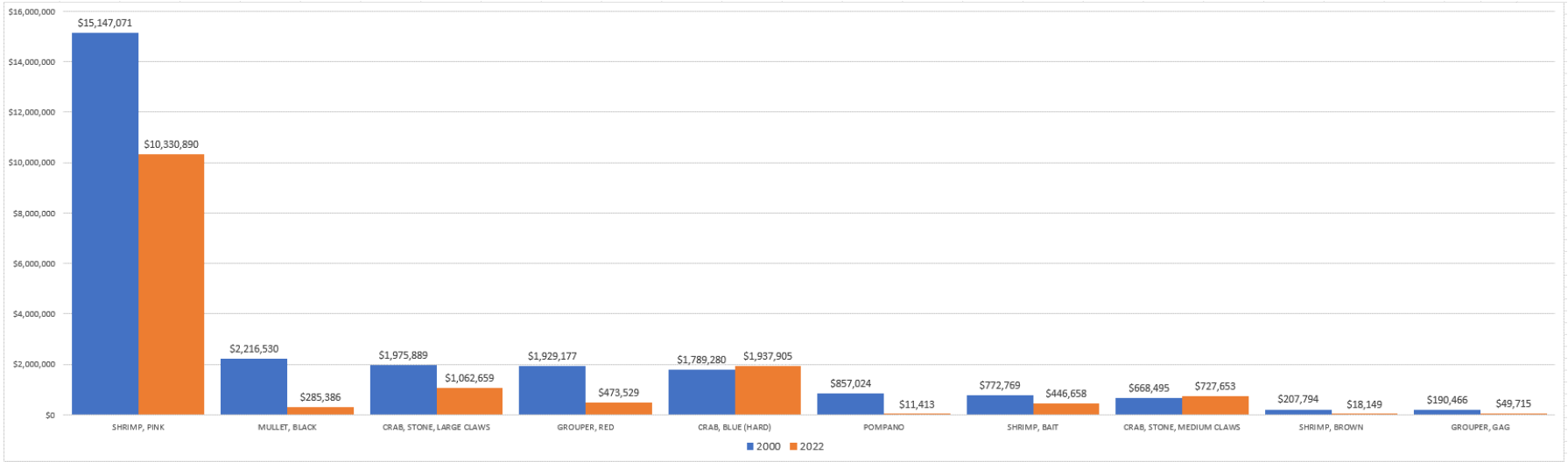


Figure E-3: Lee County Top 10 Species by Value (All values in 2023 dollars)

Note: Pink Shrimp - This species experienced an increase in pounds landed, from 2,586,308 in 2000 to 3,215,784 in 2022.

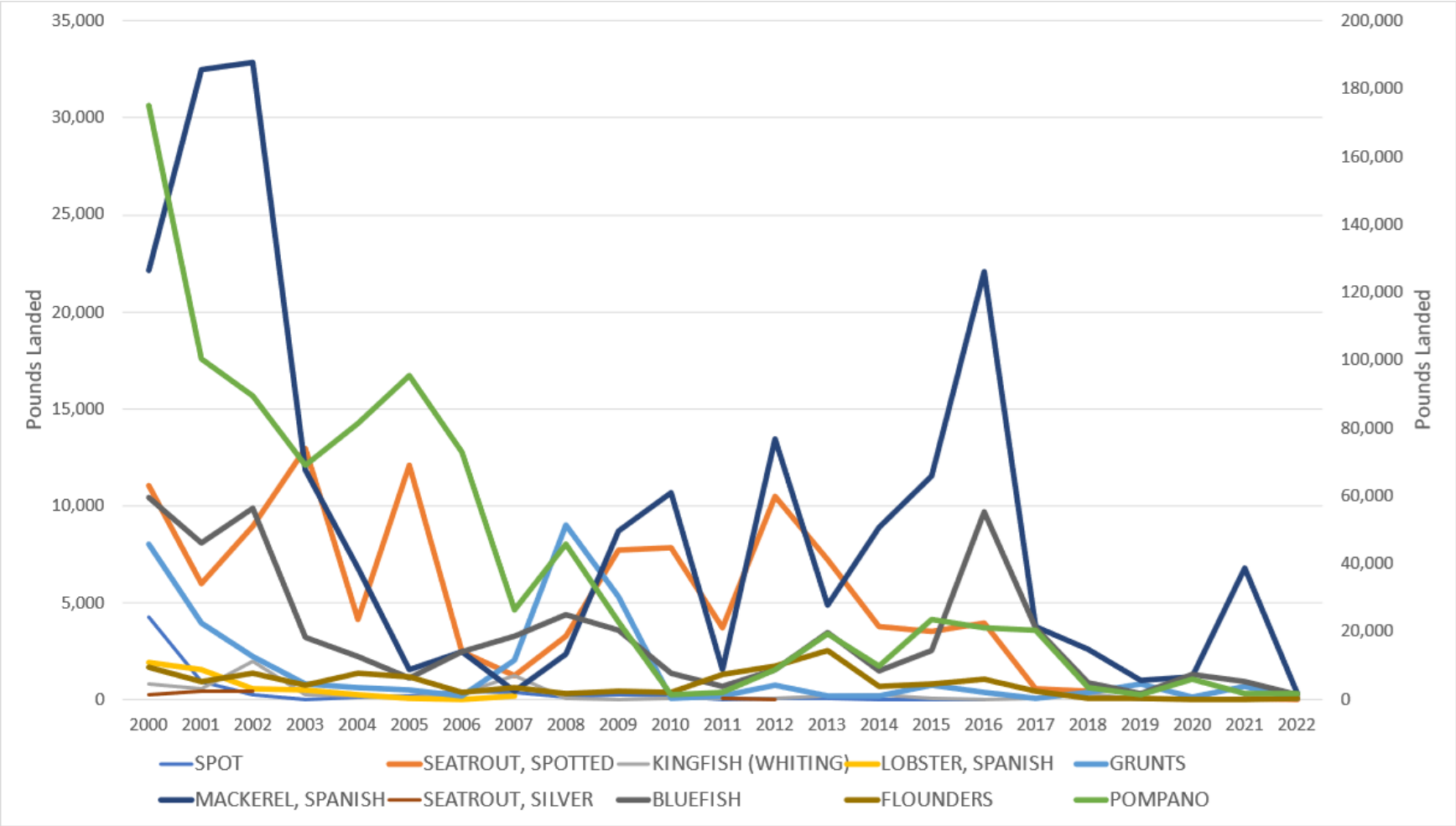


Figure E-4: Lee County Top Declining Species by Weight (Pounds)

Note: All species should be measured against the weight landed axis on the left side of the graph except pompano. The weight landed for pompano should be measured against the weight landed axis on the right side of the graph. The graph was constructed this way so that the viewer could see the values for all seven species simultaneously.

Collier County:

Figures E-5 and E-6 pertain only to Collier County. Collier County lands a similar weight of fish to that of Charlotte County. Figure E-5 includes the estimated dockside value of the ten species with the greatest value in the year 2000 for both the year 2000 and 2022 in Collier County. Stone crab claws, red grouper, black mullet, blue crab, pompano, and spiny lobster have declined in estimated value since the year 2000. This is in part due to several factors including red tides, algae bloom, fewer fishermen, gear restrictions, tougher landing limits, and increased costs.[211] Both landings and values were down for all species with the exceptions of jumbo crab claws, ungraded crab claws and king mackerel – each of which saw an increase in value of the catch and an uptick in tonnage harvested. Of note is that pompano, black mullet, and red grouper each lost more than 90 percent of the value of the catch over this period. Stone crab (medium and large claws) also experienced a decrease in weight landed from 2000 to 2022, but due to the increase in 2022 dockside prices, the fewer pounds caught in 2022 have a greater estimated value compared to the larger catch in 2000 with a lesser value per pound. The estimated value of jumbo stone crab claws went from just over $200,000 in 2000 to over $2 million in 2022. Though the pounds caught doubled in this time, increases in price account for the majority of the ten-fold increase in value as the weight landed merely doubled.

The species shown in Figure E-6 are representatives with some of the highest percentages (over 90 percent) in overall decline that did not, for the most part, have a year with greater pounds landed than that in 2000 across the 22-year time span. In Collier County, these species include the grunts, crevalle jack, jack (other), mojarra, black drum, lane snapper and red grouper. The top declining species by weight in Collier County do not follow the same trends as noticeably as the species did in Charlotte County. However, Figure E-5 indicates that commercial fishermen landed far less weight for these species in 2010 compared to 2002. Each species experienced a severe decline before 2010, though the starting year varies. For red groupers, weight landed declined by over 400,000 pounds between 2005 and 2007 and a further 60,000 between 2007 and 2010 (over 83 percent decline between 2005 and 2010). Though the decline in weight landed for crevalle jack started earlier, in 2003, commercial anglers landed 9,000 pounds less of the species in 2010 compared to 2003 (90 percent decline between 2003 and 2010). The species experienced another spike and decline between 2016 and 2021, though less significant than the initial decline. An event in the early 2000s paired with chronic issues could have played a role in the decline and then minimal recovery of these species.

[211] Florida Department of Agriculture and Consumer Services, Division of Marketing and Development, 2022. Florida Seafood Report, 2002 – 2021. Bureau of Strategic Development, August. Available here.

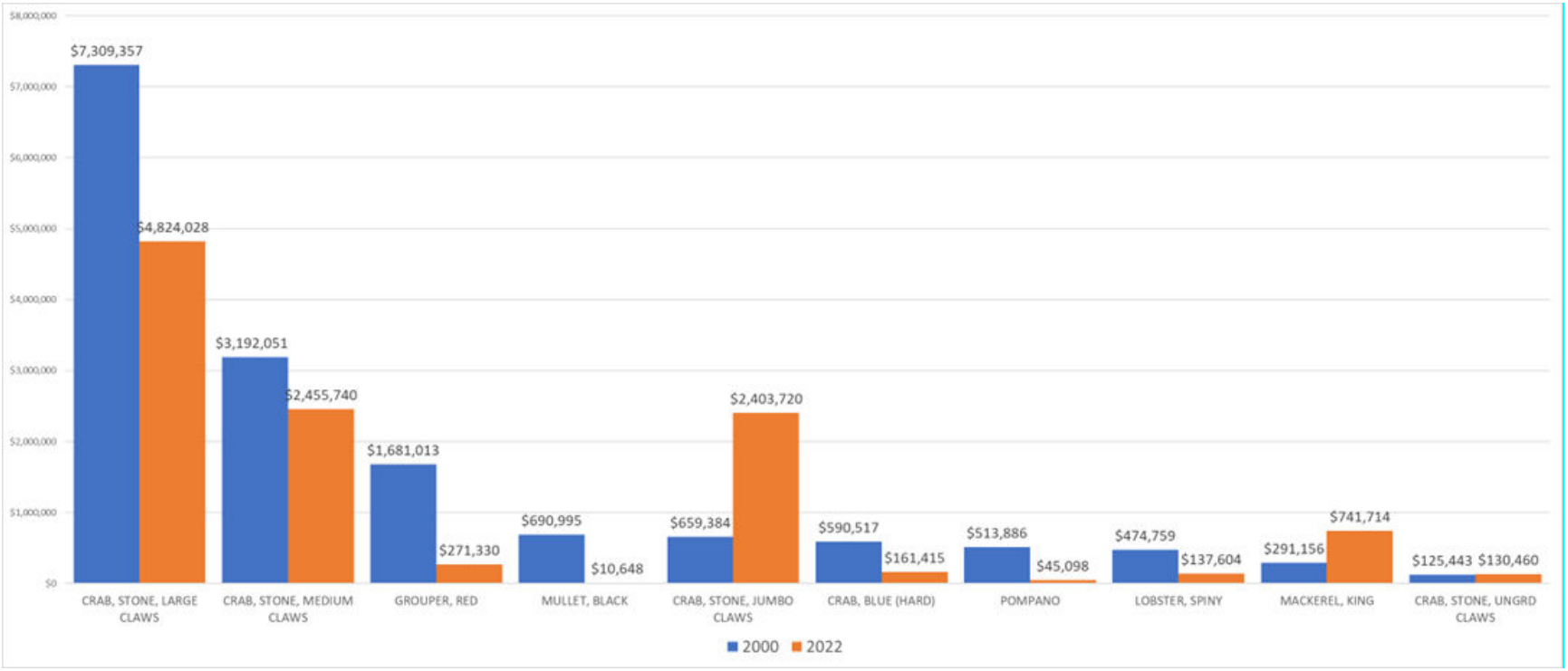


Figure E-5: Collier County Top 10 Species by Value (All values in 2023 dollars)

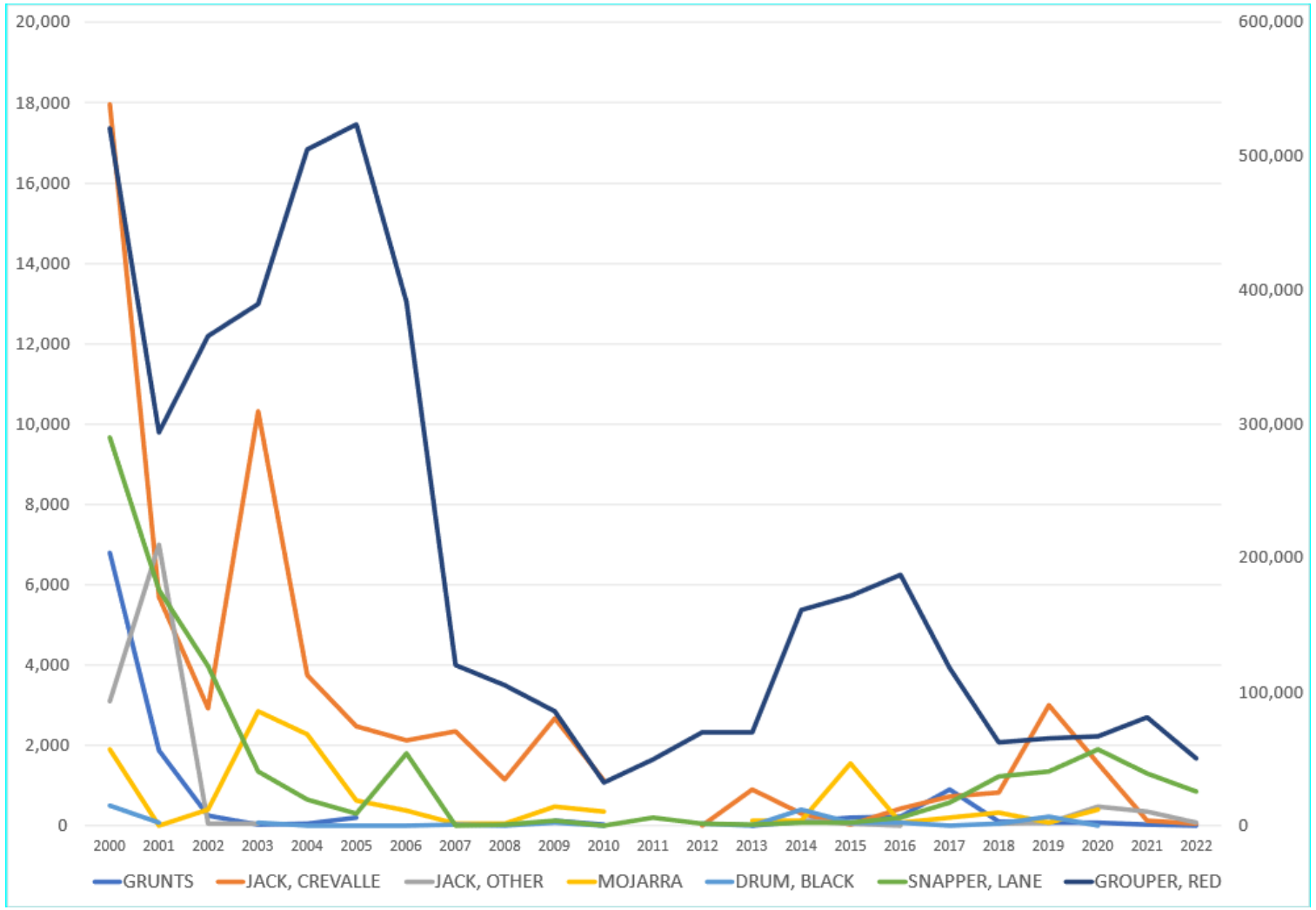


Figure E-6: Collier County Top Declining Species by Weight (Pounds)

Note: All species should be measured against the weight landed axis on the left side of the graph except red grouper. The weight landed for red grouper should be measured against the weight landed axis on the right side of the graph. The graph was constructed this way so that the viewer could see the values for all seven species simultaneously.

Appendix F: Supplemental Information on Recreational Fishing

In 2020, NOAA released a technical memorandum focused on the economic contribution of marine angler expenditures on fishing trips across the United States. They broke the analysis down by region. Of particular interest is the West Florida region that covers the Gulf Coast of Florida. The researchers found that marine recreational anglers spend an average of $434 per angler per day on for-hire trips, $62 on private or rental boat trips, and $55 on shore trips in 2023 dollars.[212]

Fedler (2011) considered the specific economic impact of recreational tarpon fishing in the Caloosahatchee River and Charlotte Harbor region of Florida. His research showed that recreational tarpon anglers spend a daily average of $333 and an annual average of $3,326 on fishing expenditures (in 2023 dollars).[213] From these values, we can deduce that tarpon anglers fish an average of 10 days per year. Fedler also considered the economic impact of recreational reef fishing in the Florida Keys in 2012. His research showed that recreational reef anglers in the Florida Keys spend a daily average of $421 and an annual average of $8,346 on fishing expenditures (in 2023 dollars).[214] From these values we can deduce that Florida Key anglers fish an average of 19 days per year. For both studies Fedler conducted surveys online or through the telephone targeting licensed anglers identified in the FWC fishing license databases. He used the results from these surveys to inform his analyses.

The U.S. Fish and Wildlife Service's 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation found that more than 35.8 million Americans went fishing in 2016 through their comprehensive National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Of these anglers, 30.1 million fished in freshwater and 8.3 million in saltwater. In total they took 383 million trips, 322 million of which were freshwater and 61 million of which were saltwater. Considering both salt and freshwater anglers, anglers took an average of 10.6 trips per year. Freshwater anglers took an average of 10.7 trips per year, and saltwater anglers took an average of 7.3 trips per year.[215] In addition to the number of angler and trips made by anglers, the report also included the number of days the anglers fished in 2016. Using the number of trips and number of days fished, we determined that both fresh and saltwater anglers spend an average of 1.2 days per trip.

The team used the 2020 NOAA angler spending per day values to deduce the average spending per trip by recreational anglers in the study area. These values are collected from the region and are relatively recent, though reported in spending per day rather than spending per trip. To get spending per trip, we multiplied the spending per day values by 1.2 days per trip, which came from the 2016 US Fish and Wildlife survey. The resulting values were $521 per angler per trip on for-hire trips, $74 on private or rental boat trips, and $66 on shore trips in 2023 dollars. The team used Fedler's (2011) days per year spent fishing tarpon on the Caloosahatchee River to determine the number of trips taken annually by freshwater anglers in the area (8.3 trips per year). As the most prominent river in Southwest Florida, this value is representative of the anglers in this region. For saltwater anglers, the value from the Greene et al. (1993) study, 9.3 trips per year, was deemed most appropriate. Though dated, this value pertains to the saltwater

[212] Lovell, S., et al. 2020. The Economic Contribution of Marine Angler Expenditures on Fishing Trips in the United States, 2017. NOAA Technical Memorandum NMFS-F/SPO-201. March. Available here.
[213] Fedler, T. 2011. The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee River and Charlotte Harbor Region of Florida. Prepared for The Everglades Foundation. January. Available here.
[214] Fedler, T. 2013. Economic Impact of the Florida Keys Flats Fishery. Prepared for Bonefish and Tarpon Trust. May 29. Available here.
[215] US Fish and Wildlife Service. Revised 2018. 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. October. Available here.

fishermen in the larger southwest Florida region and falls between the two estimated trips per year values in the 2016 US Fish and Wildlife national survey report (7.3 and 10.7 trips per year). As seen in the Table F-1 below, saltwater anglers spend between $614 and $4,845 annually, and freshwater anglers spend between $548 and $4,324 annually depending on their fishing mode.

Table F-1: Recreational Angler Expenditures per Angler for Fresh & Saltwater Fishing (in 2023 dollars)

Mode	Expenditures per trip	Saltwater expenditures per year	Freshwater expenditures per year
For-hire	$521	$4,845	$4,324
Private/rental boats	$74	$688	$614
Shore	$66	$614	$548

While the fishing license data from FWC provides information on the numbers of anglers who fished in the Study Area, these data do not explain how many out-of-state anglers visited the southwest Florida region to fish compared with in-state anglers. However, NOAA's Fisheries' Marine Recreational Information Program (MRIP) collects survey information regarding recreational fishing from all coastal states, including trip effort and trips taken. Using this collected data, NOAA estimates the number of trips by mode and area fished. Data for West Florida include both local and visitor angler trips, providing a more accurate expenditure story than the license numbers.

For this analysis, we used the recreational catch and effort estimates. We determine the number of estimated trips in West Florida by using trip values from the state and narrowing those to the Gulf Coast Sub-region. We then summed the number of estimated trips by mode, location and overall. For all West Florida, anglers made over 40 million trips in 2022, with just over half occurring inland and just under half at sea.

Table F-2: Estimated Number of Recreational Angler Trips for West Florida in 2022

Mode	Ocean (≤ 10 miles)	Ocean (> 10 miles)	Inland	TOTAL
Shore	10,564,631	NA	10,377,532	20,942,163
Charter Boat	256,393	469,496	291,712	1,017,600
Private Rental Boat	6,148,445	2,223,139	9,962,149	18,333,733
Combined TOTAL	16,969,469	2,692,635	20,631,393	40,293,496

Source: NOAA MRIP Fishing Effort Data. Available here

By multiplying the number of recreational angler trips taken in 2022 from the MRIP dataset by the estimated expenditures per trip calculated using the spending per day value from the 2020 NOAA report and days per trip value from the 2016 US Fish and Wildlife Survey report, we ascertained the total annual expenditures made by recreational anglers. Table E-3 below shows the annual angler spending broken down by fresh and saltwater anglers and by mode of transport (or by shore). Saltwater anglers expend $1.7 billion per year, and freshwater anglers expend $1.6 billion every year. Combined, all recreational anglers on the west coast of Florida directly contribute $3.3 billion to the local economy.

Table F-3: Recreational Angler Total Expenditures for Fresh & Saltwater Fishing (in 2023 dollars)

Mode	Annual Expenditures for all Saltwater Anglers	Annual Expenditures for all Freshwater Anglers	Total Annual Expenditures for all Anglers
For-hire/charter	$378,200,000	$152,000,000	$530,200,000
Private/rental boats	$619,500,000	$737,200,000	$1,356,700,000
Shore	$697,300,000	$684,900,000	$1,382,200,000
TOTAL	$1,695,000,000	$1,574,100,000	$3,269,000,000

Table F-4: Current Recreational Freshwater Fishing Licenses by County

License Type	Charlotte	Collier	Lee	Total
Freshwater Fishing - 1 year	1,027	1,918	3,847	6,792
Freshwater Fishing - 5 year	171	336	576	1,083
Freshwater Fishing (0-4) Lifetime	13	23	59	95
Freshwater Fishing (13-64) Lifetime	41	116	182	339
Freshwater Fishing (5-12) Lifetime	3	8	11	22
Freshwater/Saltwater Fishing - 1 year	901	1,384	2,577	4,862
Freshwater/Saltwater/Hunting - 1 year	44	60	157	261
Gold Sportsman - 1 year	372	437	781	1,590
Gold Sportsman - 5 year	15	34	51	100
Hunting & Freshwater Fishing - 1 year	14	9	28	51
Military Gold Sportsman's License - 1 year	68	58	131	257
Persons with Disabilities Resident Hunting/Fishing License - Other Qualification - 5 year	186	66	309	561
Persons with Disabilities Resident Hunting/Fishing License - SSA Qualification - 2 year	120	43	187	350
Silver Sportsman's 64+ (Fresh/Hunt) - 1 year	34	43	60	137
Silver Sportsman's 64+ (Fresh/Hunt) - 5 year	5	20	39	64
Sportsman (Freshwater Only) - 1 year	4	1	10	15
Sportsman's (0-4) Lifetime	140	172	342	654
Sportsman's (13-15) Lifetime	2	5	3	10
Sportsman's (16-64) Lifetime	122	252	373	747
Sportsman's (5-12) Lifetime	16	37	47	100
Sportsman's (0-4) Lifetime Promotion	18	20	42	80
Sportsman's (13-17) Lifetime Promotion	5	6	6	17
Sportsman's (5-12) Lifetime Promotion	4	8	10	22
Sportsman's (5-21 Promotion) Lifetime	53	65	138	256
Sportsman's 64 or Older (Prior to July 1, 1998)	167	211	246	624
Sportsman's Lifetime (Prior to July 1, 1998)	7	20	25	52
Sportsman's Lifetime (Promo Upgrade)	1	2	5	8
Youth Freshwater - Hard Card Included	7	14	18	39

License Type	Charlotte	Collier	Lee	Total
Youth Gold Sportsman – Hard Card Included	0	1	0	1
GRAND TOTAL	**3,560**	**5,369**	**10,260**	**19,189**

The saltwater fishing licenses tell a similar story. Lee County residents account for over half of all residential permit holders in the Study Area (43,282), followed by Collier County (24,165) and then Charlotte County (14,331). Between charter boat captains and individual saltwater anglers, the region supports almost 82,000 residential saltwater permit holders. The most common saltwater fishing permit is the annual saltwater permit. The 5-year, lifetime and freshwater/saltwater fishing combination are also popular across the board. Some species require additional permits. Almost 9,000 residents have an annual lobster permit with 4,900 of them residing in Lee, 2,700 in Collier, and 1,300 in Charlotte. Reef and Snook fishing are even more popular. 13,500 regional residents have an annual reef fishing permit and 12,500 have an annual or 5-year Snook fishing permit. The Charter Boat and Charter Captain permits are less popular, though Lee County has significantly more residential charter license holders compared to the other two counties. The region has around 70 residents with Charter Boat licenses and 475 with Charter Captains licenses. These licenses are spread more evenly between the three counties, but again, Lee County has the most charter boat and captain license holders of the three counties.

Table F-5: Recreational Saltwater Fishing Licenses by County

License Type	Charlotte	Collier	Lee	Total
Blue Crab Trap Register	353	328	736	1,417
Charter Boat – Lobster Permit -1 year	0	10	4	14
Charter Boat – Snook Permit -1 year	0	33	11	44
Charter Boat (10 or Fewer Customers) - 1 year	0	14	2	16
Charter Boat (11 or More Customers) - 1 year	0	3	0	3
Charter Boat (4 or Fewer Customers) - 1 year	2	6	4	12
Charter Boat (6 or Fewer Customers) - 1 year	0	23	16	39
Charter Captain - Lobster Permit - 1 year	17	34	53	104
Charter Captain - Snook Permit - 1 year	50	122	111	283
Charter Captain (10 or Fewer Customers) - 1 year	36	47	78	161
Charter Captain (4 or Fewer Customers) - 1 year	88	109	117	314
Freshwater/Saltwater Fishing - 1 year	902	1,382	2,573	4,857
Freshwater/Saltwater/Hunting - 1 year	44	60	159	263
Gold Sportsman - 1 year	370	439	778	1,587
Gold Sportsman - 5 year	15	34	52	101
Lobster Permit - 1 year	1,290	2,719	4,917	8,926
Lobster Permit - 5 year	114	421	614	1,149
Military Gold Sportsman's License - 1 year	68	57	130	255
Persons with Disabilities Resident Hunting/Fishing License - Other Qualification - 5 year	186	68	312	566
Persons with Disabilities Resident Hunting/Fishing License - SSA Qualification - 2 year	122	44	187	353
Recreational Vessel - 1 year	0	1	0	1

License Type	Charlotte	Collier	Lee	Total
Saltwater Fishing - 1 year	3,040	5,099	9,809	17,948
Saltwater Fishing - 5 year	892	1,704	3,084	5,680
Saltwater Fishing (0-4) Lifetime	60	111	216	387
Saltwater Fishing (13-64) Lifetime	343	1,070	1,653	3,066
Saltwater Fishing (5-12) Lifetime	17	51	65	133
Saltwater Pier - 1 year	0	3	2	5
Saltwater Pier - Snook Permit - 1 year	0	3	1	4
Saltwater Shoreline Fishing - 1 year	699	932	2,219	3,850
Shore-based Shark Fishing Permit - 1 year	113	96	219	428
Snook Permit - 1 year	1,750	3,398	5,809	10,957
Snook Permit - 5 year	176	529	718	1,423
Sportsman's (0-4) Lifetime	140	172	342	654
Sportsman's (13-15) Lifetime	2	5	3	10
Sportsman's (16-64) Lifetime	122	252	372	746
Sportsman's (5-12) Lifetime	16	37	47	100
Sportsman's (64 or older) Lifetime - 1 year	0	0	4	4
Sportsman's (0-4) Lifetime	0	1	0	1
Sportsman's (0-4) Lifetime Promotion	18	20	42	80
Sportsman's (13-17) Lifetime Promotion	5	6	6	17
Sportsman's (5-12) Lifetime Promotion	4	8	10	22
Sportsman's (5-21 Promotion) Lifetime	53	65	138	256
Sportsman's 64 or Older (Prior to July 1, 1998)	167	211	241	619
Sportsman's Lifetime (Prior to July 1, 1998)	7	20	25	52
Sportsman's Lifetime (Promo Upgrade)	1	2	5	8
State Reef Fish Angler - 1 year	2,363	3,546	6,048	11,957
State Reef Fish Angler Resident Senior - 1 year	419	370	612	1,401
Stone Crab Trap Registration - 1 year	255	445	667	1,367
Youth Gold Sportsman - Hard Card Included	0	1	0	1
Youth Saltwater - Hard Card Included	12	54	71	137
GRAND TOTAL	**14,331**	**24,165**	**43,282**	**81,778**

Though fishing permit holders may use their permit anywhere in the state, recreational fishing clearly plays an important role in the southwest Florida economy based on the number of residents that participate in this activity. It is especially important in Lee County where the majority of residential saltwater and freshwater fishing licenses are purchased.

Appendix G: Supplemental Information on the Coastal Economy

Crosswalk Between IMPLAN and NAICS (ENOW) Sectors

ENOW Sectors	IMPLAN	IMPLAN Sector Description	NAICS (ENOW)	NAICS Sector Description
Living Resources:	14	Animal production, except cattle and poultry and eggs	112511	Finfish Farming and harvesting
	14		112512	Shellfish Farming
	14		112519	Other Aquaculture
	17	Commercial fishing	114111	Finfish Fishing
	17		114112	Shellfish fishing
	17		114119	Other Marine Fishing
	92	Seafood product preparation and packaging	311710	Seafood Product Preparation and Packaging
	406*	Retail - Food and beverage stores	445220	Fish and Seafood Markets
	398**	Wholesale - Grocery and related product wholesalers	424460	Fish and Seafood Merchant Wholesalers
Offshore mineral resources	29	Sand and gravel mining	212321	Construction Sand and Gravel Mining
	29		212322	Industrial Sand Mining
	20	Oil and gas extraction	211111	Crude Petroleum and Natural Gas Extraction
	20		211112	Natural Gas Liquid Extraction
	35	Drilling oil and gas wells	213111	Drilling Oil and Gas Wells
	36	Support activities for oil and gas operations	213112	Support Activities for Oil and Gas Operations
	457	Architectural, engineering, and related services	541360	Geophycical Exploration and Mapping Services
Marine Transportation	416	Water transportation	483111	Deep Sea Freight Transportation
	416		483113	Coastal and Great Lakes Freight Transportation
	416		483112	Deep Sea Passenger Transportation
	416		483114	Coastal and Great Lakes Passenger Transportation
	420***	Scenic and sightseeing transportation and support activities for transportation	488310	Port and Harbor Operations
	420***		488320	Marine Cargo Handling
	420***		488330	Navigational Services to Shipping
	420***		488390	Other Support Activities for Water Transportation
	312	Search, detection, and navigation instruments manufacturing	334511	Search, Detection, Navigation, Guidance, Aeronautical and Nautical System and Instrumennt Manufacturing
	422	Warehousing and storage	493110	General Warehousing and Storage
	422		493120	Refrigerated Warehousing and Storage
	422		493130	Farm Product Warehousing and Storage
Marine construction	56	Construction of other new nonresidential structures	237990	Other Heavy and Civil Engineering Construction
Ship and Boat Building	360	Ship building and repairing	336612	Ship Building and Repair
	361	Boat building	336611	Boat Building and Repair
Tourism and Recreation	382	Sporting and athletic goods manufacturing	339920	Sporting and Athletic Good Manufacturing
	402	Retail - Motor vehicle and parts dealers	441222	Boat Dealers
	420***	Scenic and sightseeing transportation and support activities for transportation	487210	Scenic and Sighseeing Trasportation, Water
	420***		487990	Scenic and Sighseeing Trasportation, Other
	451	General and consumer goods rental except video tapes and discs	532293	Recreation Goods Rental
	482	Other educational services	611620	Sports and Recreation Instruction
	501	Museums, historical sites, zoos, and parks	712130	Zoo and Botanical Gardens
	501		712190	Nature Parks and Other Similar Institutions
	504	Other amusement and recreation industries	713930	Marinas
	504		713990	Amusement and Recreation Services Not Elsewhere Classified
	507	Hotels and motels, including casino hotels	721110	Hotels (except Casino Hotels) and Motels
	508	Other accommodations	721191	Bed and Breakfast Inns
	508		721211	RV Parks and Recreational Camps
	509	Full-service restaurants	722511	Full Service Restaurants
	510	Limited-service restaurants	722513	Limited Service Eating Places
	511	All other food and drinking places	722514	Cafeterias
	511		722515	Snack and Nonalcoholic Beverage Bars

*rkets (small part of 406)

**all portion of wholesale - grocery

***cluded in both marine transportation and tourism and recreation

Within Proximity to Coast

NOAA also produces a coastal economy dataset via the National Ocean Economics Program (NOEP). While the ocean economy data by ENOW includes sectors and industries that are defined by their use of ocean resources as direct inputs, the Coastal Economy Data by NOEP is defined purely by geography as the sum of economic activity taking place within the coastal region. Essentially, the coastal economy comprises all businesses that are within zip codes that have a coastal portion. These data are a different, but still important source of information about the coastal economy. While the sectors that are directly related to coastal activities are one type of connection, the coastal data suggests that industries within proximity to the coast are somehow connected and part of the coastal economy.

Coastal Economy data is presently available until 2021, and includes all activities and industries reported by the Bureau of Labor Statistics for the coastal counties and consists of all economic activity in the coastal region. Studies based on these data have pointed out that there is ambiguity in the definition of "coastal" for these data.[216] Coastal Economy Data are presented by the following NAICS sectors called "super sectors" in BLS NAICS-based employment data:

- Construction
- Education and Health Services
- Financial Activities
- Information
- Leisure and Hospitality
- Manufacturing
- Natural Resources and Mining
- Other Services
- Professional and Business Services
- Public Administration
- Total, all industries
- Trade, Transportation, and Utilities

Similar to ENOW data, data for the Coastal Economy includes GDP, Employment, and Establishments by sector. However, these data are not broken down by industries like that for ENOW data. Also, while ENOW data is provided for very specific sectors, these data are presented for a broader set of sectors within the coastal geography.

Since NOEP data associates coastal economies as those with coastal zip codes, the impact of the economies within these zip codes was analyzed through IMPLAN. A summary of the results is included in the table below. Across the three counties, the coastal economy, as identified by geography, accounts for over 470,000 jobs and $78.2 billion in output (Table G-1).

Table G-1: 2021 IMPLAN Share of Total Economic Activity from Coastal Economy Region by County

Baseline	Charlotte County		Collier County		Lee County		3-County Region	
	Employment	Output (billions)	Employment	Output (billions)	Employment	Output (billions)	Employment	Output (billions)
Total	48,933	$7.5	149,477	$26.3	271,827	$43.8	473,928	$78.2

Sources: IMPLAN. 2021. Charlotte County, Collier County and Lee County, Florida Data. Purchased at: www.implan.com on May 4, 2023.

[216] Colgan, Charles S. 2004. Employment and Wages for the U.S. Ocean and Coastal Economy. Monthly Labor Review. November. Available here.

Charlotte County

In Charlotte County, the coastal economy accounts for 48,933 jobs and $7.5 billion in economic output. Employment represents 67 percent of total employment in the county and output represents 68 percent of total county output. Essentially, the coastal economy accounts for two thirds of the county's total economy. Therefore, economic activity near the coast is a vital component of the county's overall economic prosperity. Charlotte County's coastal region contributes 10 percent of the tri-county area's employment and 9.5 percent of its total economic output. So, while the coastal region is an essential part of the county's economy, it contributes far less to Study Area's coastal economy compared to Lee and Collier County.

Lee County

In Lee County, the coastal economy accounts for 271,800 jobs and $43.8 billion in economic output. Employment linked to the coastal economy accounts for 69 percent of total employment in the county and output accounts for 70 percent of the county's total output. These percentages indicate that the coastal region of Lee County is an essential piece of the county's total economy as it represents greater than two thirds of the entire county economy. Lee County's coastal region contributes 57 percent of the tri-county area's employment and 56 percent of its total economic output. Not only is the coastal region a huge contributor to the county's economy, but the Study Area's as well. Any impact to Lee County's coastal region could seriously affect the Study Area's economy.

Collier County

In Collier County, the coastal economy accounts for 149,500 jobs and $26.3 billion in economic output. Employment represents 65 percent of total employment in the county and 66 percent of total output in the county. Again, economic activity in the coastal region accounts for approximately two thirds of the county's total economy, highlighting this region's importance to the county's overall economy. Collier County's coastal region contributes 32 percent of the Study Area's employment and 34 percent of its total economic output. Collier County accounts for three times more of the tri-county area's employment and output than Charlotte County but is not as strong as Lee County's coastal economy.

Whole County

Employment and wage and salary income data for counties that are provided through the IMPLAN system are used as a point of comparing the water-related portions of the county to the whole county data. Data from the IMPLAN system are from the Bureau of Labor Statistics, the Bureau of Economic Analysis, and the U.S. Census Bureau. The results are provided in Table G-2.

Table G-2: 2021 IMPLAN Total Economic Activity by County

Baseline	Charlotte County		Collier County		Lee County		3-County Region	
	Employment	Output (billions)	Employment	Output (billions)	Employment	Output (billions)	Employment	Output (billions)
Total County	73,034	$11.0	229,965	$40.1	393,953	$62.9	696,952	$114.1

Sources: IMPLAN. 2021. Charlotte County, Collier County and Lee County, Florida Data. Purchased at: www.implan.com on May 4, 2023.

Charlotte County

Charlotte County's entire economy accounts for 73,000 in employment and $11 billion in economic output. Its economic impact is less than half that of Collier County and less than one fifth of Lee County. Overall, it contributes 10 percent of the tri-county region's employment and economic output.

Lee County

Lee County's entire economy accounts for 394,000 in employment and $63 billion in economic output. It has the largest economic impact of all three counties, contributing 57 percent of the tri-county region's total employment and 55 percent of the region's economic output.

Collier County

Collier County's entire economy accounts for 230,000 in employment and $40.1 billion in economic output. Its economic impact falls between that of Lee and Charlotte County, contributing 33 percent of the tri-county region's total employment and 35 percent of the region's economic output.

Summary of Study Area

The team considered two ways of identifying the coastal economy in southwest Florida. The first considered industries directly tied to water resources. The second considered all economic activity within coastal zip codes including economic activity not directly related to water resources. This view of the coastal economy has merit because much of the economic activity is due to the nearby water resources. The coast draws in tourists and residents alike. Without the water, economic activity in these regions would likely be far reduced. Despite the merit to this approach, the team ultimately decided to view the coastal economy using the first approach – only considering economic activity directly tied to coastal industries. Though conservative, there is no doubt that this consideration of the coastal economy is wholly reliant on water resources in the Study Area. An impact to these resources would have a profound effect on this coastal economy.

For the Study Area, tri-county region, 151,300 jobs are generated from the direct sectors of the economy sectors, including all three economic impacts (direct, indirect, and induced). These sectors also generate $18.8 billion in economic output. For both employment and output, the majority of both are generated directly, followed by indirect and then induced impacts.

Table G-3: 2021 IMPLAN Economic Impact Summary

Baseline	Charlotte County		Collier County		Lee County		Study Area	
	Jobs	Output (billions)	Jobs	Output (billions)	Jobs	Output (billions)	Jobs	Output (billions)
Whole County	73,034	$11.0	229,965	$40.1	393,953	$62.9	**696,952**	**$114.1**
Coastal Economy	48,933	$7.5	149,477	$26.3	271,827	$43.8	**473,928**	**$78.2**
Direct Sectors	15,404	$1.7	48,576	$6.0	87,300	$11.1	**151,280**	**$18.8**
Direct	12,432	$1.2	40,619	$4.5	66,745	$7.3	**119,796**	**$13**
Indirect	1,915	$0.3	4,918	$0.9	12,605	$2.3	**19,438**	**$3.5**
Induced	1,057	$0.2	3,039	$0.6	7,950	$1.5	**12,046**	**$2.3**

Sources: IMPLAN. 2021. Charlotte County, Collier County and Lee County, Florida Data. Purchased at: www.implan.com on May 4, 2023.

Charlotte County

Charlotte County's coastal economy directly tied to water accounts for $1.7 billion in economic output, $1.2 billion of which is direct, $0.3 billion is indirect, and $0.2 billion is induced. Though the economic output is less than that of the other two counties, the economic output generated by the direct coastal sectors still accounts for 15 percent of the whole economic output. Employment tells a similar story with the direct coastal sectors accounting for 21 percent of the county's total employment.

Lee County

Lee County's coastal economy directly related to water resources accounts for $11.1 billion in total economic output. Of the $11.1 billion, $7.3 billion is direct, $2.3 billion is indirect, and $1.5 billion is induced. The total economic output from direct coastal sectors in Lee is greater than that of Collier and Charlotte combined and accounts for 18 percent of the whole county's total economic output. Employment tells a similar story with the direct coastal economy accounting for 17 percent of the county's total employment.

Collier County

The water-related coastal sectors in Collier County account for $6 billion in total economic output. Of this total, $4.5 comes from direct economic impacts, $0.9 comes from indirect impacts, and $0.6 comes from induced impacts. The total economic output from Collier's direct coastal economy falls between Charlotte and Lee Counties, accounting for 15 percent of the county's total economic output. Employment tells a similar story with the direct coastal economy accounting for 18 percent of the county's total employment.

Appendix H: Supplemental Information on Property Values

Bechard used property level data from the Zillow Transaction and Assessment Dataset to look at six Gulf Coast counties in Southwest Florida (including Charlotte, Lee, and Collier) between 2002 and 2018. During that sixteen-year time frame there were four major algal bloom events that lasted for over three consecutive months (Jan-March 2005; Aug- Nov 2005; Aug- Nov 2006; and June- Dec 2018.[217] Thirty-nine of the events that occurred during those periods lasted 10 days or more in a single month. Of those 39, 46 percent affected the coastal waters of our study area (8 in Charlotte County, 5 each in Lee and Collier). The highest number of incidents (11) occurred in Sarasota County-immediately north of Charlotte County.[218]

Bechard found that during a bloom event, properties of any type within a mile of an affected area sold for 20 percent less than those in an unaffected area. When he focused exclusively on residential properties that percentage decrease increased to 25%.[219] Those results weaken as distance from the coast increased, with price drops remaining in the 15-20 percent range for properties between 1 and 5 miles from shore. Hence total property values that are at risk of loss from degraded value are primarily within one mile of a water body. Using parcel data from county assessors' offices in the Study Area, Conservancy of Southwest Florida (COSWFL) analysts used Geographic Information System (GIS) software to select those properties that were within one mile of a waterway and those within five miles.

The total property value of all parcels in each county is shown below in Table 4-16. The total property value of just the parcels within one mile of a waterway is also shown, and as well the percentage of the entire county value. Not surprisingly, the properties within a mile of a waterway make up a higher percentage of total property value, than they do total number of properties, and this suggests the properties nearer to the water in general are more valuable than those farther away. For example, when the entire Study Area is considered, the properties within a mile of a waterway account for 21 percent of all parcels, but fully 39 percent of property value. This disparity is most distinct in Collier County where 20 percent of the properties account for 48 percent of the total parcel value.

Also, in Florida, the taxable value of a property is determined by the property appraiser. As set forth in the Florida constitution, the property appraiser is required, on an annual basis, to assess all real property in their county as of January 1st. Each parcel has a "just value" and "assessed value" and a "taxable value". The "just value" is the same as the fair market value, representing the amount a "willing purchaser would pay a willing seller" in an open market.[220] The "assessed value" is the just value minus assessment limitations (for example the Save our Homes 3% cap, conservation easements, etc.).[221] The "taxable value" is the assessed value minus exemptions (for example the Homestead Exemption reduces the taxable value of a property by $50,000).[222]

[217] Bechard, Andrew. 2020. Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Towards the Shore. Journal of Real Estate Finance 62:242-257. Available here. Page 245.
[218] Bechard, Andrew. 2020. Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown Towards the Shore. Journal of Real Estate Finance 62:242-257. Pg 245. Available here.
[219] Ibid. Pg. 248. Available here. For condominiums the impact was not as great, with condominium sale prices only dropping 16 percent during a bloom event.
[220] Florida Law Governing Assessments. Available here.
[221] Property Tax Information for First-Time Home Buyers. Available here.
[222] Ibid. Available here.

Appendix I: Supplemental Information on Non-Market Values

Review of Non-Market Value Estimates for Recreational Activities

Beaches in Florida are known around the world for their aesthetic value and for the many recreational opportunities they provide, with four of the ten most visited beaches in the US located in the state. In 2012, with 810 million beach visits per day, beach visitation in the state surpassed that of any other US state or country. In fact, tourist visits to beaches in Florida exceed that to all theme parks and National Parks combined. Needless to say, visitation to these beaches translates into immense economic value with Florida beaches yielding an annual recreational value of about $50 billion in 2012.[223]

One study used a meta-analysis of existing studies conducted throughout the US to estimate a consumer surplus value of a beach visit of around $22 for the study area, accounting for water quality at beaches by using past closure history. The consumer surplus values of a beach day was estimated to range from $1,400 for a small, low use beach to $50,000 for a large, high use one. In addition, the value lost from a beach closure was estimated to range from around $1,000 per day to over $37,000 per day.[224]

Another study used both the visit rate and recreation values associated with beach visits in different regional areas of coastline along the Queensland coast in Australia. The value of a single beach visit was estimated per person at $35.09, which translates to $450 million in beach recreation values per year.[225]

Bird watching and other wildlife viewing constitute the fifth and seventh most popular marine recreation activities in the United States, with more than 15 million people spending nearly 650-million-person days watching birds at the shore alone.[226] A 2011 study commissioned by the FWC identified wildlife viewing as the second most popular recreational activity in Florida, with over 4.3 million people (resident and nonresident) participating in wildlife viewing, resulting in nearly $5 billion in economic impact.[227] This type of activity has a nonmarket component as well.

In 2020, Bonacquist-Currin conducted a meta- analysis of 27 stated preference willingness to pay (WTP) surveys to measure consumer surplus per person, per day (in 2020 dollars) for bird watching. The study estimated that the consumer surplus per person per day ranged from a low of $0.29 (in 2020 dollars) to a high of $824.53. [228]

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[223] Jim Houston. 2013. The Value of Florida Beaches. Available at: https://www.fsbpa.com/13AnnualConfPresentations/HoustonValueofFloridaBeaches.pdf

[224] S.F. Lyon, Merrill N.H., Mulvaney K.K., and Mazzotta M.J. 2018. Valuing Coastal Beaches and Closures Using Benefit Transfer: An Application to Barnstable, Massachusetts. J Ocean Coast Econ. 2018 May 31;5(1):1. doi: 0.15351/2373-8456.1086. PMID: 30148207; PMCID: PMC6104649. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6104649/#:~:text=The%20net%20economic%20value%20of,society%20of%20providing%20the%20amenities.

[225] Rolfe, John and Daniel Gregg. 2012. Valuing Beach Recreation Across a Regional Area: The Great Barrier Reef in Australia. Available at: https://ageconsearch.umn.edu/record/124433/files/2012AC%20Rolfe%20CP.pdf

[226] Pendleton, L., H. Understanding the Potential Economic Value of Marine Wildlife Viewing and Whale Watching in California: Using the Literature to Support Decision-Making for the Marine Life Protection Act. Available here.

[227] The 2011 Economic Benefits of Wildlife Viewing in Florida. Prepared for Florida Fish and Wildlife Conservation Commission. October 2013. Pg. 3. Available here.

[228] Bonacquist-Currin, M. 2020. The Economic Value of Birdwatching: A Meta-Analysis and summary of Stated Preference Studies. A Thesis Presented to he Faculty of the Graduate School of Cornell University. December. Available here.

Specific to Florida, a 1997 study used travel cost demand models to estimate the nonmarket economic user values for recreating visitors to the Florida Keys/Key West that participated in natural resource-based activities including wildlife watching. The results were limited to visitors (nonresidents of Monroe County) to the Florida Keys/Key West that engaged in at least one natural resource-based activity on their visit to the area. The annual weighted average expenditure was estimated at $654 per person-trip, and all visitors that engaged in natural resource-based activities had a total annual user value of about $1.2 billion. Beach activities accounted for about $233 million in annual user value, viewing nature and wildlife about $224 million, fishing about $171 million, snorkeling about $156 million, and scuba diving about $49 million.[229]

A 2019 study by Borisova, T., et al. reviewed six Florida-based studies published in peer-reviewed academic journals that examine the value assigned to freshwater-based recreation by recreational tourists.[230] Analysis of studies conducted for different sites in the region showed that the average WTP for fishing, motorized boating, and non-motorized boating was $70.98, $57.83, and $108.38 per person per day, respectively. The average for all the different activities that visitors engaged in (e.g., backpacking, biking, camping, hiking, hunting, fishing, etc.) was $66.70 per person per day for the southern region of the United States.[231] The values estimated within the individual studies are provided below:

- **Shrestha et al., 2007 (Travel Cost Method):** The study surveyed visitors at five sites in the Apalachicola River Basin. Some of the activities that visitors were engaged in were water-based (such as swimming), while others were land-based (such as camping). Overall, researchers found that on average visitors' WTP for nature-based recreation was $787.76 per trip, or $74.18 per visit-day (given that the estimated average length of a trip was approximately 11 days).
- **Ehrlich et al., 2017 (Travel Cost Method):** A 2014 phone survey of a sample of Florida residents from 49 counties in north, central, and south Florida was used to estimate the number of tourists who visited the St. Johns River Basin as a proportion of the Florida population, and to collect information on the frequency of visitation. Households valued recreation in the St. Johns River Basin at an average of $212.50 per year per household over their actual expenditure for recreational trips.
- **Bi et al., 2019 (Willingness to Pay):** Used interviews of recreational visitors at several sites along the free-flowing and impounded sections of the Ocklawaha River to estimate visitors' WTP for their recreational experiences. The study found that the WTP is $152.79 per person per year (above their actual trip expenditure) for those involved in fishing activities and $69.98 per person per year (above their actual trip expenditure) for those engaged in the other types of recreational activities.
- **Shrestha et al., 2002 (Contingent Valuation):** The study estimated the value visitors derive from water-based recreation at Sweetwater Springs, Silver Glen Springs, Juniper Springs, and Salt Springs sites in the Ocala National Forest. Day visitors were willing to pay an average of $4.88 per visitor per trip (above the actual expenditures incurred for the trip), given the current facilities at the spring sites. Day visitors were willing to pay more, $8.75 per visitor per trip, for

[229] Leeworthy, V., R., and Bowker, J., M. 1997. Nonmarket Economic User Values of the Florida Keys/Key West. October. Available here.
[230] Borisova, T., et al. 2019. Economic Value of Florida Water Resources: Value of Freshwater-Based Recreational Experiences. August. Available here.
[231] Borisova, T., et al. 2019. Economic Value of Florida Water Resources: Value of Freshwater-Based Recreational Experiences. August. Available here.

moderately improved facilities (e.g., basic grocery, camping facilities, daytime tours), and $11.72 per visitor per trip for greatly improved facilities (e.g., children's play area, restaurant, rental cabins, weekend tours). In turn, for visitors who stayed overnight, WTP averages were $9.33, $12.95, and $17.45 per visitor per trip, for different levels of improvements to spring site facilities, respectively.

- **Wu et al., 2018 (Travel Cost Method):** The study estimated the value that visitors derived from recreation at four spring sites located in north central Florida: Blue Springs (Madison County), Fanning Springs State Park, Ichetucknee Springs State Park, and Blue Springs (Gilchrist County, High Springs area). Analysis of the survey responses showed that the estimated average trip was valued at $28.91 per person per trip, not including actual trip expenditures. Given an average expected trip frequency of 2.33 per person per year, the annual consumer surplus per person per year is $67.36.

Appendix J: Regulating Water Quality

Chronic Water Degradation

The US Environmental Protection Agency (EPA) identifies seven broad ecosystem services benefit categories including "clean and plentiful water".[232] As illustrated in the graphic below, clean water is not only a critical part of our natural resource base, but it also provides benefits to humans and wildlife and helps manage and mitigate changing natural processes.[233]

Figure J-1 Benefits of Clean Water

Listing and Prevalence of Criteria Pollutants

Under the Clean Water Act, EPA establishes limits for and tracks approximately 150 pollutants that have the potential to impact aquatic life and human health.[234] The state of Florida also classifies waters, designates uses and tracks criteria pollutants.[235] Temperature, salinity, pH, dissolved oxygen, nitrogen (total and organic), chlorophyll, phosphorus, turbidity, heavy metal concentration, and fecal indicator bacteria are typically parameters of interest. In our study the six parameters in Table 6-1 below are of particular interest, both because of their role in illustrating estuary and water body health, and because most of the listed waterbodies in our study area are listed because the thresholds for one or more of these criteria have been exceeded.

[232] Ecosystem Services- EnviroAtlas. US EPA. Available here.
[233] Clean and Plentiful Water. EnviroAtlas. US EPA. Available here.
[234] National Recommended Water Quality Criteria- Organoleptic Effects. Available here.
[235] Surface Water Quality Standards, Classes Uses, Criteria. Florida Department of Environmental Protection. Available here.

Table J-1. Indicator Variables for Assessing Ambient Water Quality

Indicator Variable	Cause for Concern
Temperature	Fish and aquatic species require certain temperature ranges to survive; temperature imbalances also encourage growth of harmful organisms (algae)
Dissolved Oxygen	Species require oxygen to survive, low levels of dissolved oxygen can also be an indicator of increased harmful plant growth and algal blooms
Nitrogen/Phosphorus	High levels of nutrients fuel growth of algal blooms
Chlorophyll	Measure of the presence of microscopic photosynthetic organisms (aka algae)
Turbidity	Measure of water clarity- indicates the presence of suspended materials (living or dead), increased sediment loads can smother habitat and interfere with fishing and swimming
Fecal Indicator Bacteria	Waterborne pathogens threaten human health

Each water body, or segment of a waterbody has a unique identification number (WBID). Data are collected for criteria indicators by WBID. Every two years states are required to provide EPA with a list of segments of streams and rivers, and lakes, that have pollutant loads that exceed federal standards, this list is referred to as a "303(d) list". Once a reach or waterway is "listed" states are then required to develop a plan to address issues so that the waterbody can meet water quality standards. These plans are referred to as TMDL (Total Maximum Daily Load) plans. There are several factors to keep in mind when using listings and TMDL databases as tools for understanding water quality in an area. The first is that "listing" likely underestimates the number of damaged or degraded water bodies. Listing does not occur until a water body exceeds a particular standard for a defined amount of time. So, there may be waterbodies in an area that are being degraded but have not yet reached the threshold level of contamination or damage required for inclusion on a 303(d) list.

The second is that "listing" does not immediately lead to clean up. States are able to rank and prioritize waterbodies for the development of TMDL plans.[236] Once a waterway is on a list it is monitored, but no clean up action typically occurs until the TMDL plan is developed and approved- which can take years.

Third, once a TMDL plan is in place the waterway in question is removed from the list (or "de-listed) but that does not mean that clean-up has occurred- it just means that a plan has been developed and approved. So, if the number of "listings" goes down between reporting periods, that does not necessarily mean that improvements in water quality have actually occurred. Monitoring continues, but those data are now reported as part of a TMDL database, not a 303(d) database- which makes it extremely difficult to accurately assess the state of water quality on a waterbody.

[236] TMDL Prioritization. Division of Environmental Assessment and Restoration. Florida Department of Environmental Protection. Available here.

Water Quality in the Study Area

In our study area Collier County has a robust program to track and report water quality data and materials are easily located on the county website.[237] Lee County has some data on their website, but the information is general, and most is outdated.[238] Charlotte County did not hire a water quality coordinator until 2021 or launch an ambient water quality monitoring program until June 2022.[239]

> *"Engineering is important, but we can't engineer our way out of this… when talking about water we focus on 'quantity' but we should be focused on 'quality' … we are trying to use a shotgun when a rifle is what's needed"*
>
> *Captain*

According to the Florida Department of Environmental Protection verified list for the 2020-2022 Biennial Assessment there are four listed estuaries in Charlotte County (three for nitrogen and one for enterococci). There are 10 streams that are co-located in Charlotte and Lee Counties that are listed for e-coli. There are nine bodies (estuaries and streams) in Collier County that are listed for dissolved oxygen, E.coli, nitrogen/phosphorus) and two bodies that span Lee/Collier County are listed for E.coli and enterococci.[240]

There are an additional 12 reaches in the Caloosahatchee Estuary in Lee County and three that span Lee & Collier County that are being evaluated for listing. There are nine reaches that are under consideration in Charlotte County and seven in Charlotte Harbor. [241]

In addition to state and county government, there are several organizations that track and report on water quality status in the three-county study area including the Peace/Mayaka and Clausa Waterkeepers, the Coastal Heartland National Estuary Partnership (CHNEP) and the Sanibel-Captiva Conservation Foundation (SCCF).

Their data show that not only are water bodies in the three-county study area severely degraded but the trends are increasing downward. According to an analysis of FDEP published data done by the Calusa Waterkeeper, and as noted in Chapter 4, nearly 36 percent of the water bodies in Charlotte County, 45 percent in Lee and almost 25 percent of the water bodies in Collier County are listed as impaired. [242]

As explained above, it is likely that these percentages underestimate the numbers of waterbodies or segments of water bodies that are degraded or vulnerable because the data only track criteria pollutants and water bodies only make it onto the list when a threshold of contamination is reached.

Drivers of Chronic Poor Water Quality

In our three-county study area, population growth, lack of growth management, and antiquated regulations are key drivers of increased contamination and continued degradation.

[237] Collier County Pollution Control Water Quality Reports and Maps. Available here.
[238] Lee County's Current Water Quality Status. Available here.
[239] Charlotte County Project Plan for Ambient Surface Water Monitoring Program. Available here.
[240] Florida Department of Environmental Protection. Comprehensive Verified List. Available here.
[241] Florida Department of Environmental Protection. Comprehensive Study List. Available here.
[242] Calusa Waterkeeper. March 2021. Water Quality Impairment Status and Trends of Southwest Florida Counties 2018-2020. Pg. 8. Available here.

Population growth is rapid across Florida. According to the US Census Bureau, the Punta Gorda Metropolitan Statistical Area, which includes all of Charlotte County is the 5th largest area for population growth in the United States[243], followed by Lee County (9th), and Collier (12th).[244]

The 1985 Florida Growth Management Act required all counties to have comprehensive growth management plans that aligned with state and regional plans.[245] These strategies guide planning, zoning, and permitting and are supposed to ensure that growth rates do not exceed the carrying capacity for water, sewer, wastewater treatment (and other public services like police and fire protection) and that new development is compliant with codes, regulations, and standards.

Growth and development have the potential to impact water quality through multiple pathways. Growth results in changes in density and changes in ratios of pervious to impervious surfaces, which impacts not only the amount of contamination entering the ecosystem, but also the concentration of contaminants.

Growth and development also can result in increased demand for and pressure on water, sewer, and wastewater treatment and management. The way that lawns are managed impacts runoff and nutrient concentrations in runoff. Increased traffic and use of automobiles and other forms of transportation increases brake dust (which contains heavy metals) and particulate matter which make their way into waterbodies through stormwater runoff. This is summarized nicely by FDEP,

> *Unmanaged urban stormwater creates a wide variety of effects on Florida's surface and ground waters. Urbanization leads to the compaction of soil; the addition of impervious surfaces such as roads and parking lots; alteration of natural landscape features such as natural depressional areas that hold water, floodplains, and wetlands; construction of highly efficient drainage systems; and the addition of pollutants from everyday human activities. These alterations within a watershed decrease the amount of rainwater that can seep into the soil to recharge our aquifers, maintain water levels in lakes and wetlands, and maintain spring and stream flows. Consequently, the volume, speed and pollutant loading in stormwater that runs off developed areas increases, leading to flooding, water quality problems and loss of habitat.* [246]

In addition to the clear and tangible impacts of human population growth and resulting anthropogenic impacts on water quality, climate change is another human-related driver of chronic poor water quality. The ocean is the largest carbon sink on the planet. As carbon dioxide continues to accumulate in the atmosphere, more carbon is dissolved in the ocean, causing the water to become more acidic.[247] These conditions hinder calcification, impeding mollusks' and crustaceans' ability to grow strong shells. In

[243] Semon, Nancy. Gulfshore Business. November 4, 2023. Charlotte County Ranked Fifth-Fasted Growing Region in the Nation. Available here.
[244] Regan, Adam. Gulfshore Business. March 25, 2022. Lee Among 10 Fastest Growing Counties in the U.S. Available here.
[245] Carriker, Roy. Florida's Growth Management Act: An Introduction and Overview. IFAS Extension FE 643. Available here.
[246] Florida Department of Environmental Protection. ERP Stormwater. Available here.
[247] National Oceanic and Atmospheric Administration. Ocean Acidification. Available here.

addition, the acidification paired with increasing temperatures lead to coral reef bleaching events, which can kill the coral and destroy a critical habitat for countless aquatic species.[248] As waterbodies continue to fall outside their typical ranges for pH and temperature, the impacts on aquatic life will compound and result in serious habitat alterations and loss of life.

Sea level rise and saltwater intrusion are additional symptoms of climate change. Both phenomena push saltwater inland via groundwater and surface water.[249] While oceanic species thrive in a high salinity environment, inland ecosystems are not equipped to handle saltwater. Ecosystems are forced to migrate inland, following their preferred salinity level, but the speed at which saltwater is pushing inland can exceed the speed at which ecosystems can migrate and ecosystems are often blocked by man-made or natural barriers.[250] This issue is particularly concerning for marsh habitats that support a variety of wildlife. In addition to the environmental implications of high salinity water, it is not safe for people to drink the saltwater that has begun contaminating coastal wells throughout Florida.[251]

Climate change is also contributing to more frequent, intense storms, storm surges, and hurricanes. Though storms are distinct events, they result in chronic water quality issues. For example, stormwater can overload wastewater treatment systems and result in the release of millions of gallons of partially treated or completely untreated sewer water into natural waterways.[252] This water generally contains bacteria, diseases, pharmaceuticals, excess nutrients, and many other harmful chemicals that negatively impact water quality. These events have even been tied to harmful algal blooms.[253] Storms can also cause septic systems to leak sewage into groundwater, adding fecal bacteria to local water bodies. Needless to say, excess nutrients, bacteria, and chemicals dumped into Florida's water systems by climate induced storms have long-term negative impacts on water quality.

There are two issues at play when assessing the anthropogenic impact on water quality. One is the question of whether existing regulations are adequate to regulate and manage things like stormwater runoff, wastewater treatment, etc. The second is whether or not existing regulations, regardless of their stringency, are being correctly applied and enforced.

Regulatory Tools

While there are many important regulatory tools that have the potential to have a positive impact on water quality if properly applied, this report will focus on the following three: the State Water Resource

[248] Florida Oceans and Coastal Council. 2009. The Effects of Climate change on Florida's Ocean and Coastal Resources: A Special Report to the Florida energy and Climate Commission and People of Florida. June. Available here.
[249] Florida Oceans and Coastal Council. 2010. Climate Change and Sea-Level Rise in Florida: an Update of the Effects of Climate Change on Florida's Oceans and Coastal Resources. December. Available here.
[250] Smith, Karin, and Esterson, Kristopher. 2022. Saltwater Intrusion in Coastal Aquifers: The Inland Migration of Saltwater Poses a Threat to Water Supply and Critical Freshwater Habitats. South Florida Water Management District. August 3. Available here.
[251] Napper, Robert. 2013. Saltwater Intrusion of Port Richey Wells Could Cost Residents for Years to Come. April 26. Available here.
[252] Haydocy, Emma. 2022. A Supercharged Atlantic Hurricane Season: How Stronger, Wetter Storms Exacerbate Florida's Sewage Pollution Crisis. October 17. Available here.
[253] Bayles, T. 2023. Water Quality Report for Southwest Florida. March 26. Available here.

Implementation Rule; Fertilizer Ordinances; and adoption of "advanced wastewater treatment" standards for wastewater treatment.

State Water Resource Implementation Rule

Adopted in 1990, the State Water Resource Rule sets a specific minimum performance standard that post development stormwater treatment systems remove 80 percent of the post development average annual pollutant load of pollutants that cause or contribute to violations of water quality standards. [254]

Fertilizer Ordinance

Excess nitrogen is known to impact water quality, have harmful impacts on wildlife and habitat and contribute to the frequency and duration of harmful algal blooms. With the addition of single-family homes, residential, and commercial areas, the number of lawns and landscaped areas increases, and so does the use of nitrogen-based fertilizer. Fertilizer ordinances can incentivize utilization of native landscaping, require the use of slow-release nitrogen fertilizer, and establish "black out" periods (typically 1 June-30 September) banning fertilizer use during the rainy season. These types of ordinances currently exist across Florida, including in the City of Punta Gorda and unincorporated Charlotte County, in unincorporated Lee County and the cities of Bonita Springs, Cape Coral, Ft. Myers Beach and Sanibel, and the cities of Naples and Marco Island located in Collier County, to name a few.[255] Over 100 counties and cities have adopted these types of ordinances, but in 2023 the state imposed a one-year moratorium on creating new or strengthening existing ordinances.[256]

Septic Systems and Sewers

Because of regional geology and high-water tables, conventional septic systems are particularly vulnerable in Florida.[257] Specific to our study area, a 2011 water quality assessment stated that *"groundwater from the non-sewered portion of Captiva contributes nitrogen to near shore surface waters especially on the estuary side of Captiva"*.[258] The same report notes that,

> *"There are several sources of nitrogen that impact water quality in developed areas including stormwater runoff, fertilizer runoff, and air pollution… coastal communities with concentrations of septic system drain fields (which remove only a small amount of nitrogen and phosphorous) are known to impact local near shore water quality as well as the water quality in bayous and salt water canals… Studies leading to the mandatory implementation of central sewer… on comparable barrier islands like Sanibel, on highly developed islands like Marco Island and more recently in nearby Charlotte Harbor, have documented the impacts of concentrated septic tanks and motivated subsequent septic tank replacement programs.*[259]

[254] ibid
[255] Florida Fertilizer Ordinances. University of Florida, IFAS Extension. Available here.
[256] Achumba, Adaure, Florida Lawmakers Move to End Seasonal Fertilizer Bans. May 3 2023. Available here.
[257] Coty Keller. Managing Nutrients to Save Charlotte County's Estuaries and Economy: A Report for the Pease Mayakka Waterkeeper. September 2022. Pg 10. Available here.
[258] Captiva Island Wastewater Alternative Study, Lee County Board of County Commissioners. June 2018. TKW Consulting Engineers Inc. Pg. 1. Available here.
[259] Ibid Pg. 2

These findings have programs not only to convert from "onsite treatment and disposal" (aka septic) systems to sewer, but also to review and evaluate the performance of secondary wastewater treatment plants. The concern is that water from advanced secondary WWTPs still contains nutrients that can cause excessive algae growth and related negative impacts to receiving waters. This is particularly a concern in areas where treated (otherwise known as "grey") water is used for irrigation. Advanced wastewater treatment systems are "any process that can reduce impurities in wastewater below what is attainable through conventional secondary or biological treatment. [260] Sanibel Island is an example of a community that moved beyond secondary treatment to adopt advanced wastewater treatment island wide after discovering that treated water used for irrigation still contained unacceptably high levels of nitrogen. The City of Ft. Myers also has two advanced wastewater treatment facilities that serve the city and much of Lee County.[261]

Ongoing Regulatory Developments

In December 2022, US EPA determined that Florida water quality standards did not reflect current science and do not go far enough to protect citizens from pollutants and adverse health effects. [262] In January 2023, the EPA issued an additional directive giving FDEP twelve months to develop improved standards for 40 criteria pollutants, to develop standards for an additional 30 pollutants as well as to develop an adequate plan for collecting data for these pollutants. These findings indicate that current standards, even if effectively enforced and applied, are not adequately protective of human and environmental health. These findings do not consider any potential exposure implications associated with changes in storm or flood frequency, duration or intensity, or any changes in temperature or sea level rise.

Summary

It is well documented that extreme events can have a strong impact on species in an ecosystem. In coastal areas extreme events include severe storms, algal blooms and human induced events like chemical spills or water releases.[263] Our review documents the reality that baseline water quality in the three-county study area is significantly chronically degraded and that degradation continues and is accelerating. This means that when a single negative water quality event occurs (hurricane, flood, red tide, or blue green bloom) the system is already weakened and stressed. We know that if a human body is weakened through sequential shocks to the system or when an acute event occurs to a body weakened by chronic illness or disease, the body is less able, and less likely to fend off or survive an additional acute event. The same is true for species and ecosystem health. This is illustrated by Stevens et al. who examined the ability of Snook to rebound after an extreme freeze event in 2010 and found that for Snook in the Northern Indian River Lagoon area, where the cold event was immediately followed by an algal bloom event, the species could not recover. While there was initial ability to resist the cold event, in subsequent years the Snook population failed to recover and four years later was still 65 percent below pre cold event levels.[264] While

[260] Tuser, Christina. What is Advanced Wastewater Treatment. Wastewater Digest. Dec 1, 2021. Available here.
[261] City of Fort Meyers. Available here.
[262] Soule, Douglas. and J. Call. EPA: Florida Must Change Water Quality Standards to Protect Citizen's Health. Tallahassee Democrat. December 5, 2022. Available here.
[263] P. Stevens, A Blewett, E Boucek, et. al. Resilience of Tropical Sport Fish Population to a Severe Cold Event Varies Across Five Estuaries in Southern Florida. August 2016. Pg. 1 Available here.
[264] Ibid. Pg. 8. Available here.

one study is not definitive, this example does illustrate the vulnerability of populations to multiple acute events. During our engagement with stakeholders in the three-county study area we heard multiple anecdotes (based on firsthand experience with fisheries) detailing loss of fish populations over time and observed increases in required recovery time following multiple, sequential negative water quality events, suggesting the need for further empirical investigation to better document these relationships.

Appendix K: Tipping Points

Any individual with memories of romping around their childhood playground should be able to understand the dire issues currently facing the coastal Floridian ecosystem. Consider the seesaw; with two willing participants, it is a machine that provides great amusement, allowing users to bob one another up and down by continually shifting their center of balance. However, if only one seat is occupied, there is nothing to counteract the weight of the lone rider, and the seesaw cannot function. In the world of ecology, this concept can be represented by the term 'tipping point,' or the moment in which the natural systems that have kept Earth's climate stable for millennia become irreversibly damaged.[265] The larger an ecosystem, the greater its ability to resist the changes placed on it by outside forces - but we are approaching a point in which many biological communities will be unable to keep up with the threats they face from climate change and the impacts of human society. This phenomenon can be seen playing out in real time with the melting of Arctic Sea ice, the decimation of the Amazon rainforest, and the severe changes occurring for organisms off the coast of southwest Florida.

Climate change impacts ocean life in several key ways.[266] Increasing direct exposure to sunlight has warmed ocean temperatures, threatening to eradicate a wide array of organisms which have evolved to only function within a precise temperature window. Warmer waters are physically unable to hold enough oxygen to prevent suffocation in fish and marine mammals, and the issue is exacerbated further by the fact that higher temperatures cause metabolic rates (and thus the demand for oxygen) to increase as well. As atmospheric carbon dioxide levels rise, the pH of the ocean lowers, limiting several chemical processes which are essential to the lives of shellfish, corals, and all the organisms that depend on them. On top of these problems, coastal ecosystems are also at the mercy of anthropogenic impacts such as pollution and overfishing, which result in a loss of habitat, a reduction in biodiversity, and an increase in the frequency of toxic algal blooms.[267]

One population currently facing these issues is *Crassostrea virginica*, commonly known as the Eastern oyster, which has been identified as an extremely valuable ecological component of the Caloosahatchee, Loxahatchee, Lake Worth Lagoon, and St. Lucie estuaries.[268] In these regions and many more, oysters form large reefs which host an extremely diverse collection of commercially relevant finfish and crustaceans; a single acre of reef has been estimated to add an additional $40,000 in value to coastal communities.[269] Many organisms depend on oyster reefs for many different aspects of their existence, chief among them being recruitment, the process by which newly hatched fish survive long enough to become a more dominant force in the food web. The small interstitial spaces between reef structures provide shelter from predators, waves, and storms,[270] and are an essential component of coastal life for dozens of resident and transient species. Oysters also provide the benefit of filtering out loose sediment and detritus (an

[265] Rojas, Diego. 2021. "What Are Climate Change Tipping Points?" The Climate Reality Project, October 15. Available here.

[266] Heinze, Christoph, et al.2021. The Quiet Crossing of Ocean Tipping Points. *Proceedings of the National Academy of Sciences* 118, no.9. February. Available here.

[267] Barnard, Patrick, et al. 2021. Multiple Climate Change-Driven Tipping Points for Coastal Systems. *Scientific Reports* 11, no. 1. July. Available here.

[268] Volety, Aswani K., et al. 2014. Ecological Condition and Value of Oyster Reefs of the Southwest Florida Shelf Ecosystem. *Ecological Indicators* 44. September. Available here.

[269] Ibid.

[270] Love, Gabrielle, Anna Braswell, Angela B. Collins, and Edward Camp. 2022. How Oyster Reefs Can Affect Finfish Recruitment. University of Florida Institute of Food and Agricultural Sciences: FA250. Available here.

individual oyster can filter anywhere between 4 and 40 liters of water an hour),[271] allowing light to penetrate deeper into the water column and promote photosynthesis in the aquatic plants that the entire ecosystem ultimately sits atop.

However, despite the critical role they play in the health and prosperity of these environments, the coverage of oyster reefs has dramatically decreased in recent years. It is estimated that worldwide oyster abundance is now at only 10 percent of previous levels,[272] with the chances of a significant recovery looking slimmer every year. Ocean acidification has made it more difficult for reefs to get the calcium carbonate they need to grow their hard, outer shells, and freshwater runoff, particularly from urban and agricultural environments, has drastically increased the amount of sediment and contaminants reaching reef waters. Oyster populations have failed to show any positive growth in multiple Florida estuaries, despite restoration efforts that attempt to replace clutch (biological material which serves as a base structure for oysters to grow on) destroyed by commercial fishing.[273] Additionally, as climate change pushes the natural world towards various tipping points, we can expect to see a series of regime-shifts, where drastic changes occur within an ecosystem in order to achieve a new ecological equilibrium. One such regime-shift currently impacting oysters in southwest Florida is the mass replacement of reefs with red mangrove forests; it has been estimated that more than 80 percent of previously uncovered reefs have fully converted into islands of interconnected mangroves over the last 80 years.[274] These areas have now been completely restructured, and research shows that this process is occurring at a faster rate in recent decades, meaning that quick and decisive action is required if Florida wants to preserve its remaining oyster population.

Another group showing significant signs of ecological struggle is coastal seagrass. Seven species of seagrass are found in Florida, including turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), widgeon grass (*Ruppia maritima*), and three different species of Halophila grass.[275] As several of those common names suggest, one of the central functions of seagrass in both marine and estuarine ecosystems is acting as a primary food source for urchins, conches, and popular local megafauna like sea turtles and manatees. Their leaves serve as an additional food source to many different organisms, such as the array of algae and small animals which take up residence upon them, the predators which consume those organisms, and the bacteria which break down the organic matter left behind after a seagrass plant dies. Crustaceans and shellfish rely on seagrasses for shelter, and their root structures and fallen leaves help fight erosion by stabilizing soil and trapping loose sediment, respectively. Seagrass fields are also a significant carbon sink, sequestering up to half of the total amount of carbon

[271] Volety, Aswani K., et al. 2014. Ecological Condition and Value of Oyster Reefs of the Southwest Florida Shelf Ecosystem. *Ecological Indicators* 44. September. Available here.
[272] Ibid.
[273] Pine III, W. E., et al. 2023. Collapsed Oyster Populations in Large Florida Estuaries Appear Resistant to Restoration Using Traditional Clutching Methods – Insights from Ongoing Efforts in Multiple Systems. *Marine and Coastal Fisheries* 15, no. 5. October. Available here.
[274] Hesterberg, Stephen G., Kendal Jackson, and Susan S. Bell. 2022. Climate Drives Coupled Regime Shifts Across Subtropical Estuarine Ecosystems. *Proceedings of the National Academy of Sciences* 119, no. 33. August. Available here.
[275] Florida Department of Environmental Protection. 2023. Florida Seagrasses. August 14th. Available here.

stored in the world's oceans, and act like 'coastal canaries,' responding quickly and visibly to different environmental stressors, making them a useful population to serve as the basis of climate studies.[276]

It is estimated that between 2011 and 2019, 19,000 hectares of seagrasses were lost in the Indian River Lagoon, nearly 60 percent of the population.[277] These losses are representative of recent reductions in seagrass coverage across all of Florida, and are driven by a variety of factors, including hypersaline conditions, extreme temperatures, sulfide toxicity, decreases in water clarity, and influxes in nutrients like phosphorus and nitrogen.[278, 279] These phenomena limit the growth of a population that is worth over $20 billion a year to the state of Florida[280] and evidence shows that a recent 'critical slowing down' in seagrass recovery rates could indicate that the population is quickly nearing a major tipping point.[281] The increasing dominance of toxic 'red tide' algae blooms also points to an ecological instability which threatens to completely restructure the ecosystem and shift it towards a new state of equilibrium.[282] A lack of available seagrass has already been identified as the primary cause behind the large die off of manatees that occurred in the Indian River Lagoon in 2021 and 2022 – the death toll reached nearly 2,000 individuals, a quarter of the manatee population.[283]

[276] Morris, L. J., et al. 2022. Seagrass in a Changing Estuary, the Indian River Lagoon, Florida, United States. *Frontiers in Marine Science* 8. January. Available here.
[277] Ibid.
[278] El-Hacen, et al. 2018. Evidence for Critical Slowing Down in Seagrass: A Stress Gradient Experiment at the Southern Limit of its Range. *Scientific Reports* 8, no. 1. November. Available here.
[279] Janicki Environmental, Inc. 2022. Identifying Potential Drivers of Change in Seagrass and Algal Community Composition in SWFL Aquatic Preserves. March. Available here.
[280] Morris, L. J., et al. 2022. Seagrass in a Changing Estuary, the Indian River Lagoon, Florida, United States. *Frontiers in Marine Science* 8. January. Available here.
[281] El-Hacen, et al. 2018. Evidence for Critical Slowing Down in Seagrass: A Stress Gradient Experiment at the Southern Limit of its Range. *Scientific Reports* 8, no. 1. November. Available here.
[282] Janicki Environmental, Inc. 2022. Identifying Potential Drivers of Change in Seagrass and Algal Community Composition in SWFL Aquatic Preserves. March. Available here.
[283] Kearny, Bill. 2023. Save it or Lose it: As Seagrass Vanishes, a Mass Death of Marine Life and a Brown-Water Future. *Sun Sentinel.* August. Available here.