



2020

Economic Impacts of Water Quality Issues in the Gulf of Mexico

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Economic Impacts of Water Quality Issues in the Gulf of Mexico

Project Overview

For over five years, Gulf of Mexico states dealt with nearly annual appearances of massive Harmful Algal Blooms (HABs) that impacted tourism, fishing and coastal ecosystems. The research objectives of this project focused on quantifying the linkages between economic outcomes and Gulf of Mexico coastal health, specifically HABs. Results from the project were intended to enable resource managers and their state and federal partners to quantify the economic implications for HABs and their avoidance, and assess restoration investments and/or management actions. The tools developed in this project estimated impacts measured in revenues, employment, wages and property values – values the public can understand. An important discovery was the critical linkage between social media metrics and economic impacts – as opposed to linkage between scientific data (HAB cell counts) and economic effects, which was weak or non-existent. To our knowledge, this was the first work to link economic impacts relating to Harmful Algal Blooms to social media activity. An online dashboard was developed and published which allows users to assess the economic impacts across time, geography and type (tourism, fishing, property values, etc.). The dashboard was designed to use publicly available data and thereby able to be replicated and transferrable to other Gulf States.



Introduction

Severe Harmful Algal Blooms (HAB) occurred in the Gulf of Mexico between 2015 and 2019, when multiple HAB events fouled waters, ruined vacations and caused respiratory distress for vulnerable residents and visitors. Images of marine animals fallen victim to HAB events received national media attention, and hotels, restaurants and real estate workers found themselves on the receiving end of cancelled sales, forced price reductions, and dramatic drops in beach visitors. The economic impact of HAB events has been explored by other researchers for specific categories: hotel or restaurant revenues in specific communities, real property values in specific counties, additional local government costs at the County level for clean-up, and so forth¹. However, a cumulative estimate of the economic impact from HABs has not been compiled.

For a broad and diverse area like Florida, how could one compile an estimate that credibly captured the cumulative economic effects of HABs? Assembly of publicly available data to capture the significant economic impacts from HABs on the Gulf of Mexico states, and particularly Florida, was the impetus for this project. The research team proposed evaluation of economic data (restaurant sales, fishing revenues, etc.), scientific data (cell counts, water quality data, Dept. of Health reports), and social media data (Facebook and Twitter mentions, Google analytics) to isolate economic results linked to red tide events or the perception of red tide events.

Local communities experienced HAB events differently, and at different points in time. The research team partnered with CHNEP, a NEP located in Southwest Florida that experienced very high-profile HAB events in 2017 and 2018 to gain local access. CHNEP has a number of stakeholder committees, and the intent was to use meetings and workshops with these committees as an avenue to vet data and assumptions with locals who lived through the HAB events and experienced the impacts firsthand. The committee members represent numerous interacting agencies, Federal, state and local governments, and trade groups – a diverse representation of a diverse community.

Methods

Armed with a plan to integrate local perception with publicly available data, we set out to collect publicly available data. Ultimately, the funding agency desires a model that is replicable across all five Gulf coast states. By using only publicly available data, results can be replicated for the remaining states.

I. Economic Data

The economic data explored for the analysis includes metrics representing tourism, housing sales, and fishing activity. In addition, the team acquired data regarding local government costs to clean up the after effects of HAB events, public health costs, lifeguard impacts including absenteeism and lost wages, and costs relating to marine mammal strandings. The following sections describe the various economic indicators collected pertinent to the analysis of recent HAB events in the Gulf of Mexico. The metrics identified represent tourism, housing sales, commercial and recreational fishing and boating revenues, and related measures. Data was compiled in time series formats to mark milestones for the economic relationships between HAB events. Several metrics appeared to show strong relationships to HAB events, such as marine mammal strandings, beach attendance, cleanup costs by local governments, however other data may show seasonality effects and required further analysis.

¹ Adams and Larkin (2006)



The information is organized as follows:

1. Tourism effects, including accommodation and food sales, restaurants, tours and beach activity
2. Boating and fishing, both Commercial and Recreational
3. Ecosystem impacts such as Marine mammal strandings
4. Other Variables Explored
5. Summary

Tourism Effects

Accommodation & Food Services by County

This variable represents the share of total sales (in millions of dollars) from hotel businesses. Accommodation and food services sector businesses in areas closest to HAB events were expected to experience the greatest losses. For purposes of identifying a uniform boundary for the most impacted areas across the Gulf, the “Coastal High Hazard Area” or the Category 1 Hurricane Storm Surge Zone identified by the Florida Division of Emergency was used as a proxy to identify the properties most likely to have experienced impacts. As noted elsewhere, seasonality also suppresses sales, and analysis was done to determine the relationship between sales and HAB events.

Figures 1 and 2 show the share of accommodation and food services revenues in the Coastal vs. Non-Coastal area by County for 2017 and 2018; **Figure 3** shows the overall revenue trends without controlling for location across 2016 to current.

Figure 1. Share of Accommodation and Food Services Revenues in the Coastal Vs. Non-Coastal Area by County for 2017

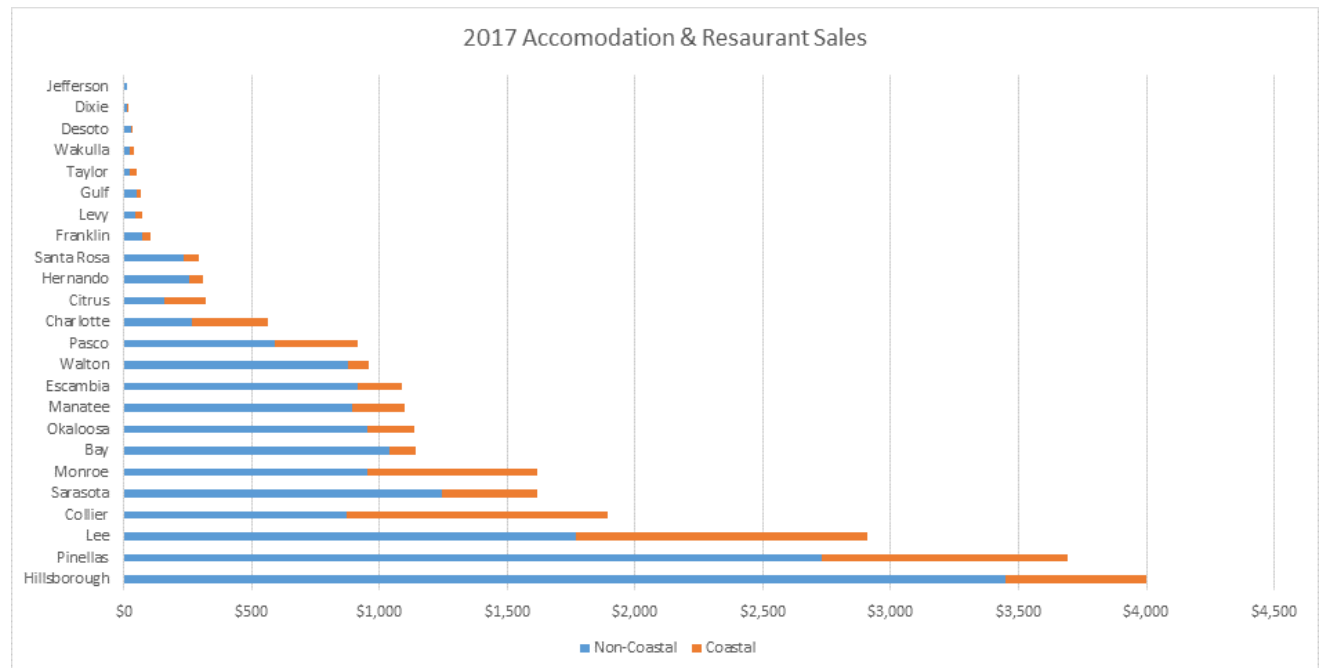


Figure 2. Share of Accommodation and Food Services Revenues in the Coastal Vs. Non-Coastal Area by County for 2018

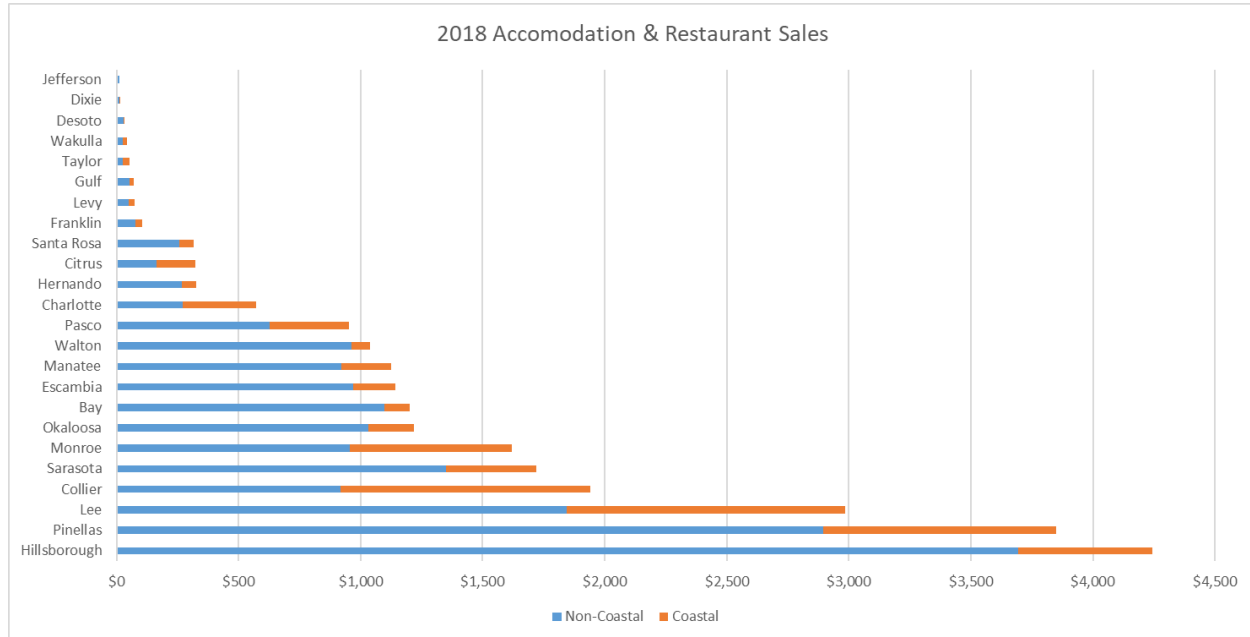
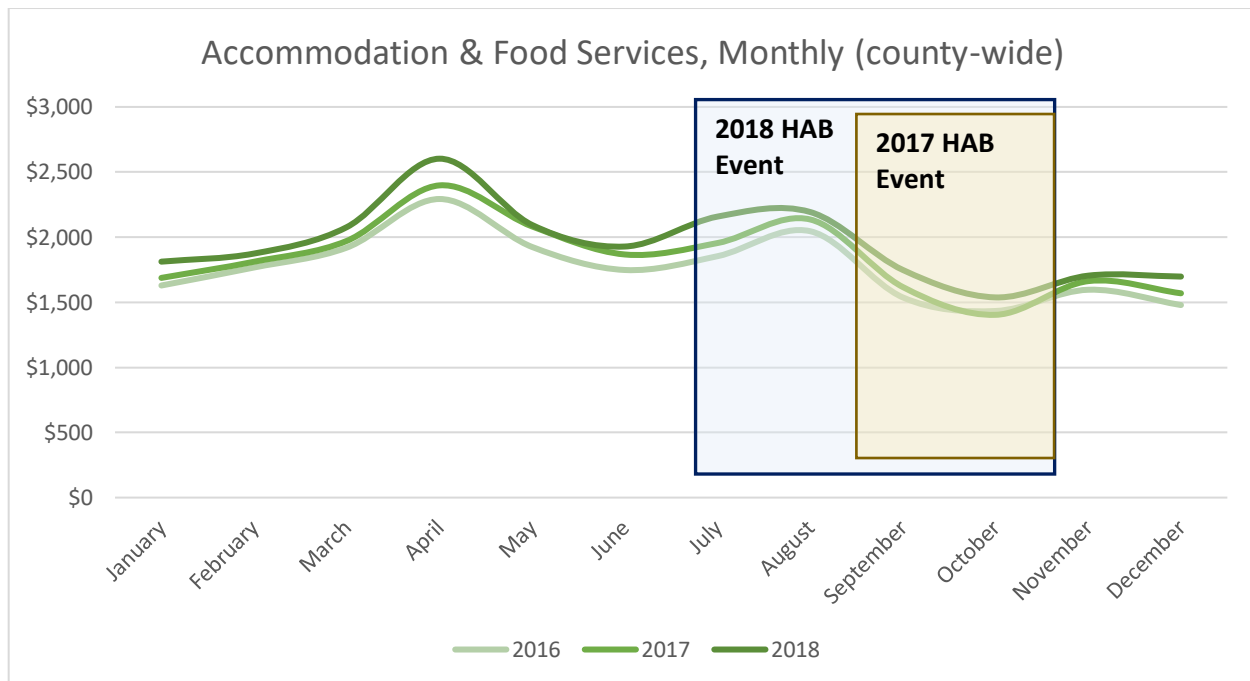


Figure 3. Overall Revenue Trends without Controlling for Location across 2016 to Current.

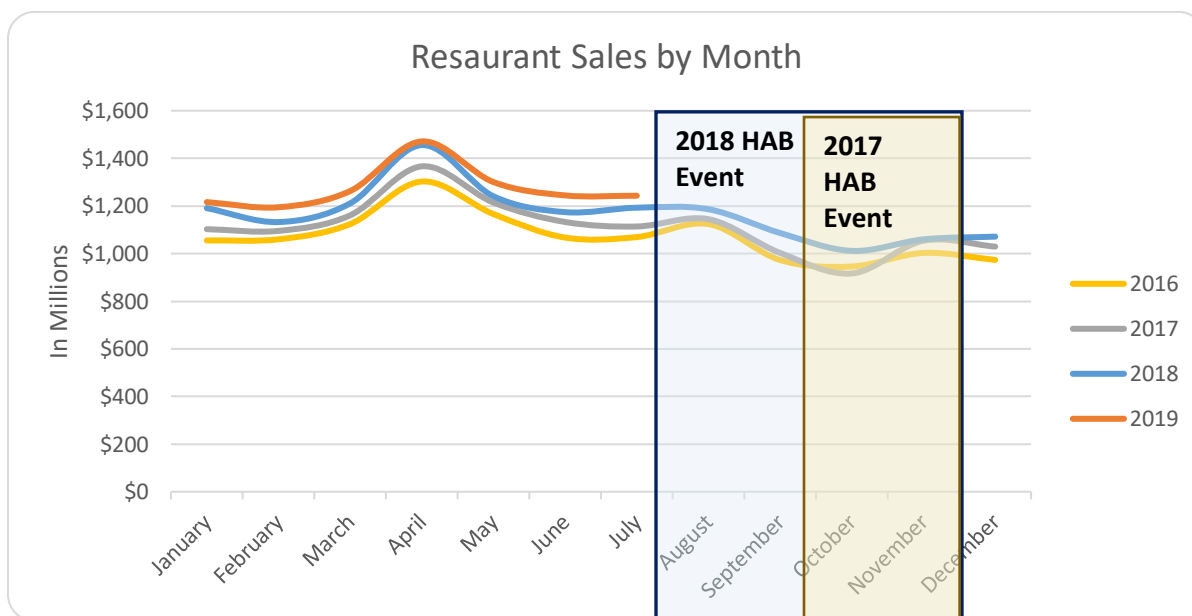




Monthly Taxable Restaurant Sales by County

This variable represents monthly taxable sales (in millions of dollars) at restaurants, lunchrooms, and catering services at county level and is secondary revenue data compiled by FDOR. Restaurants (specifically coastal restaurants) are impacted by HAB events (Larkin, 2006) and the data was tested to determine whether changes in restaurant sales are statistically different during periods of red tide. The revenues of restaurants and lodging establishments (hotels and motels) were expected to be directly related to inclement environmental conditions. Interviews with coastal restaurant owners reflected revenue and employment declines of 50 – 90% during HAB events. **Figure 4** provides a snapshot of summary data for Gulf County restaurants.

Figure 4. Gulf County Restaurant Sales by Month, 2016 - 2019



Boating and Fishing

Monthly Commercial Fishing Revenues and Food & Bait Commercial Landings by County

This variable represents monthly taxable sales of commercial fishing at county level; summary data for all Gulf Counties and by County is reflected in **Figures 5** and **6**, respectively. It is secondary data compiled by the FDOR. Florida's commercial fisheries are normally estimated to generate \$3.2 billion in income annually and support 76,700 jobs (FWC, 2019). Commercial fisheries faced a direct loss due to HAB events and contextual information is critical to determine how areas are economically impacted. Revenue from commercial fisheries was expected to decline as HAB cell counts rise. Additional to the taxes collected is the monthly estimated value of commercial fishing at county level compiled by the FWC. Because of the high public interest in seafood safety, the economic impact of commercial and recreational fishery represents an important point to understand the response of people to the troubles caused by HABs (Sanseverino et al., 2016). Total Commercial Fish Landings per county by year are also reported, with some counties recording declines from 2016 values and others reporting increases.



The Florida Fish and Wildlife Conservation Commission's (FWC) Fisheries-Dependent Monitoring division collects data on more than 200 species of fish and invertebrates caught from Florida waters. Fishery-dependent data is collected directly from people who harvest and release aquatic species and is used to monitor catch rates and assess the health of exploited fish and invertebrate populations. Commercial fisheries include any species that are harvested and sold for human consumption, for medical use, in aquarium or souvenir trades, or for any other for-profit purpose. This data is readily accessible via FWC's website for food and bait categories and can be downloaded annually by the following categories: Statewide; by coast, county, month, and by area fished. Data by county by month is not readily available via FWC's queries due to confidentiality issues. As such, data was received from the Florida Fish and Wildlife Conservation Commission in a matter that allowed for analyzing landings by county and by month in order to determine landings trends and calculate losses due to red tide events.

Additional analysis was completed to determine what factors such as the reopening of fisheries may be contributing to the increase in landings; some scientists have anecdotally noted that the nearshore nutrients may (very) temporarily increase fish landings. **Figure 5** shows total landings in pounds and dollars for all Gulf Counties; **Figure 6** shows county-level data for 2016 – 2018.

Figure 5. Total Landings in Pounds and Dollars for All Gulf Counties

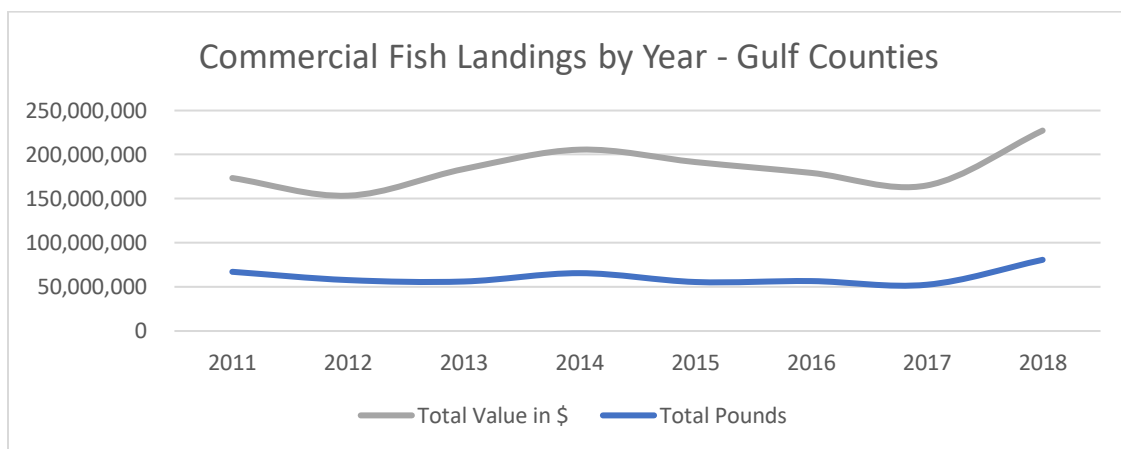
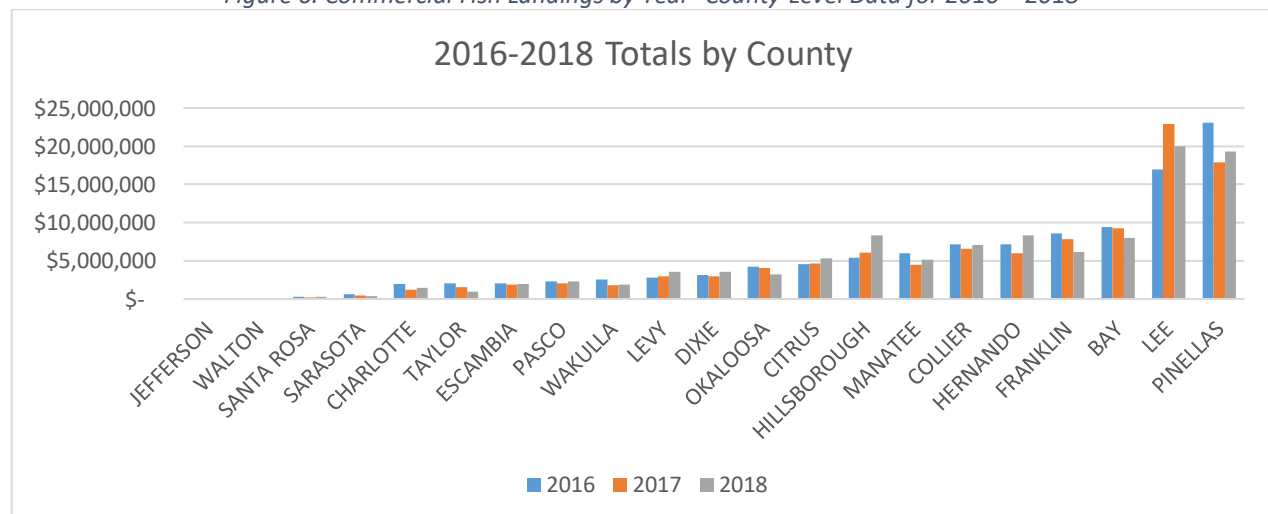


Figure 6. Commercial Fish Landings by Year -County-Level Data for 2016 – 2018

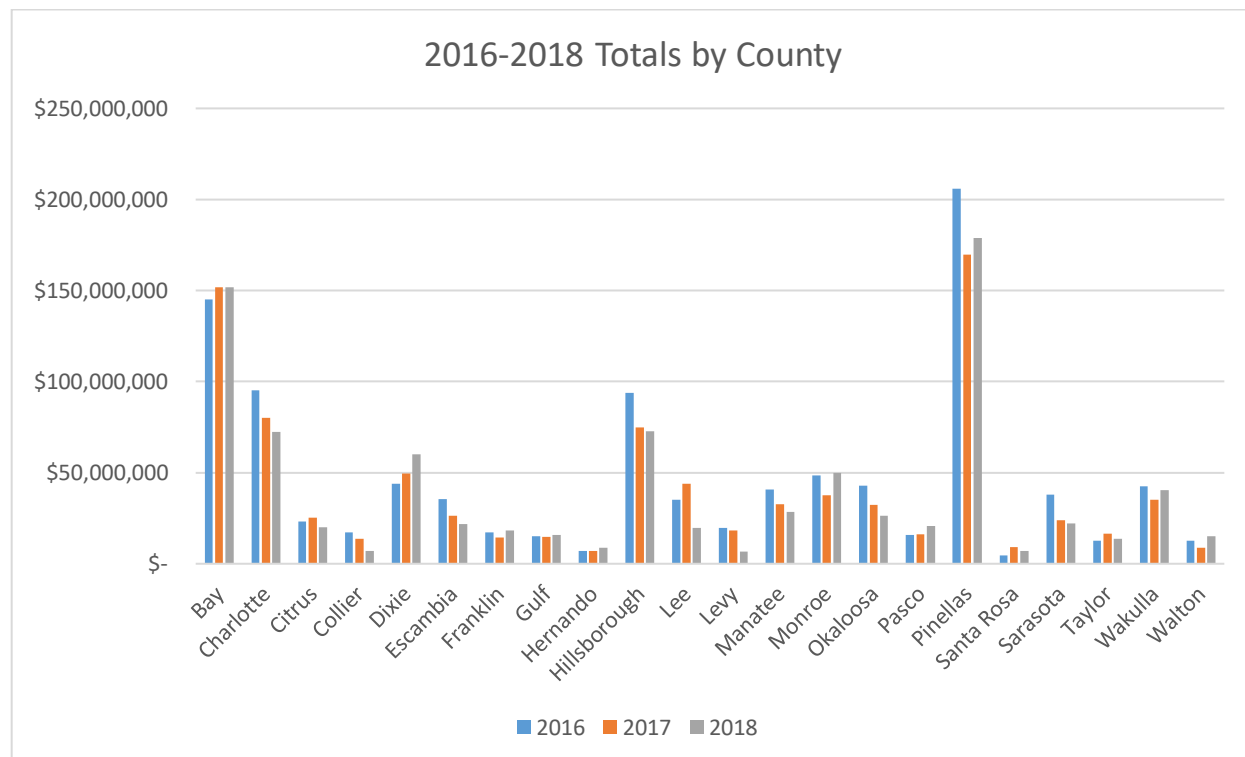




Recreational Fishing by County

Recreational fishing can be defined as fishing for pleasure rather than profit (US Dept Commerce, 2018). To estimate the economic impacts of recreational fishing, it is important to look at angler participating in fishing activities, the equipment they purchase, the boats they rent, gas they purchase, and travel expenses they may incur. Data was obtained from the National Oceanic and Atmospheric Administration Fisheries Marine Recreational Information Program (MRIP). The MRIP provides data from NOAA Fisheries and its state, regional, and federal partners, which use in-person, telephone, and mail fishing surveys to measure the number of trips saltwater anglers take and the number of fish they catch. Total economic value for recreational fishing in coastal counties was estimated by taking Marine Recreational Information Program (MRIP) trip data from NOAA Fisheries across each of the relevant coastal counties in Florida and multiplying them by the estimated “per trip” expenditure on recreational fishing activities. This is in line with previous literature calculating contributions of recreational fishing activities in various regions. Historical trip data from the MRIP database was used to predict what the recreational demand would have been without the presence of a HAB event and then compared to the actual demand during the HAB event. Expenditures on recreational fishing were estimated by NOAA for Florida anglers and utilized for the estimation of impacts. **Figure 7** provides the estimated expenditures from recreational fishing across the Gulf Coast Counties.

Figure 7. Recreational Fishing Spending by Year -County-Level Data for 2016 – 2018

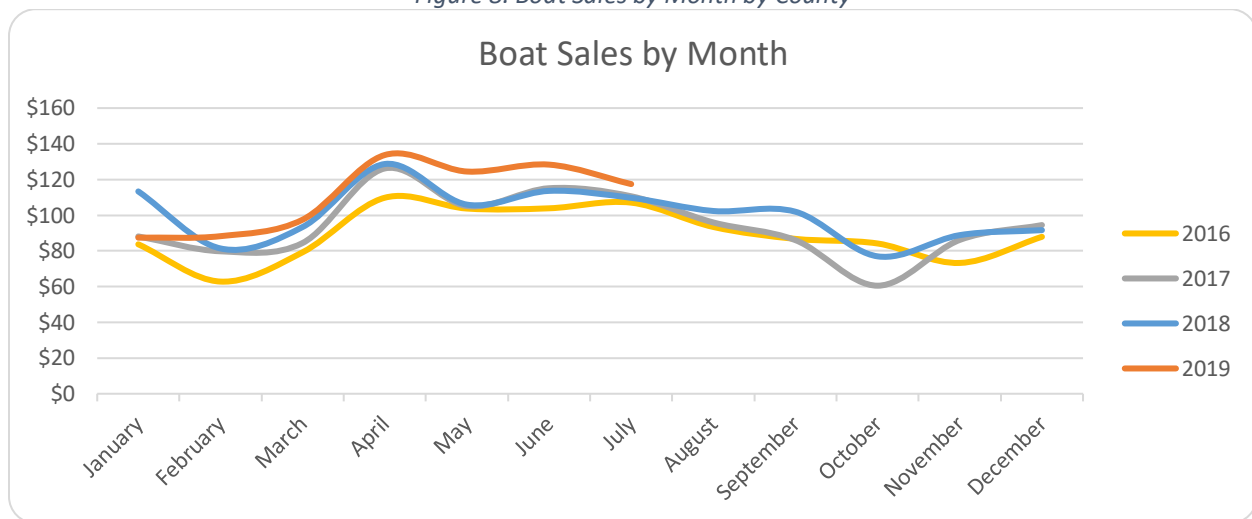




Monthly Taxable Boat Dealership Sales by County

This value represents monthly taxable sales of boat dealers at county level compiled by the FDOR². The boating industry represents one of the business sectors impacted by HAB events. As HAB events worsen, it is expected that boat dealers will lose revenue (i.e., they will be negatively impacted by HAB events). The focus on coastal business revenues (or establishments benefiting the coast) allows for the use of consistently reported gross revenue data correlated with tax revenues, reflecting beach, tourism, recreation, and other data (Larkin, 2006). Analysis revealed that boat sales in October 2017 observed a 27% decrease year-over-year, but recovered slightly in 2018 remaining below 2016 values. Seasonality may suppress sales, so additional analysis was done to determine the relationship between sales and HAB events. **Figure 8** provides summary data by County.

Figure 8. Boat Sales by Month by County



² Florida Department of Revenue



Property Values

Parcel level data received from the FDOR which falls within the “Coastal High Hazard Area” or the Category 1 Hurricane Storm Surge Zone identified by the Florida Division of Emergency was selected for analysis (FDOR, 2019). Properties within close proximity to the Gulf of Mexico are adversely affected by HAB events. It is estimated that as HAB events occur more frequently, properties will continue to be impacted; FAR (2015) found impacts on sales values from water quality incidents ranging from 11-15% of total property value. Aggregated across the Gulf county area, the numbers quickly become very large. As Collier, Pinellas, and Lee Counties have the highest number of properties subject to HAB events, these counties are likely to experience the highest impacts from HAB events. **Table 1** provides summary property data across Gulf counties.

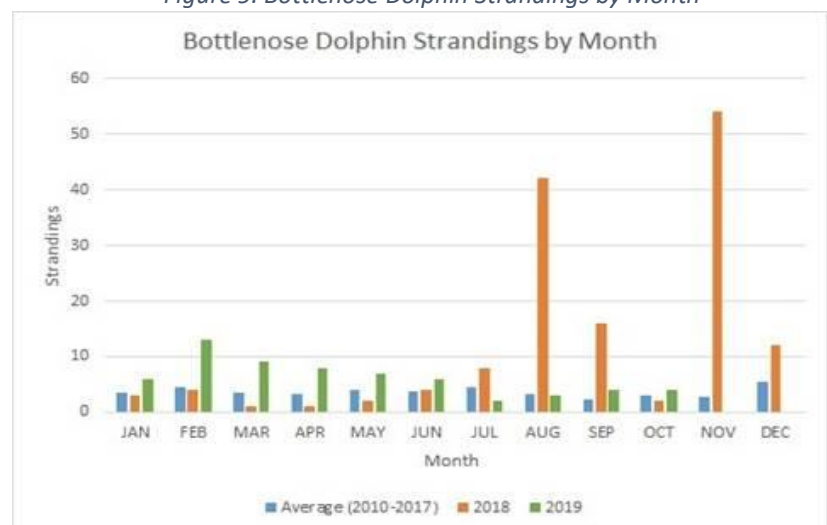
Table 1. Property values across Gulf Counties within CHHA and/or 6 miles of Gulf shoreline.

Distance	Count	Total Just Value
Waterfront	126,028	\$58,506,963,021
1/8 mile	69,740	\$20,726,053,214
1/4 mile	60,760	\$16,543,946,737
1/2 mile	69,571	\$22,170,228,372
1 mile	91,672	\$28,637,424,240
2 miles	84,585	\$27,716,506,361
4 miles	42,316	\$22,073,055,614
Total	544,672	\$196,374,177,559

Ecosystem Impacts Such as Marine Mammal Strandings

NOAA provided data regarding the marine mammal strandings per county by month. The following chart shows Bottlenose Dolphin strandings by month for 2018 and 2019. NOAA recorded nearly 130 strandings for the 2018 HAB event, showing strong relationships of marine mammal strandings to HAB events (NOAA, 2019). In addition, some endangered species were notably lost, and gained national attention. Nonmarket values will be used to estimate the public willingness to pay values associated with the dolphin loss and the endangered species losses, which have a significantly different value to Americans.

Figure 9. Bottlenose Dolphin Strandings by Month





Additional Variables Explored

Additional variables were explored including government and resident costs to clean-up after HAB events, Lifeguard Absenteeism, Health Impacts and Ecotourism Estimates. Ultimately due to unreliable publicly available data surrounding these data points, the economic impacts for these were not estimated.

Summary of Economic Data

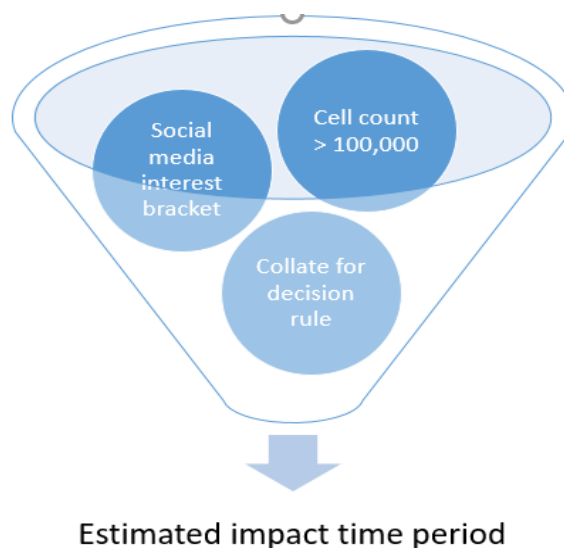
In order to accommodate the project objectives, the collected data was integrated into a geodatabase. The geodatabase also contained non-economic data including cell count information which directly reports the HAB incidence, and digital media data that counts the frequency of searches for “red tide” and related terms by computer users in a particular location, which are aggregated by county. An important point of research was determining whether the incident (the HAB event), or the digital media is more closely tied to the actual behavioral changes that cause some of the primary economic losses. For example, several stakeholders in the restaurant and leisure industry reported that on days with no red tide present, customers cancelled reservations for meals, trips, or equipment rentals because they had been exposed to media that inferred red tide presence.

II. Scientific and Social Media Data

Data was obtained and analyzed for both scientific measures – cell counts of *k. brevis* – and digital media measures, such as trends in google searches, twitter mentions and other social media sources.

The digital media and HAB cell count data were used to identify months in which revenue losses could defensibly be attributed to the HAB event, and then aggregated for the economic impact dashboard tool. **Figure 10** shows the process which was used to identify the time period of impact across metro areas. While revenue estimates are largely prepared at the county level, digital media is compiled at the metro or regional scale. Therefore, county values were aggregated to metro scale. Using the combination of these metrics, the time period of June 2018 – November 2018 was identified as the umbrella period of impact for Gulf coast counties revenue losses by industry sector that could be attributed to the HAB event for these months, subject to normalizing for hurricane and other effects. The process was repeated for each metro area and brought into the dashboard at the county level. The following provides details about the methodology for identifying the time periods to estimate economic impacts.

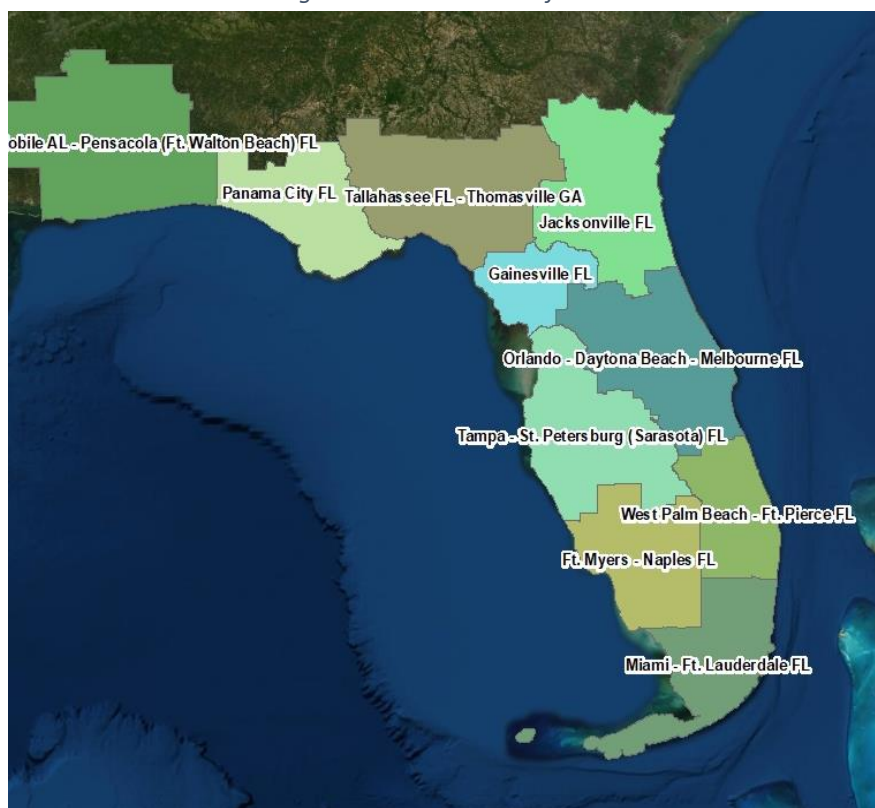
Figure 10. Decision rules for estimating HAB impact time period



Cell Count & Digital Media Data

Cell count data was obtained from Florida Fish and Wildlife Conservation Commission (“FWC”) and NOAA for water sampling results. Throughout this report, digital media will refer to Google trends, which provided the most continuous and consistent data set for the area in question along the Gulf of Mexico at the metro level. Sampling locations were geocoded in GIS, and linked to county and metro metrics by location; **Figure 11** shows a map of the metro areas and their boundaries which were used in the estimation of economic impact of HAB events. The Gulf of Mexico borders seven metro areas: Mobile-Pensacola, Panama City, Tallahassee-Thomasville, Gainesville, Homosassa, Tampa-St. Petersburg-Sarasota, and Ft. Myers- Naples.

Figure 11. Metro areas of Florida



Analysis

Correlation analysis was conducted to test the relationships between the scientific and social media data. A high correlation was detected between the cell count data at the county and metro level, reflecting presence of red tide, and digital media data, reflecting online searches for terms like “red tide”, “algal bloom”, and “karenia brevis”. The correlation was strongest with average cell count at the metro level, and more moderate using maximum cell count at the metro level, which was an interesting finding. It is possible that the digital media data reflect more of the duration effects of longer blooms, which affect behavior and spending patterns, while the maximum cell count may represent more of the episodic or “spiking” behavior of the harmful algal blooms. The effect was consistent, such that average cell count was ultimately used for the relationships underlying the economic impacts.

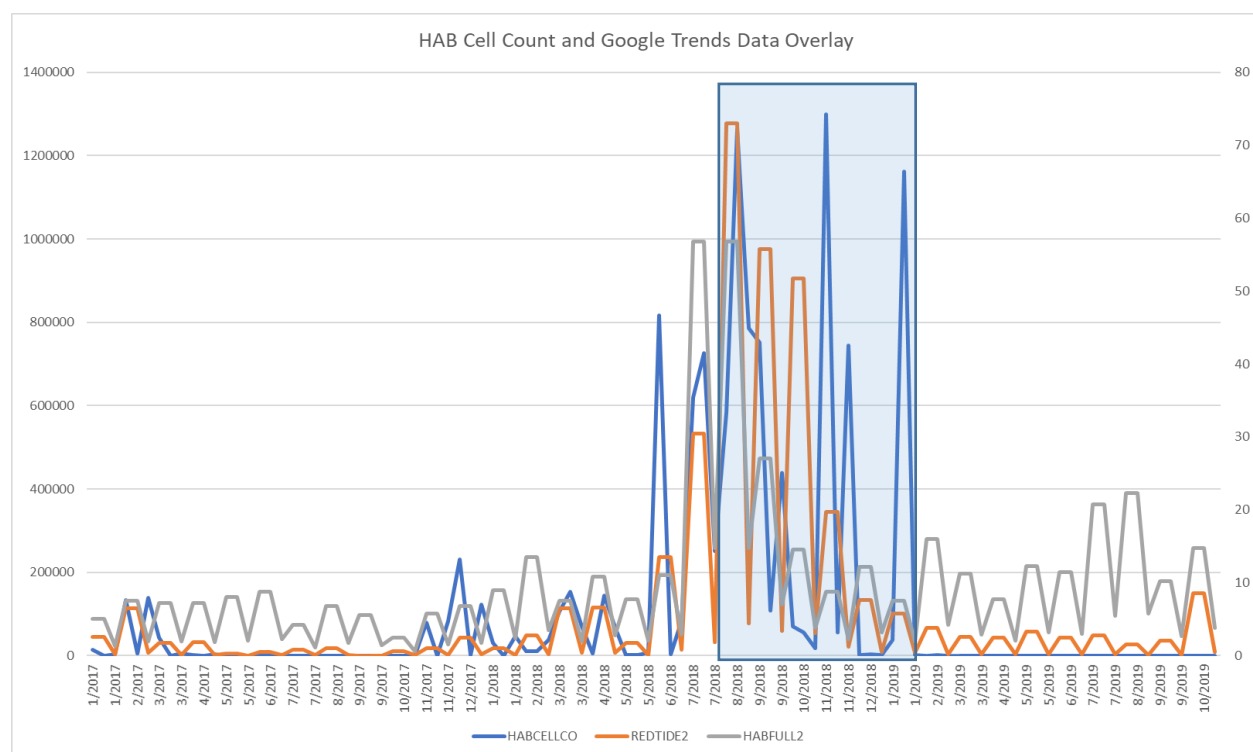
There were no or very low correlations found at the metro level between the scientific/cell count data and



the economic variables. The exceptions were for specific months with the highest cell counts – October and November 2018 specifically showed negative correlations with fishing trips, commercial fishing revenues, and marine recreation rentals in Pensacola and in Ft. Myers/Naples. On the other hand, digital media data showed high correlation with several economic variables such as recreational marine rentals, boat sales, seafood sales, recreational rentals (jet-skis, etc.) and commercial fishing across metro areas.

Figure 12 shows the results of analysis comparing actual cell count data with digital media data for the Ft. Myers - Naples metro area. The shaded box shows the months for which statistical analysis reflected a moderate to strong correlation (ranging from 0.55 to 0.97), and for which impacts were estimated. Similar plots for each of the metro areas were prepared and analyzed.

Figure 12. HAB cell count by month and google trends data for Ft. Myers – Naples Metro area



FT MYERS - RED TIDE TREND 2 CORRELATION MATRIX												
Variable	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
HABCELLCO	0.61	0.02	0.83	0.43	(0.15)	0.61	0.96	0.73	0.55	0.97	0.45	(0.38)



The correlation data shown in **Figure 12** was used to isolate the timing of economic impacts and the revenue that would have resulted from normal business patterns was estimated for each metro area. Using data from public sources including tax records, the actual revenue was compared to the estimated revenue pattern to calculate the foregone revenue for 2018 during the period of impact for each metro area. **Table 2** shows the estimated impact periods for each metro area which was utilized to estimate the economic impacts; however, for property sales, impacts extend into January 2019, as there is a lagged effect on sales due to the nature of real estate transactions. As no correlation was found and no HAB cell count was reported for the Gainesville area, no economic impacts were attributed to the HAB in this region.

Table 2. Economic Impact Periods

Metro Area	Ft. Myers – Naples, FL	Mobile, AL – Pensacola, FL	Panama City, FL	Tallahassee, FL – Thomasville, GA	Tampa - St. Petersburg, FL
Months High HAB Cell Activity	6/2018 - 11/2018	10/2018- 11/2018	9/2018 - 11/2018	11/2018	9/2018 - 12/2018
Months High HAB Media Activity	6/2018 - 10/2018	7/2018 - 11/2018	6/2018 - 11/2018	7/2018 - 10/2018	6/2018 - 11/2018
Impact Period	June - November	October - November	September	October - November	September- November

Source: TBG Work Product

Summary of Scientific & Digital Media Data

Economic impacts were estimated using the correlation identification approach for restaurants & accommodations, commercial fishing, recreational fishing, boat dealer revenues, property sales, and marine mammal strandings.



Findings

Economic Data

The various economic indicators pertinent to the analysis of recent HAB events in the Gulf of Mexico includes metrics identified to represent commercial and recreational fishing, tourism, housing sales, boating revenues and marine mammal mortalities. Other metrics identified in the scope including expenditures by local governments, health impacts, lifeguard absenteeism and seafood were explored, however analysis found data to be inconsistent and therefore unsuitable for incorporation into the analysis. Data was compiled in time series formats to mark milestones for the economic relationships between HAB events. Brief descriptions and summaries of the inputs based on the analysis of impact time periods identified in the analysis of the scientific and digital media data is described below.

i. Commercial Fishing

Commercial Fishing values represent ex-vessel values of fish landings from Florida Fish and Wildlife Conservation Commission's database. Monthly landings values along Florida's gulf coast was obtained, though due to confidentiality, some counties were combined and re-apportioned based on the county's annual share. The values were used to project what landings would have been without a HAB event to estimate the loss due to the HAB event. **Table 3** shows the estimated losses in Commercial Fish Landings by metro area.

Table 3. Commercial Fishing Values

Metro	Predicted (No HAB)	Actual (with HAB)	Loss
Ft. Myers - Naples FL	\$11,665,429	\$8,450,666	-\$3,214,764
Mobile AL - Pensacola (Ft. Walton Beach) FL	\$1,311,843	\$1,025,121	-\$286,722
Panama City FL	\$1,669,520	\$1,262,702	-\$406,819
Tallahassee FL - Thomasville GA	\$989,686	\$453,015	-\$536,671
Tampa - St. Petersburg (Sarasota) FL	\$14,510,993	\$13,200,277	-\$1,310,716

Source: FWC, TBG Work Product

ii. Recreational Fishing/Marine Recreation

Recreational fishing can be defined as fishing for pleasure rather than profit (US Dept. Commerce, 2018). To estimate the economic impacts of recreational fishing, it is important to look at anglers participating in fishing activities, the equipment they purchase, the boats they rent, gas they purchase, and travel expenses they may incur.

Total economic value for recreational fishing in coastal counties was estimated by taking Marine Recreational Information Program (MRIP) trip data from NOAA Fisheries across each of the relevant coastal counties in Florida and multiplying them by the estimated "per trip" expenditure on recreational fishing activities. This is in line with previous literature calculating contributions of recreational fishing activities in various regions³. Historical trip data from the MRIP database was used to predict what the recreational

³ See for example Loomis (2005), NMFS (1986), U.S. Department of Commerce (2018), Southwick Associates (2018),



demand would have been without the presence of a HAB event and then compared to the actual demand during the HAB event. Expenditures on recreational fishing were estimated by NOAA for Florida anglers and utilized for the estimation of impacts. **Table 4** shows the estimated losses in marine recreation including fishing by metro area.

Table 4. Recreational Fishing Values

Metro	Predicted (No HAB)	Actual (with HAB)	Loss
Ft. Myers - Naples FL	\$97,527,706	\$69,448,255	-\$28,079,451
Mobile AL - Pensacola (Ft. Walton Beach) FL	\$10,748,845	\$8,438,704	- \$2,310,141
Panama City FL	\$23,092,400	\$23,092,400	\$-
Tallahassee FL - Thomasville GA	\$9,670,669	\$8,866,341	-\$804,328
Tampa - St. Petersburg (Sarasota) FL	\$103,720,721	\$87,893,665	-\$15,827,055

Source: NOAA, TBG Work Product

iii. Tourism – Food & Accommodation Revenues

This variable represents monthly taxable sales (in millions of dollars) at restaurants and catering services at county level and is secondary revenue data compiled by FDOR. Restaurants (specifically coastal restaurants) are impacted by HAB events (Larkin, 2006). Estimates for food and accommodations within the Coastal High Hazard Area (“CHHA”) were obtained to establish the baseline estimates of the taxable sales within the county that are closest to the coast and therefore most likely to be negatively impacted by HAB events. Once the CHHA values were determined, results were extrapolated to incorporate restaurants that would be highly affected by beach conditions but are not directly waterfront, in line with literature precedent. **Table 5** shows the estimated food and accommodation sales in the coastal high hazard area and the estimated loss from HAB events.

Table 5. Food & Accommodation Values

Metro	Predicted (No HAB)	Actual (with HAB)	Loss
Ft. Myers - Naples FL	\$2,179,948,388	\$1,906,038,567	-\$273,909,821
Mobile AL - Pensacola (Ft. Walton Beach) FL	\$455,606,204	\$400,702,881	-\$54,903,324
Panama City FL	\$273,589,971	\$239,784,699	-\$33,805,272
Tallahassee FL - Thomasville GA	\$10,723,534	\$9,862,854	-\$860,680
Tampa - St. Petersburg (Sarasota) FL	\$2,899,086,729	\$2,543,048,851	-\$356,037,879

Source: FDOR, Larkin et al., Esri, TBG Work Product



iv. Property Values

Properties within close proximity to the Gulf of Mexico are adversely affected by HAB events. Property Sales data received from Zillow which falls within the “Coastal High Hazard Area” or the Category 1 Hurricane Storm Surge Zone identified by the Florida Division of Emergency was selected for analysis (FDOR, 2019). It is estimated that as HAB events occur more frequently, properties will continue to be impacted; FAR (2015) found impacts on sales values from water quality incidents ranging from 11-15% of total property value. Aggregated across the Gulf county area, the numbers quickly become very large. For lost sales, transactional costs including brokerage fees, real estate agent commissions, appraisals, etc., are lost permanently; based on industry data, 12% of the estimated lost sales is included as lost transaction fees. For completed sales, the midpoint of the FAR estimate, or 13%, is estimated as an average loss. **Table 6** shows the estimated loss of sales transaction fees *due to sales that did not occur* as well as *lost transaction fees from reduced property values for completed transactions* across the metropolitan areas in the analysis. **Table 7** shows the loss in sales values due to reductions in property values for completed transactions across the metropolitan areas.

Table 6. Property Transaction Fee Losses

Metro	Predicted transaction fees (No HAB)	Actual transaction fees (With HAB)	Loss
Ft. Myers - Naples FL	\$694,201,989	\$571,170,198	-\$123,031,791
Mobile AL - Pensacola (Ft. Walton Beach) FL	\$15,302,169	\$12,164,405	-\$3,137,763
Panama City FL	\$4,421,677	\$3,217,861	-\$1,203,816
Tallahassee FL - Thomasville GA	\$1,516,773	\$1,265,257	-\$251,516
Tampa - St. Petersburg (Sarasota) FL	\$448,102,452	\$369,590,582	-\$78,511,870

Source: Zillow, TBG Work Product

Table 7. Property Sales Affected by Reduced Water Quality

Metro	Predicted Sales (No HAB)	Actual Sales (With HAB)	Loss
Ft. Myers - Naples FL	\$5,470,978,911	\$4,759,751,653	-\$711,227,258
Mobile AL - Pensacola (Ft. Walton Beach) FL	\$116,517,293	\$101,370,045	-\$15,147,248
Panama City FL	\$30,822,425	\$26,815,510	-\$4,006,915
Tallahassee FL - Thomasville GA	\$12,119,322	\$10,543,810	-\$1,575,512
Tampa - St. Petersburg (Sarasota) FL	\$3,540,139,675	\$3,079,921,517	-\$460,218,158

Source: Zillow, FDOR, TBG Work Product



v. Boat Sales – New & Used

This value represents monthly taxable sales of boat dealers at county level compiled by the FDOR⁴. As HAB events occur, boat dealers are negatively impacted and their revenue losses are included in the HAB impacts. The focus on coastal business revenues (or establishments benefiting the coast) allows for the use of consistently reported gross revenue data correlated with tax revenues, reflecting beach, tourism, recreation, and other data (Larkin, 2006). Boat Dealers in the Ft. Myers – Naples Metro area lost the most in revenues due to 2018 HAB events, with an estimated \$62 million loss. **Table 8** shows the estimated loss of sales transactions across the metropolitan areas in the analysis.

Table 8. Boat Sales Values

Metro	Predicted (No HAB)	Actual (with HAB)	Loss
Ft. Myers - Naples FL	\$265,333,343	\$ 203,317,608	-\$62,015,735
Mobile AL - Pensacola (Ft. Walton Beach) FL	\$ 23,290,271	\$ 20,442,996	-\$2,847,275
Panama City FL	\$ 1,776,925	\$ 1,755,498	-\$21,427
Tallahassee FL - Thomasville GA	\$ 2,423,924	\$ 2,069,968	-\$353,956
Tampa - St. Petersburg (Sarasota) FL	\$160,350,659	\$ 143,169,991	-\$17,180,668

Source: FDOR, TBG Work Product

vi. Ecosystem impacts such as Marine Animal Strandings

FWC provided data regarding marine animal strandings and mortalities per county by month and the cause of death, providing official numbers on mortalities related to red tide events. In addition, some endangered species were notably lost, and gained national attention. Nonmarket values were used to estimate the public willingness to pay values associated with the species losses. In addition, endangered species, which have a significantly higher value to Americans based on previous research, would exceed these values. As such, these estimates should be considered a lower bound of actual costs to the public of HAB-induced marine animal costs. Two metro areas along the Gulf Coast had the concentration of mortalities associated with red tide: Tampa-St. Petersburg and Ft. Myers – Naples. **Table 9** shows the estimated value of marine mammals lost due to HAB events.

Table 9. Marine Animal Values

Metro	Reported Incidents of Animal Mortalities*	Value
Ft. Myers - Naples FL	81	-\$134,692,004
Mobile AL - Pensacola (Ft. Walton Beach) FL	-	-
Panama City FL	-	-
Tallahassee FL - Thomasville GA	-	-
Tampa - St. Petersburg (Sarasota) FL	71	-\$63,188,841

*Incidents include reports of at least 1 animal death recorded; but not additive treatment of animals per incident. There were over 80 Manatees alone recorded for the Fort Myers – Naples Metro and 65 for Tampa – St. Petersburg Metro Area.

⁴ Florida Department of Revenue

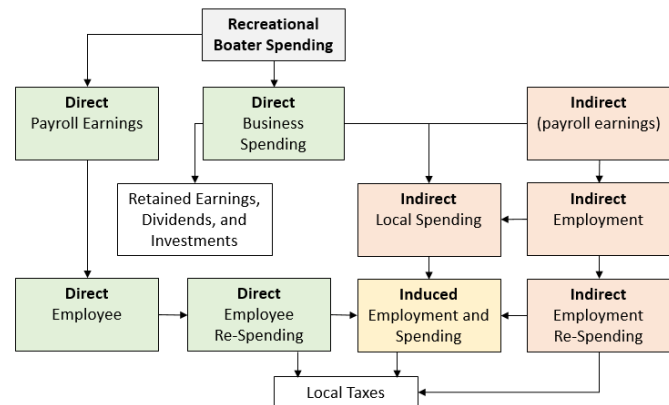


Source: FWC, TBG Work Product

Economic Impact Effects

To estimate the overall economic impacts associated with HAB events along the Florida Gulf Coast, the project team utilized IMPLAN, an econometric modelling application that generates regional economic impact multipliers. IMPLAN estimates the flows of supply and demand between and within counties by industry sector, and converts this estimate of cash flows to economic impacts – measured through jobs, revenues, and personal income. An important element of input-output modeling is understanding these flows, and using appropriate data to determine, for example, how much of a boat dealer's stock was purchased within the dealer's county, versus from an adjacent county, or from elsewhere in the region or state. The local purchases generate indirect and induced impacts, while those made outside the area do not. IMPLAN calculates the specific margins based on data prepared by the Bureau of Economic Analysis. **Figure 13** shows a flow chart of the Economic Impact Analysis.

Figure 13. Economic Impact Flow Chart



As the economic data is at the county level and the impacts are then aggregated to Metro level identified from social media trends, models for each metro area were created. The IMPLAN models utilized in the estimation across each metro included the following:

- I. Food & Accommodation, including restaurants and hotels
- II. Commercial Fishing
- III. Recreational Fishing
- IV. Boat Sales
- V. Property Sales

Tables 10-14 show metro area summaries of each HAB impact type analyzed. Each model used the Inputs described in the economic data section and the scientific and social media correlations. Fort Myers – Naples Metro Area and the Tampa – St. Petersburg Metro Areas had the largest impacts from HAB events, consistent with anecdotal evidence. For the Fort Myers area, Property Sales Transactions saw the largest impact in terms of output, with \$164 million lost from HAB events during 2018. Food and Accommodation Sales had the largest negative impact from HAB events for the Tampa – St. Petersburg Metro Area with \$251 million lost from HAB events.



Table 10. Ft. Myers-Naples Metropolitan Area Estimated Economic Impacts

Impact Type	Employment (Jobs)	Labor Income (Payroll)	Value Added in millions of \$	Output
Boat Sales	-524	-\$32.0	-\$50.9	-\$36.6
Commercial Fishing	-15	-\$0.8	-\$1.3	-\$1.8
Recreational Fishing	-391	-\$21.2	-\$25.4	-\$27.2
Food & Accommodation	-3,016	-\$95.2	-\$151.1	-\$145.3
Property Transaction Fees	-1,024	-\$39.7	-\$70.9	-\$163.5
Total Annual Impacts	-4,969	-\$189	-\$300	-\$374

Source: TBG Work Product

Table 11. Panama City Metropolitan Area Estimated Economic Impacts

Impact Type	Employment (Jobs)	Labor Income (Payroll)	Value Added in millions of \$	Output
Boat Sales	0	\$0.0	\$0.0	\$0.0
Commercial Fishing	-2	-\$0.1	-\$0.1	-\$0.2
Recreational Fishing	0	\$0.0	\$0.0	\$0.0
Food & Accommodation	-447	-\$14.0	-\$22.6	-\$21.8
Property Transaction Fees	-9	-\$0.3	-\$0.6	-\$1.4
Total Annual Impacts	-458	-\$14	-\$23	-\$23

Source: TBG Work Product

Table 12. Mobile, AL – Pensacola, FL Metropolitan Area Estimated Economic Impacts

Impact Type	Employment (Jobs)	Labor Income (Payroll)	Value Added in millions of \$	Output
Boat Sales	-30	-\$1.6	-\$2.6	-\$1.9
Commercial Fishing	-1	\$0.0	-\$0.1	-\$0.1
Recreational Fishing	-37	-\$1.3	-\$1.7	-\$2.2
Food & Accommodation	-768	-\$21.4	-\$35.0	-\$37.0
Property Transaction Fees	-28	-\$1.1	-\$1.9	-\$4.4
Total Annual Impacts	-863	-\$25	-\$41	-\$46

Source: TBG Work Product



Table 13. Tallahassee, FL – Thomasville, GA Metropolitan Area Estimated Economic Impacts

Impact Type	Employment (Jobs)	Labor Income (Payroll)	Value Added in millions of \$	Output
Boat Sales	-4	-\$0.2	-\$0.3	-\$0.2
Commercial Fishing	-2	-\$0.1	-\$0.1	-\$0.2
Recreational Fishing	-7	-\$0.2	-\$0.2	-\$0.3
Food & Accommodation	-7	-\$0.1	-\$0.2	-\$0.2
Property Transaction Fees	-1	\$0.0	-\$0.1	-\$0.2
Total Annual Impacts	-21	-\$0.6	-\$1.0	-\$1.0

Source: TBG Work Product

Table 14. Tampa – St. Pete, FL Metropolitan Area Estimated Economic Impacts

Impact Type	Employment (Jobs)	Labor Income (Payroll)	Value Added in millions of \$	Output
Boat Sales	-170	-\$10.4	-\$16.4	-\$15.9
Commercial Fishing	-5	-\$0.2	-\$0.4	-\$0.6
Recreational Fishing	-273	-\$10.5	-\$13.9	-\$18.6
Food & Accommodation	-4,561	-\$141.7	-\$229.6	-\$251.4
Property Transaction Fees	-937	-\$46.3	-\$83.6	-\$173.1
Total Annual Impacts	-5,947	-\$209	-\$344	-\$460

Source: TBG Work Product

Tax Impacts

Additionally, tax impacts were estimated. The revenues and payroll lost in each area in turn create losses of tax revenues; spending does not occur to generate sales tax; employment is lost that would have generated payroll tax; and income is lost that would have generated income tax. **Table 15** describes the State and Local Tax Impacts by Metro Area across each impact category, while **Table 16** describes the Federal Tax Impacts.

Table 15. State & Local Tax Impacts by Metro Area – in millions of \$

Metro Area	Boat Sales	Commercial Fishing	Recreational Fishing	Restaurants and Accommodations	Property Transaction Fees
Ft. Myers - Naples FL	-\$8.38	-\$0.10	-\$2.08	-\$18.00	-\$6.25
Mobile AL - Pensacola (Ft. Walton Beach) FL	-\$0.46	-\$0.01	-\$0.20	-\$4.40	-\$0.19
Panama City FL	\$0.00	-\$0.02	\$0.00	-\$2.75	-\$0.05
Tallahassee FL - Thomasville GA	-\$0.04	-\$0.01	-\$0.02	-\$0.03	-\$0.01
Tampa - St. Petersburg (Sarasota) FL	-\$2.36	-\$0.04	-\$1.49	-\$26.99	-\$6.69

Source: TBG Work Product





Table 16. Federal Tax Impacts by Metro Area – in millions of \$

Metro Area	Boat Sales	Commercial Fishing	Recreational Fishing	Restaurants and Accommodations	Property Transaction Fees
Ft. Myers - Naples FL	-\$7.50	-\$0.16	-\$4.04	-\$21.86	-\$8.42
Mobile AL - Pensacola (Ft. Walton Beach) FL	-\$0.37	-\$0.01	-\$0.26	-\$4.78	-\$0.23
Panama City FL	\$0.00	-\$0.02	\$0.00	-\$3.09	-\$0.07
Tallahassee FL - Thomasville GA	-\$0.02	-\$0.01	-\$0.02	-\$0.03	-\$0.01
Tampa - St. Petersburg (Sarasota) FL	-\$2.32	-\$0.05	-\$2.17	-\$31.92	-\$10.26

Source: TBG Work Product

Outreach Activities

The project team and CHNEP reached out to stakeholders through CHNEP’s various committees and directly through institutional contacts. Stakeholders reached include CHNEP staff, CHNEP Community Advisory Committee, CHNEP Technical Advisory Committee, and CHNEP Management Committee as well as 74 other individuals during data collection. Draft results were also presented to the Florida Sea Grant technical group and the GOMA Water Quality group at the Mid-Year meeting.

The dashboard was presented at several stakeholder forums to solicit input on assumptions and format. The Balmoral Group presented the preliminary dashboard results for public feedback to CHNEP’s Management Advisory Committee on January 8, 2020. The group provided comments and helpful feedback which was incorporated into the dashboard. The project team participated in two additional CHNEP stakeholder meetings in May 2020 to present the final dashboard results for vetting and feedback. The May 2020 presentations were well-received and no further revisions were requested. Committee members reported that the dashboard would be very useful to them.



Summary

This Gulf Star project is intended to advance a goal of the Governor’s Action Plan III relating to Economic Health, under the Water Resource Priority Issue:

Protect the economic health within the Gulf of Mexico by identifying and understanding the linkages between healthy water resources and a healthy Gulf economy.

The project fulfilled the Plan’s Actions by serving as pilot for other Gulf coast states, engaging a variety of audiences (agency staff, technical experts, and the public), and by evaluating how HABS—which affect water quality, human health and aquatic life— impact the region’s economy.

The economic impacts of HABs were estimated in terms of revenues, employment, wages and property values. Specifically, the research found losses of nearly \$1 billion and tax revenue declines of \$178 million across the 23 Gulf Coast counties in Florida were statistically attributable to the 2017-2019 Red Tide event in Florida. Table 17 shows the breakdown of losses in revenue and taxes (federal, state, and local).

Table 17. Revenue and Tax Losses from the 2017-2019 Red Tide event across Gulf Coast counties

Impact Category	Revenue Losses – in Millions of \$	Tax Losses – in Millions of \$
Tourism (Food & Accommodation)	\$ (455.70)	\$ (113.85)
Commercial Fishing	\$ (2.90)	\$ (0.43)
Recreational Fishing	\$ (48.30)	\$ (10.28)
Boat Sales	\$ (54.60)	\$ (21.45)
Property Values	\$ (342.60)	\$ (32.18)
Total	\$ (904.10)	\$ (178.19)

Source: TBG Work Product

While data limitations precluded an evaluation of the economic impacts of HABs on human health, the value of 152 marine mammals stranded by the HAB event was estimated at \$198 million using published willingness-to-pay values. While this may seem a high number for social values, the marine animal losses were of an extreme nature and received high levels of publicity, and had a marked and distressing impact on residents and visitors.

The above estimated impacts are conservative, based on the assumptions made, completeness of data, and the statistical linkages established between water quality, social media, and remotely-sensed data. By design, the methodology is transferable to other states using publicly available information. The Governor’s Action Plan III goal has been reasonably met and application of the tool (i.e., the HAB impact dashboard) should be developed further to address the remainder of the geography of the Gulf of Mexico. Ideally, the tool would incorporate public health, should reliable data become available.

The finalized economic impact dashboard, which includes the results from the scientific, digital media, and economic data analysis, was assembled into an online interface for testing. The dashboard can be accessed here: <https://datavisual.balmoralgroup.us/GOMA-HABecon>. An overview of the dashboard can be found in the **Appendix**.



Discussion and Areas for further research

Results from the project are intended to enable resource managers and their state and federal partners to quantify the economic implications for HABs and their avoidance, and assess restoration investments and/or management actions. The analysis finds that digital media data is highly correlated with economic impacts such as changes in revenues or bookings (for fishing trips or hotel rooms, for example) while in many cases very low correlation to actual HAB cell counts was found. In other words, the actual HAB event has less bearing on economic impact than the perceived HAB event. This is an important finding, in that coastal managers may need to explore ways to manage media exposure to mitigate distorted economic impacts of future HAB events.

A number of topics present opportunities for further research related to this work. Expansions of the existing work logically could include exploring how water quality, water quantity, water sustainability, threats to human health and negative effects on aquatic life ultimately impact the Gulf economy. Additional outreach may be appropriate toward a variety of targeted audiences, to increase awareness regarding the connection between healthy water resources and a healthy Gulf economy. In a similar vein, it may be worthwhile to explore opportunities for pilot projects to demonstrate how improvements to water resources can positively affect economic drivers.

While the HABs themselves cause physical effects that cannot be ignored or downplayed, this research found that frequently the economic outcomes were unrelated to actual HABs, but highly correlated to social media. The research herein applied novel approaches to identify linkages between social media activity and economic outcomes. Additional research to further explore these linkages, and quantify the marginal value of social media posts akin to recent work by Moore (2020) may offer additional insights to managing the economic fall-out from water quality issues. Establishing the (negative) value of the social media may provide a threshold or dollar estimate for funding offsetting management actions. A tool to estimate the marginal value, once calibrated, may be sufficient to estimate economic damages without the necessity of updating all of the fishing/tourism/real estate values.



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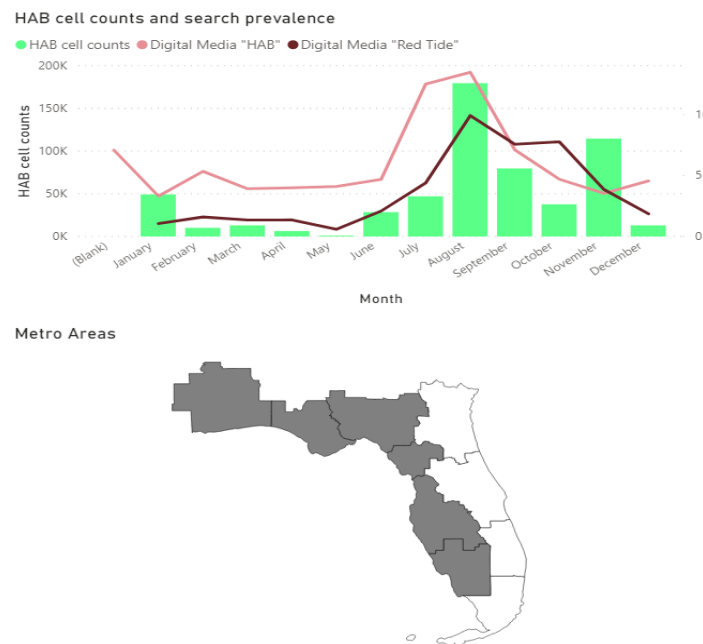
Appendix: Dashboard

The finalized economic impact data was assembled into an online interface for testing. The dashboard can be accessed here: <https://datavisual.balmoralgroup.us/GOMA-HABecon>. The dashboard includes seven pages described below:

I. Cell Count and Digital Media Correlations

This page includes visualization for the cell count data and digital media data findings of the study. The data shows the correlations associated with the digital media and cell counts which were used to define the impact periods. **Figure A-1** provides an example.

Figure A- 1. Page 2 of Dashboard



Digital Media and HAB Cell Count Relationships

A high correlation was detected between the cell count data at the county and metro level, reflecting presence of red tide, and digital media data, reflecting online searches for terms like "red tide", "algal bloom", and "*karenia brevis*". The correlation was strongest with average cell count at the metro level, and more moderate using maximum cell count at the metro level. It is possible that the digital media data reflect more of the duration effects of longer blooms, which affect behavior and spending patterns, while the maximum cell count may represent more of the episodic or "spiking" behavior of the harmful algal blooms. The effect was consistent, such that average cell count was ultimately used for the relationships underlying the economic impacts.

Additionally, There were no or very low correlations found at the metro level between the scientific/cell count data and the economic variables. On the other hand, digital media data showed high correlation with several economic variables across metro areas. The correlations data shown here was used to isolate the timing of economic impacts and the revenue that would have resulted from normal business patterns for each metro area. Using actual data from tax records, the actual revenue was compared to the estimated revenue pattern to calculate the foregone revenue for 2018 during the period of impact for each metro area.

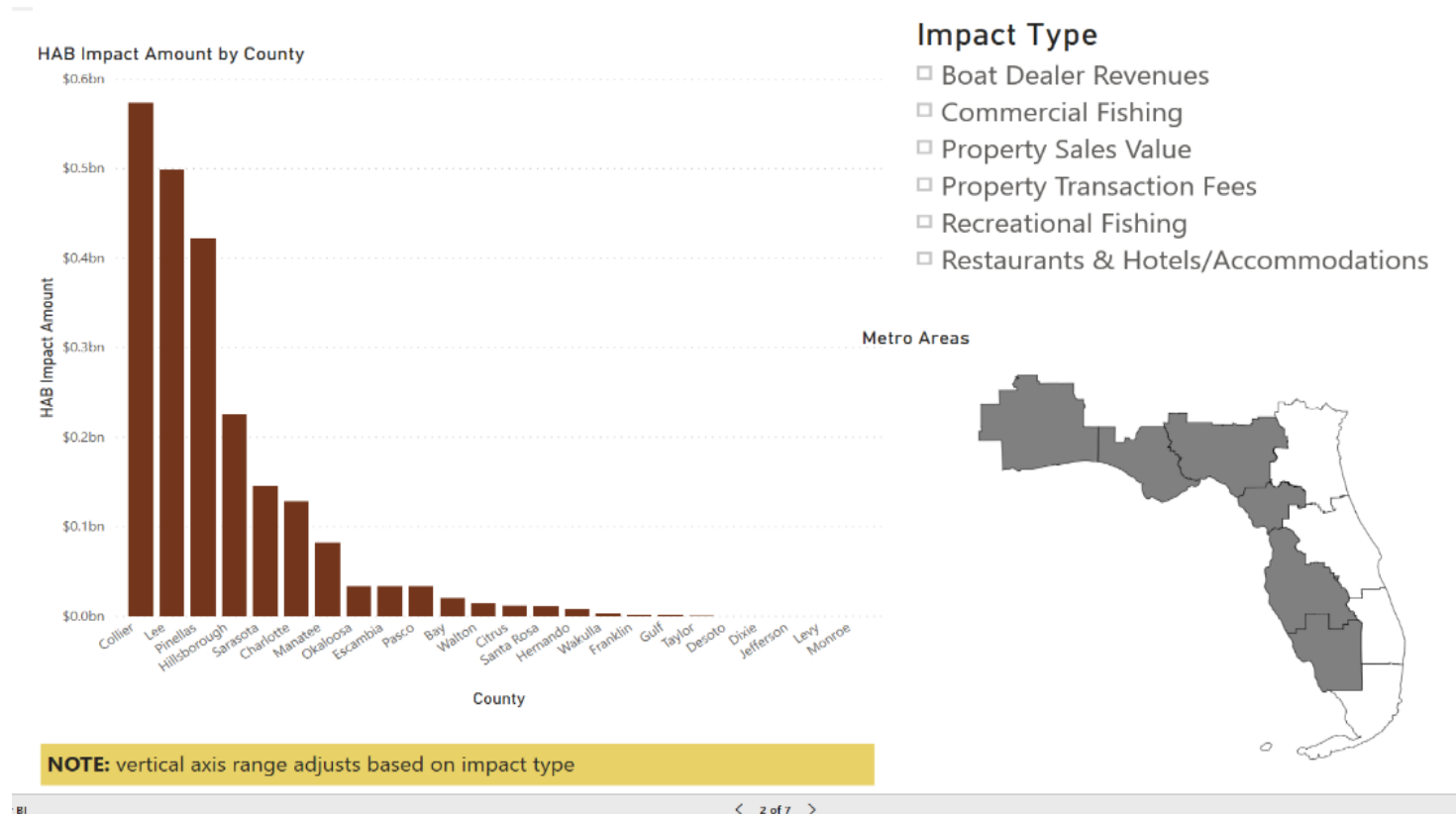




II. Summary of Impacts by Metro Region

This page includes a bar chart that provides a breakdown of HAB Impacts across Counties; when a particular county is selected, the map of metro areas will adjust to reflect which metro that county is in. The bar chart showing estimated economic impacts by county will also adjust when impact categories (boat dealer revenues, restaurants, etc.) are selected. **Figure A-2** Provides an example.

Figure A- 2. Page 3 of Dashboard



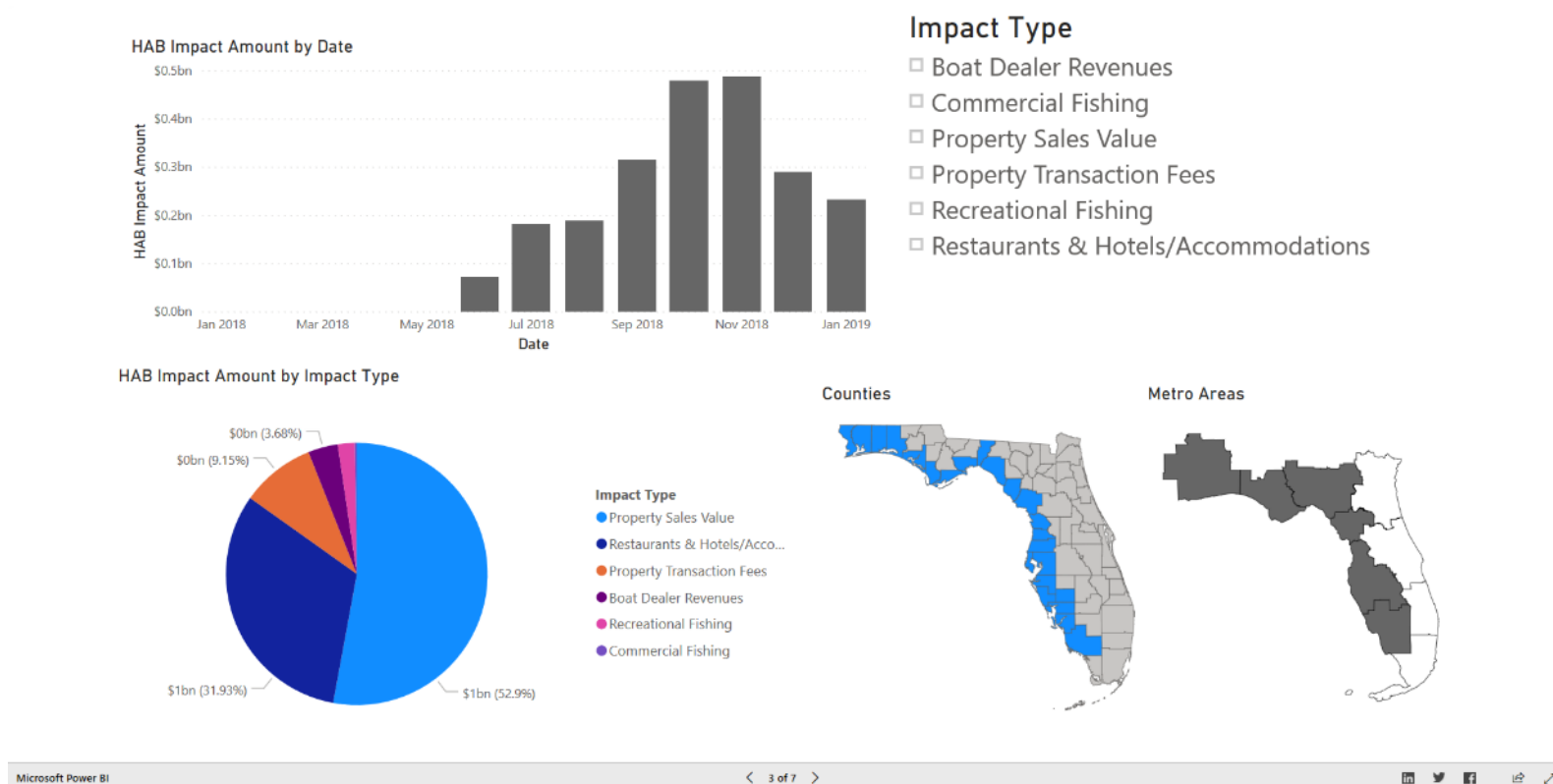


III. Impacts by Month

This page includes a bar chart that provides a breakdown of the HAB Impacts by Month in which they are realized. When a particular impact amount is selected, the bar chart will adjust. When a particular month is selected and the impact types are all deselected, a pie chart at the bottom of the page will adjust to show that month's share of the total across all impact types. Additionally, the map of metro areas allows for the bar chart showing monthly impacts to adjust and show that metro area's impact relative to the entire gulf coast total by month.

Figure A-3 provides an example.

Figure A- 3. Page 4 of Dashboard

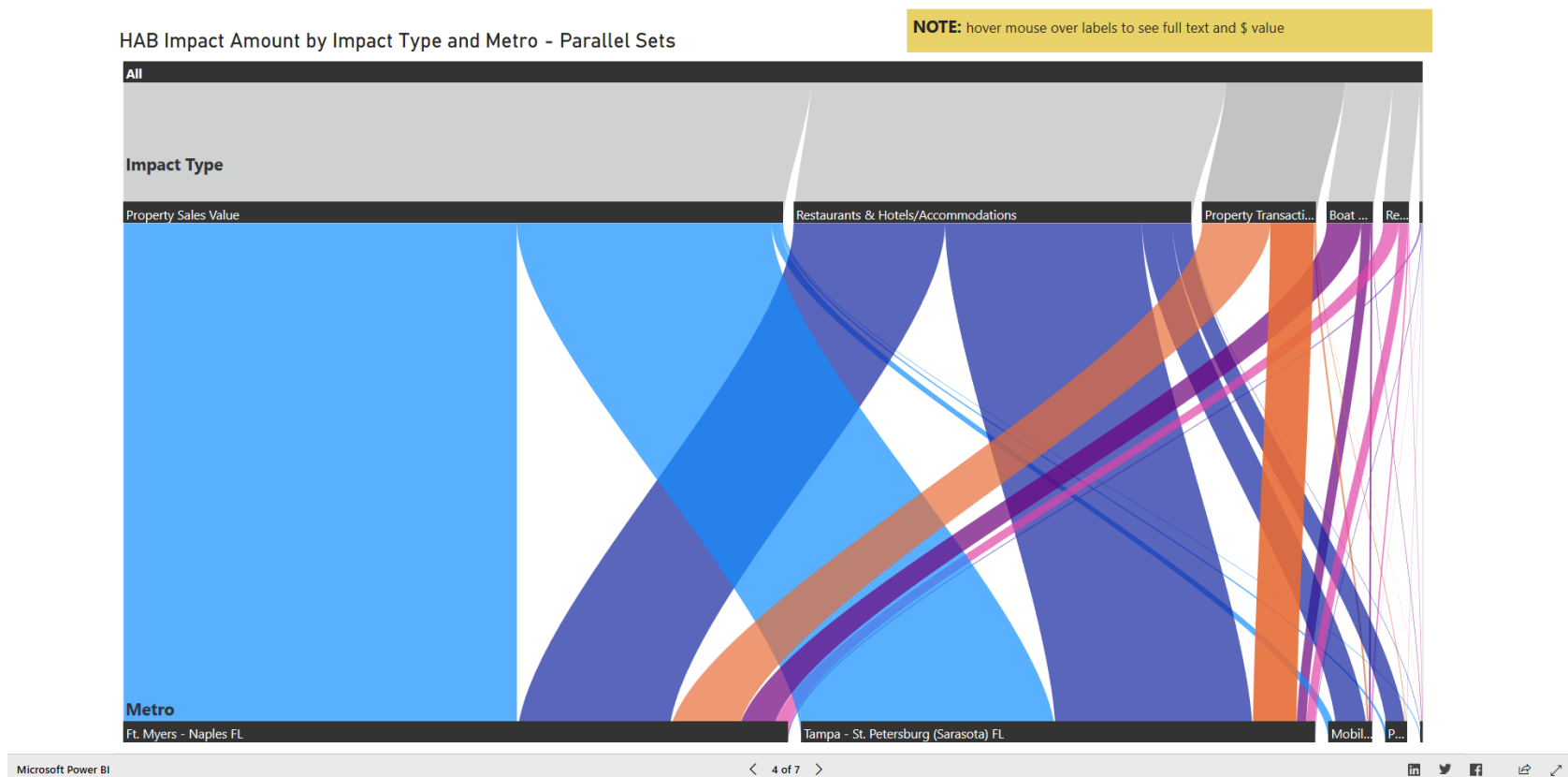




IV. Parallel Sets by Metro across Impacts

This page includes a Sankey diagram that provides a flow diagram of the HAB Impacts by Impact Type and Metro Area. Sankey diagrams are a type of flow diagram in which the width of the arrows is proportional to the flow rate. The widths of the bands are linearly proportional to the annual HAB impact amounts by impact type by metro. **Figure A-4** Provides an example.

Figure A- 4. Page 5 of Dashboard





V. Annual Economic Impact Effects by Impact Type

This page includes the estimated economic impact effects from the IMPLAN Input-Output Models. The effects are defined as Direct, Indirect and Induced effects – direct spending, indirect spending, and induced effects from direct and indirect spending. The economic impacts are further broken down through their dollar effects on payroll (labor income), value added, and total output/income - what is commonly referred to as GDP, or for a region, GRP. Jobs numbers are also included. **Figure A-5** Provides an example.

Figure A- 5. Page 6 of Dashboard

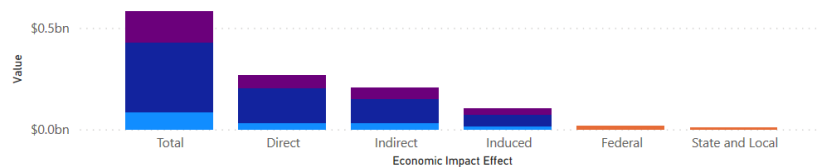
Economic Impacts of HAB event, 2018 -

by economic effect category and impact type

Metro	Economic Impact Effect	Impact Type	Category	Value
Ft. Myers - Naples FL	Direct	Properties	Labor Income	\$16,664,377
Gainesville FL	Direct	Properties	Labor Income	\$0
Miami - Ft. Lauderdale FL	Direct	Properties	Labor Income	\$0
Mobile AL - Pensacola (Ft. Walton Beach) FL	Direct	Properties	Labor Income	\$465,077
Panama City FL	Direct	Properties	Labor Income	\$139,816
Total				\$1,206,619,104

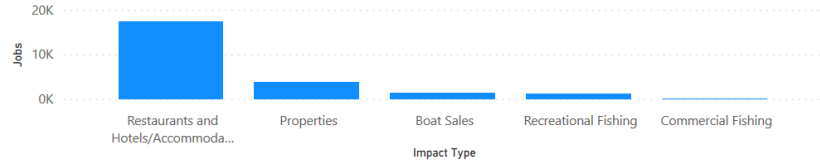
Economic Impact Effect and Category

Category ● Labor Income ● Output ● Total Taxes ● Value Added



Jobs by Category

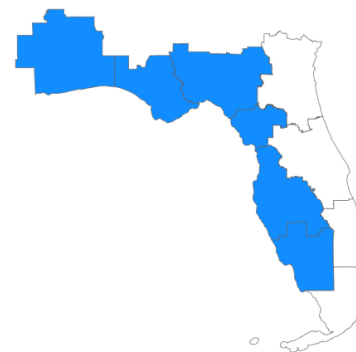
Category ● Employment



Impact Type

- ☐ Boat Sales
- ☐ Commercial Fishing
- ☒ Properties
- ☐ Recreational Fishing
- ☐ Restaurants and Hotels/Accommodations

Metro Areas



< 5 of 7 >

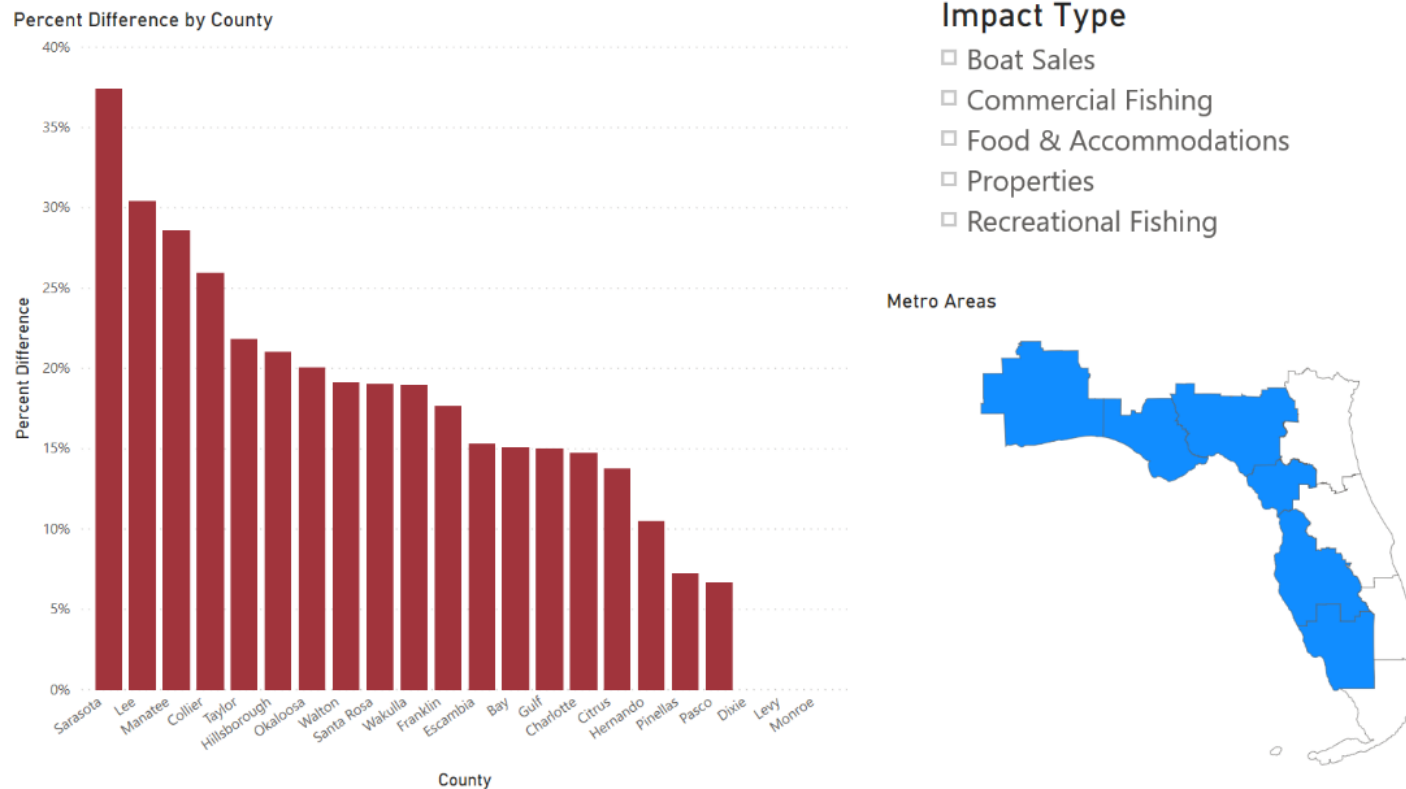




VI. Percent Impacts by County

This page includes the percent difference impacts, which help to visualize the magnitude of the revenue losses directly related to HAB events against what revenues would have been had a HAB event not occurred in 2018. This page was provided in response to comments regarding the effect of a \$50 Million loss on a \$60 Million local economy vs. a \$160 million economy. **Figure A-6** Provides an example.

Figure A- 6. Page 7 of Dashboard



< 6 of 7 >

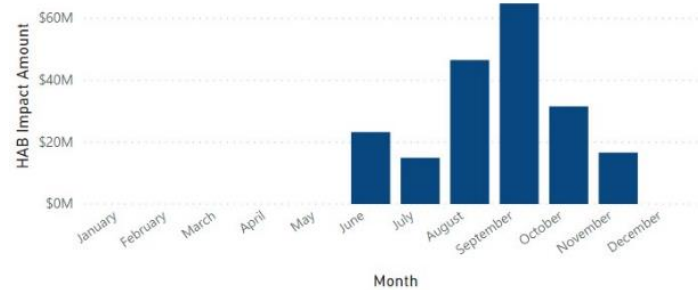


VII. Marine Animal Impacts

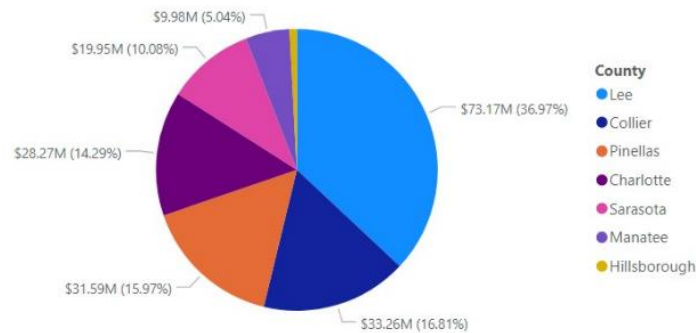
This page includes the impacts of marine animal losses on the public. The loss of marine life was widely publicized, and using willingness to pay values helps to visualize the magnitude of both the numbers of lost animals, and the value the public places on the losses of marine life. **Figure A-7** Provides an example.

Figure A- 7. Page 8 of Dashboard

Public Values: Economic Losses relating to marine animal deaths



Public Values: Economic Losses relating to marine animal deaths by County



NOTE: Public values are assigned based on published literature estimating public willingness to pay (WTP) values to avoid marine animal deaths, or to passively enjoy the marine animal. As a conservative lower bound, the WTP has been applied by incident as reported by FWC of marine animals identified during red tide fish kills. A dolphin or multiple dolphins on one fish kill report are treated as one incident, for purposes of estimating public WTP values shown here. The accompanying Technical Memorandum provides details regarding underlying assumptions and calculations.

Marine Animal Incidents

Impact Type

- ☐ Dolphins
- ☐ Manatees
- ☐ Sea Turtles



Loss Events

County: Lee (blue), Collier (dark blue), Hillsborough (orange), Manatee (purple), Pinellas (pink), Sarasota (yellow), Charlotte (light blue)

