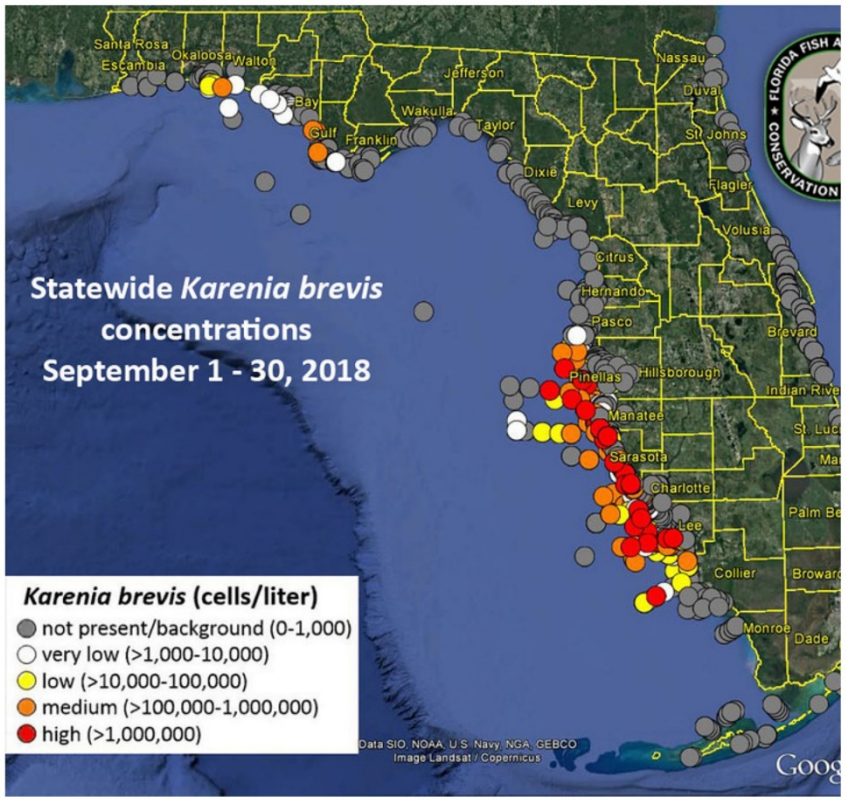
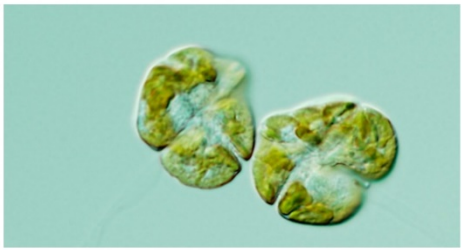

Statewide *Karenia brevis* concentrations
September 1 - 30, 2018
*Karenia brevis* (cells/liter)
not present/background (0-1,000)
very low (>1,000-10,000)
low (>10,000-100,000)
medium (>100,000-1,000,000)
high (>1,000,000)
Santa Rosa
Escambia
Okaloosa
Walton
Bay
Gulf
Franklin
Jefferson
Wakulla
Taylor
Dixie
Levy
Nassau
Duval
St Johns
Flagler
Volusia
Citrus
Hernando
Pasco
Pinellas
Hillsborough
Manatee
Sarasota
Charlotte
Lee
Collier
Monroe
Dade
Brevard
Indian River
Palm Beach
Broward
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus


2018 RED TIDE
IMPACT & RESPONSE
Volume 1: Impact Assessment
Tampa Bay & Sarasota Bay




CAUTION
RED TIDE
PRESENT

# 2018 Red Tide Impact and Response

# Volume 1: Regional Red Tide Impact Assessment
## for Tampa Bay and Sarasota Bay

December 20, 2020 (Revised March 30, 2021)
Prepared by: Science and Environment Council of Southwest Florida
Contact: Jennifer Shafer, PhD jennifer@scienceandenvironment.org

## CONTENTS



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# SUMMARY

Low-level blooms of the Florida red tide dinoflagellate *Karenia brevis* occur regularly in Gulf and coastal waters of Southwest Florida. Severe blooms that negatively impact recreation, businesses, coastal habitats, and wildlife are more rare. The sixteen-month red tide bloom that engulfed Florida's west coast from late 2017 to early 2019 was one of the longest and most severe in memory. The bloom moved up the coast south to north, reaching Sarasota in mid-June 2018 and arriving in Pinellas County waters by late August, then — with devastating effect — growing to 50 times the threshold considered "High" (> 1 million cells per liter) by Florida Fish and Wildlife Research Institute's (FWRI) red tide index. Red tide cell counts were higher and lingered longer in Boca Ciega Bay and Sarasota Bay than adjacent beach locations. The odor of decaying marine debris reached seven miles inland east of Interstate I-75 in Sarasota and Manatee Counties. Upper Tampa Bay and Pasco County waters experienced only "Low" concentrations of red tide (< 100,000 cells per liter). The red tide retreated in reverse with the last high cell counts in Pinellas in mid-November and Sarasota waters clearing by early January 2019.

This red tide impact study examines conditions in the 5-county Tampa Bay and Sarasota Bay region (Pasco, Pinellas, Hillsborough, Manatee, and Sarasota Counties) before, during, and after the red tide event across eighteen measures of community wellbeing, including beach conditions, fish, wildlife, recreation, social media sentiment, human health and welfare, tourism, and business sales. Across social and economic metrics, red tide impacts accruing in the month of September 2018 are compared to impacts from Hurricane Irma in September 2017. While these data were not collected for the purpose of measuring red tide impact in a statistical manner, exploratory data analysis shows compelling associations. This study is a companion to the Regional Red Tide Response Study described in Volume 2, which documents the red tide emergency response of the five counties and offers a Draft Red Tide Operations Plan and recommendations.

The 2017–2019 red tide event caused a profound loss of animal life in coastal habitats. Across the Florida west coast manatee population, one out of every 12 individuals lost their life to red tide in 2018. In the Tampa Bay and Sarasota Bay region alone, record numbers of manatee (171), dolphin and whale (76), and turtle (190) strandings were associated with red tide. Bird hospitals admitted almost 1600 birds — 300% above normal — but most sick birds never made it to the hospital. More than 2400 tons of dead animals were cleaned from beaches and waterways. Fish kill reports to Florida Fish and Wildlife Conservation Commission (FWC) were up 400% in Tampa Bay and Sarasota Bay, and fish abundance in Sarasota Bay seagrass beds was down 85% in August and September compared to 2017. Manatee County's commercial fisheries catch dropped 25% by weight, and Red Grouper catch across the region declined 30%.

Human communities also experienced declines in health and happiness. Asthma cases were up across the region as much as 16–17% in Sarasota County and Pinellas County. Calls to 211 social service hotlines for housing, utilities, and healthcare assistance reached a 3-year high. September 2018 saw more calls than September 2017, the month that Hurricane Irma hit the region. Meanwhile, boating activity

was down 24% and 19% in Sarasota County and Pinellas County, respectively, as evidenced by a drop in gallons of marina fuel sold. Visitors to Fort DeSoto Park were down 24%, while camping reservations dropped 39%. Twitter users weighed in with tweet counts and sentiments about red tide correlating strongly with local conditions on a variety of spatial and temporal scales. Based on word counts, most tweets were concerned with the environment (69%), while 22% were concerned with health, and 9% economy.

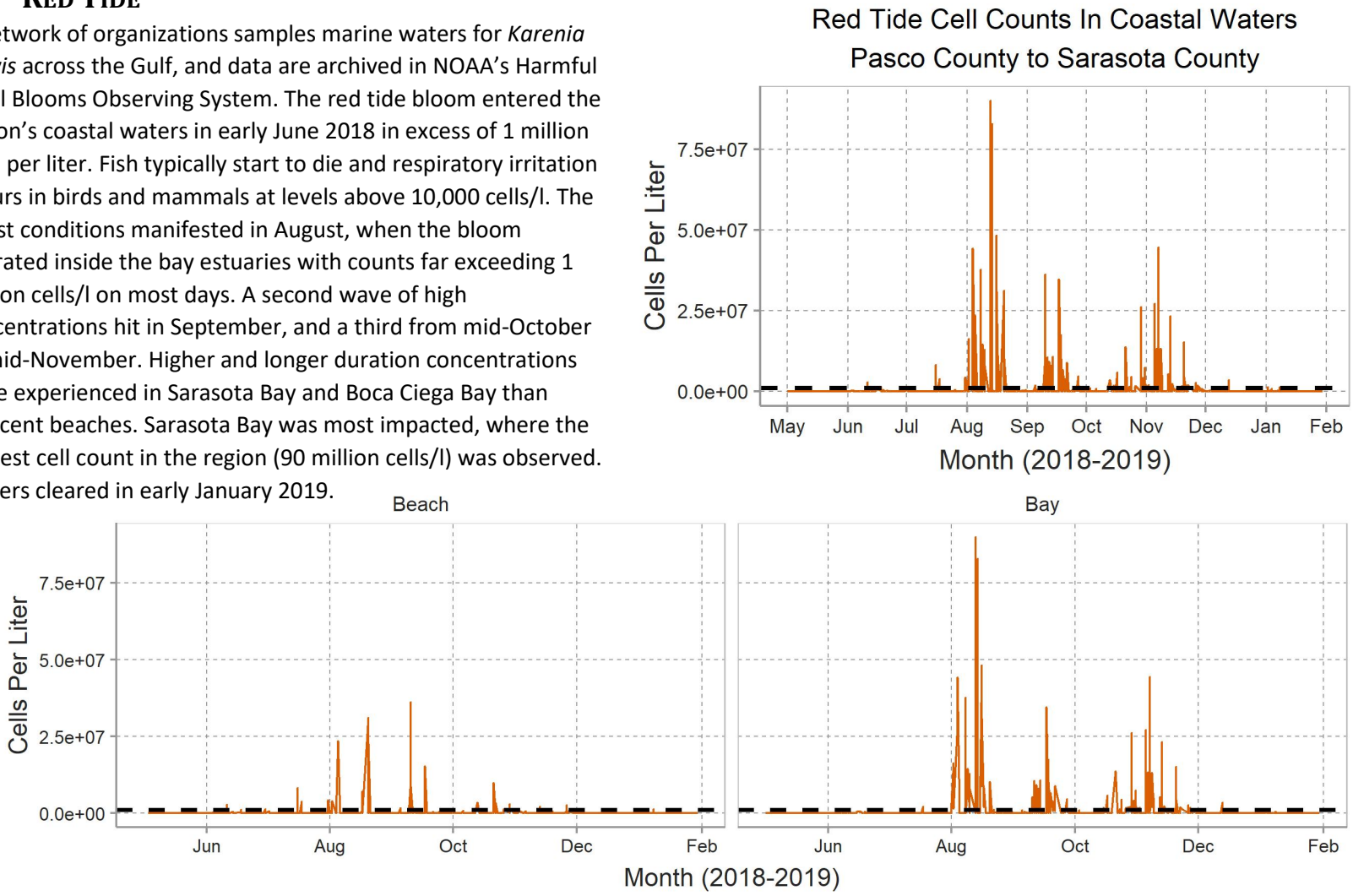
At regional and county-wide scales, red tide did not appear to have a major effect on overall business activity, unlike in the third and fourth quarters of 2017 following Hurricane Irma. Even isolating revenue of businesses located in coastal zip codes that might be susceptible to red tide, such as restaurants, only a small decline was seen in Manatee County where annual restaurants sales were down 3% for 2018 and boat sales were flat. Isolating the effect even further to businesses on the barrier islands, again only Manatee County showed a decline — restaurant gross revenues were down 27% in 2018. Air passenger traffic was apparently not affected with passenger counts showing year over year growth. However, every county in the region experienced at least one month of year over year decline in bed tax revenues during the August–December 2018 period ranging from 2% to 34%, with number of months and magnitude of tax revenue decline correlated with severity of local red tide conditions.

During red tide events, the public activates and demands environmental protection and restoration. Together with managers, they are frustrated that no historical record of impacts exists to evaluate whether red tide impacts are getting worse. In between red tide events, public interest wanes and other issues are prioritized. The purpose of this study was to develop a regionally standardized assessment methodology and communication tool to document community wide impacts of red tide, then apply that tool to the historic Florida Red Tide bloom of 2017–2019. Open science principles were applied in this study to carefully document metadata describing data sources used in this study and to develop R scripts for analyzing each dataset. Recommendations are also offered to fill data gaps. This framework can be used to document subsequent red tide events and retrospectively compare previous events. When the next major red tide occurs, there will be a standard protocol to assess the relative magnitude of its impact — to objectively evaluate if red tide impacts are getting worse. Together with the recommendations in the Regional Red Tide Response Study (Volume 2), these insights can lead to stronger protections for our estuaries.

# 1 WATER AND BEACHES

## 1.1 RED TIDE

A network of organizations samples marine waters for *Karenia brevis* across the Gulf, and data are archived in NOAA's Harmful Algal Blooms Observing System. The red tide bloom entered the region's coastal waters in early June 2018 in excess of 1 million cells per liter. Fish typically start to die and respiratory irritation occurs in birds and mammals at levels above 10,000 cells/l. The worst conditions manifested in August, when the bloom migrated inside the bay estuaries with counts far exceeding 1 million cells/l on most days. A second wave of high concentrations hit in September, and a third from mid-October to mid-November. Higher and longer duration concentrations were experienced in Sarasota Bay and Boca Ciega Bay than adjacent beaches. Sarasota Bay was most impacted, where the highest cell count in the region (90 million cells/l) was observed. Waters cleared in early January 2019.



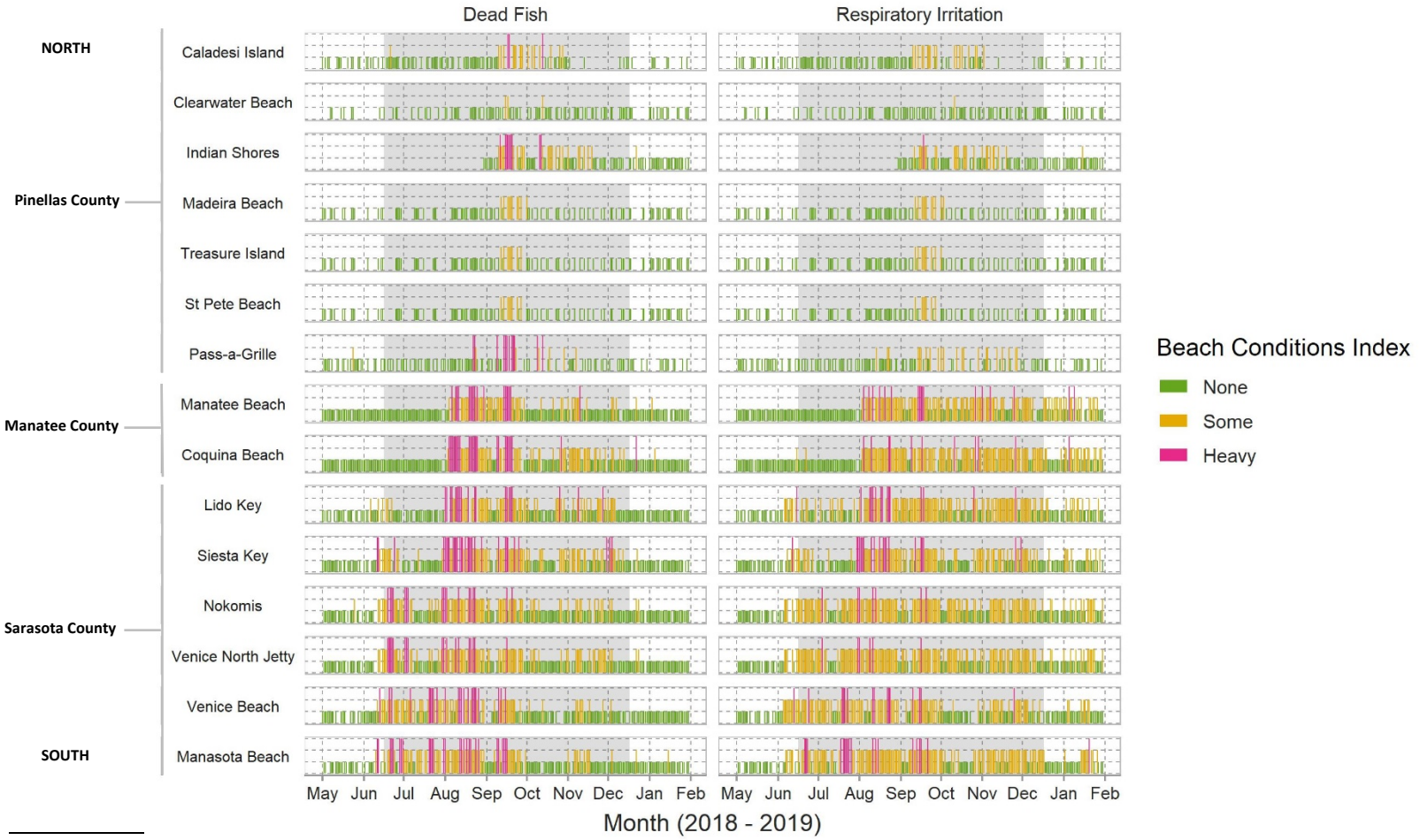

Heavy dashed line indicates the minimum cell concentration categorized as 'High' (1,000,000 cells/liter) by Florida Fish & Wildlife Research Institute.

## Red Tide Cell Counts
## May 2018 - Jan 2019


The sample location indicated in red (left panel) is the highest observed cell count (90 million cells per liter). High, Medium, and Low cell concentrations as defined by FWRI.

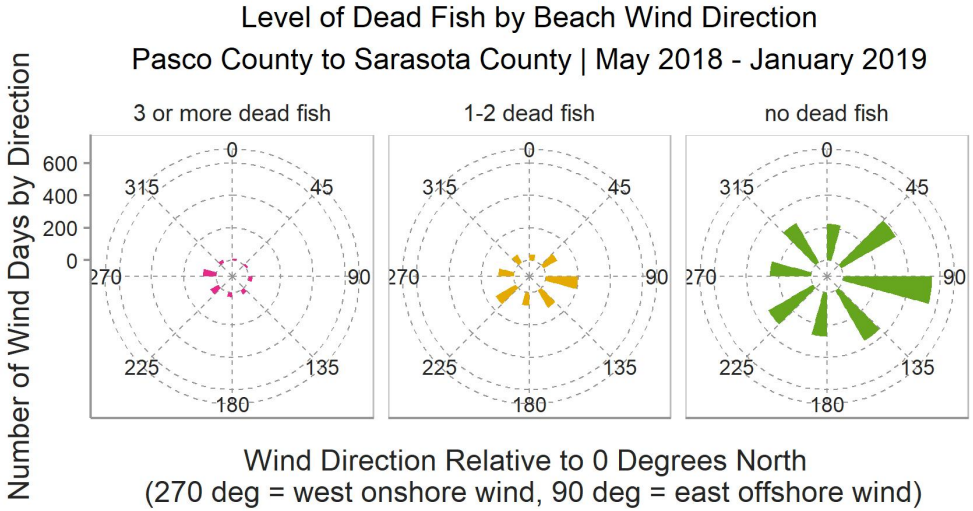
## 1.2 BEACHES

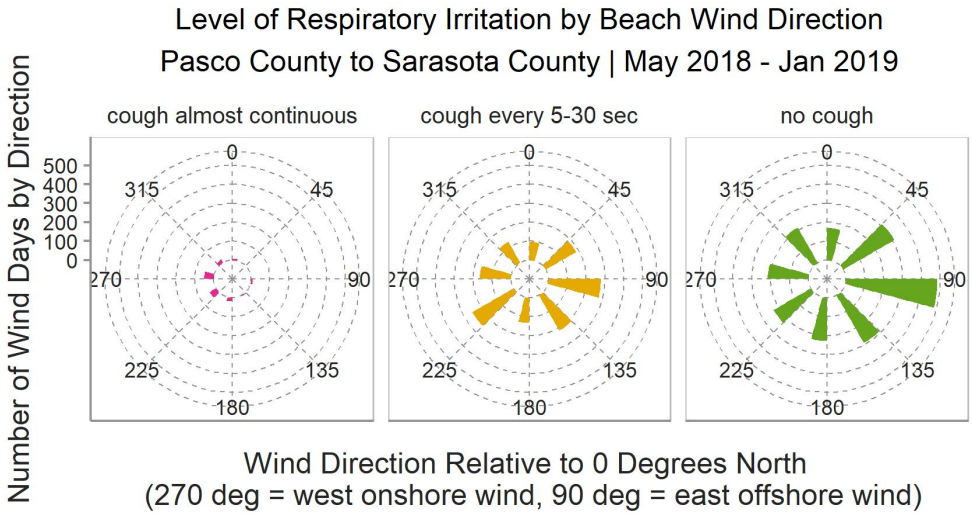
Mote Marine Laboratory maintains a Beach Conditions Reporting System (visitbeaches.org) for Southwest Florida that provides daily eyes-on reports from trained monitors. Impacts from red tide brevetoxins appeared on Sarasota County beaches in early June and lingered through January 2019[1]. Manatee County beaches were heavily impacted beginning in August and Pinellas County beaches in September (though conditions for Pinellas County were sparsely reported in this dataset). Pasco County beaches were not affected.




[1] Index: None = no fish, no cough; Some = 1–2 dead fish, cough every 5–30 seconds; Heavy = 3 or more dead fish, cough almost continuous. Peak red tide conditions July–December 2018 shaded in grey.

Beach conditions reported by trained lifeguards and volunteers showed a correlation to wind direction. Onshore westerly and southwesterly winds predominated on days with heavy fish debris and heavy respiratory irritation. On days with some or no dead fish or respiratory irritation, an easterly offshore wind predominated.



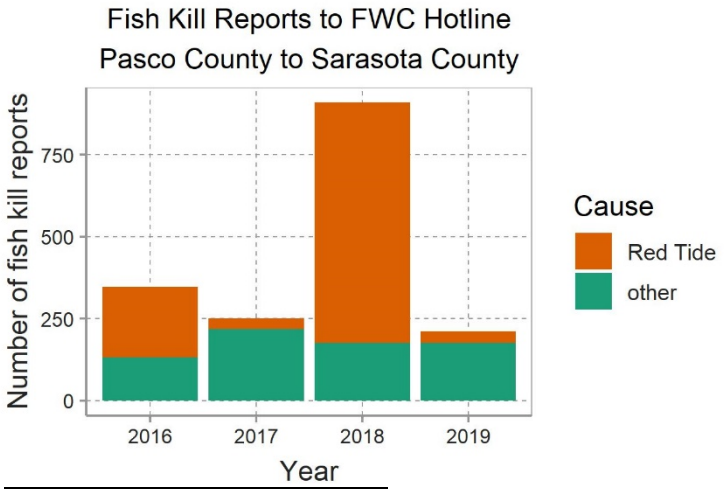



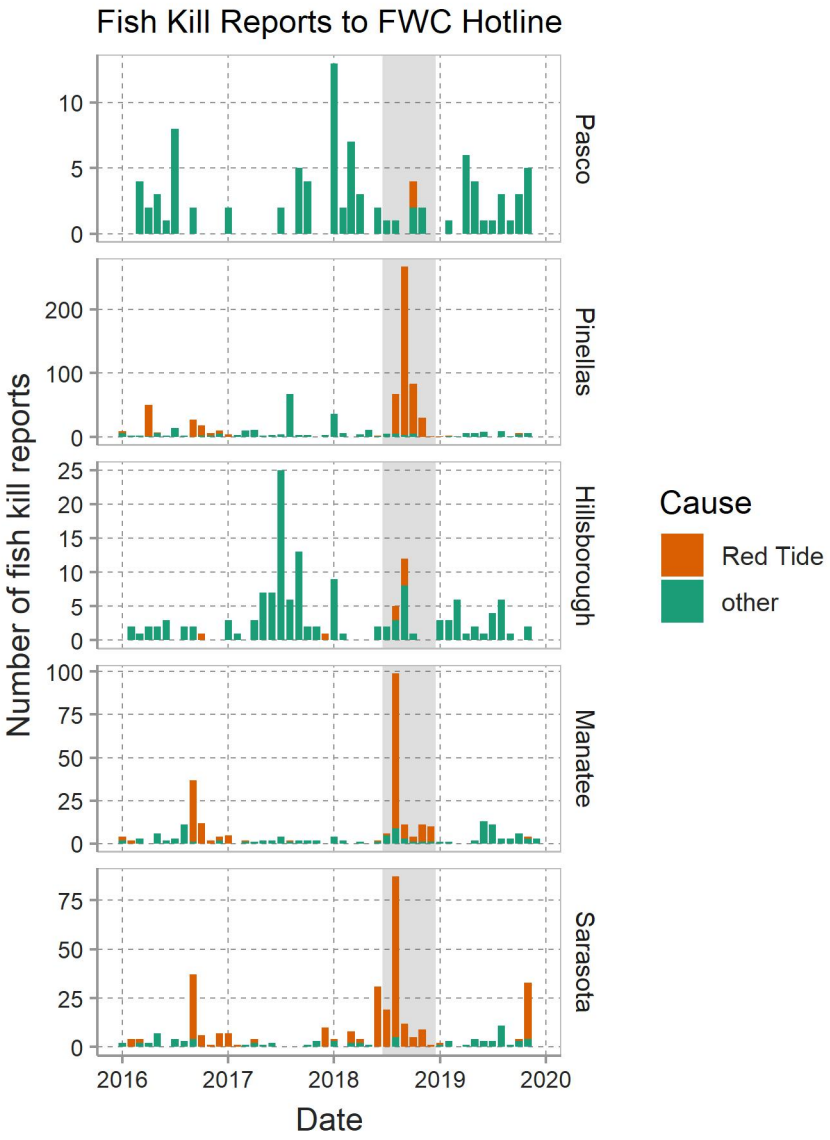
# 2 FISH

## 2.1 FISH KILLS

Florida Fish and Wildlife Conservation Commission (FWC) maintains a fish kill reporting hotline and mobile app for citizens to report incidents of dead animals found in the water or onshore. In a typical year across the region, there are about 34 fish kill reports for red tide and 175 fish kill reports for causes other than red tide. In 2018, there were 734 reports of fish kills due to red tide, 59% from Pinellas County.

The northerly migration of red tide up the coast left a trail of dead fish beginning with a few dozen reports in Sarasota in June and July 2018 and peaking in Sarasota County and Manatee County in August with 82 and 90 reports, respectively, and continuing until December[2]. Pinellas County had three times that number in a strong peak in September.



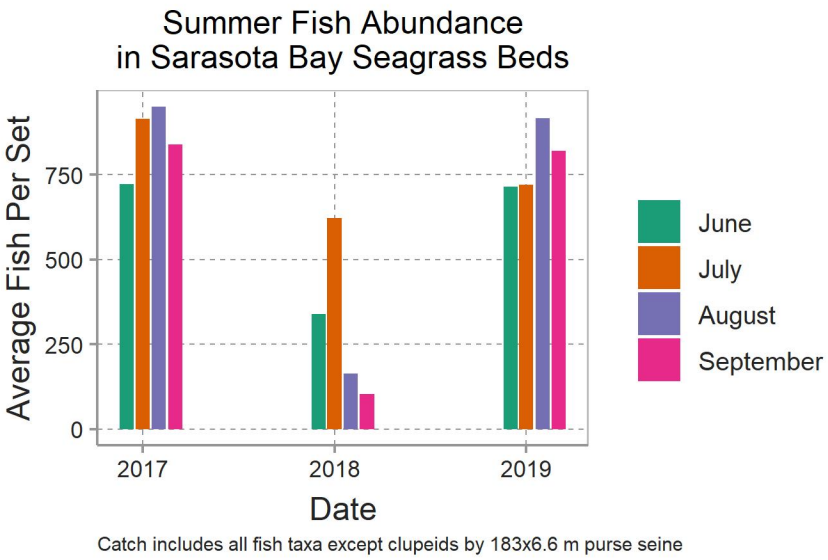




[2] Peak red tide conditions July–December 2018 shaded in grey.

## 2.2 FISH MONITORING

Chicago Zoological Society's Sarasota Dolphin Research Program (SDRP) has tracked the resident Sarasota Bay dolphin community for 50 years. The program studies their behavior, health, and ecology, including tracking abundance of fish in Sarasota Bay since 2004[3]. Seasonal purse-seining surveys in seagrass beds are performed to obtain an index of fish availability, including common dolphin prey species such as Gulf toadfish, spot, pigfish, spotted seatrout, ladyfish, mullet, sheepshead, and pinfish[4]. Annual summer sampling showed a 85% decline in fish abundance in seagrass beds in August-September 2018 compared to the same period in 2017. By the next summer, abundance had returned to 2017 levels.

The Passive Acoustic Listening Station (PALS) network of nine hydrophones in Sarasota Bay, a collaboration of SDRP, Mote Marine Laboratory, New College of Florida, and Loggerhead Instruments, also recorded the devastation to marine life. Within three days of red tide entering Sarasota Bay, listening stations around the bay fell nearly silent with regard to sounds produced by fish and snapping shrimp[5].

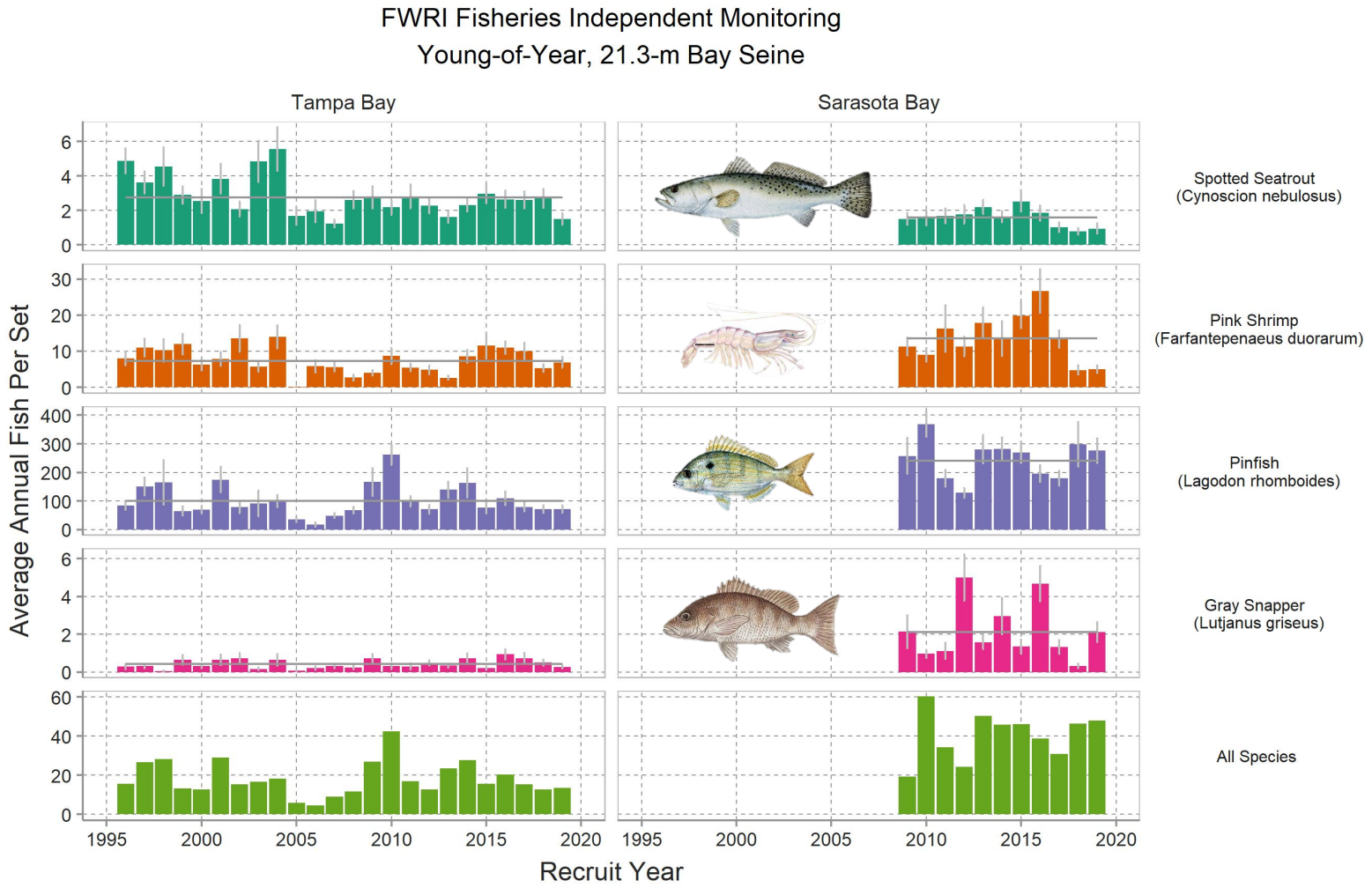



[3] Gannon, D.P., E.J. Berens, S.A. Camilleri, J.G. Gannon, M.K. Brueggen, A. Barleycorn, V. Palubok, G.J. Kirkpatrick and R.S. Wells. 2009. Effects of *Karenia brevis* harmful algal blooms on nearshore fish communities in southwest Florida. Marine Ecology Progress Series 378:171–186.

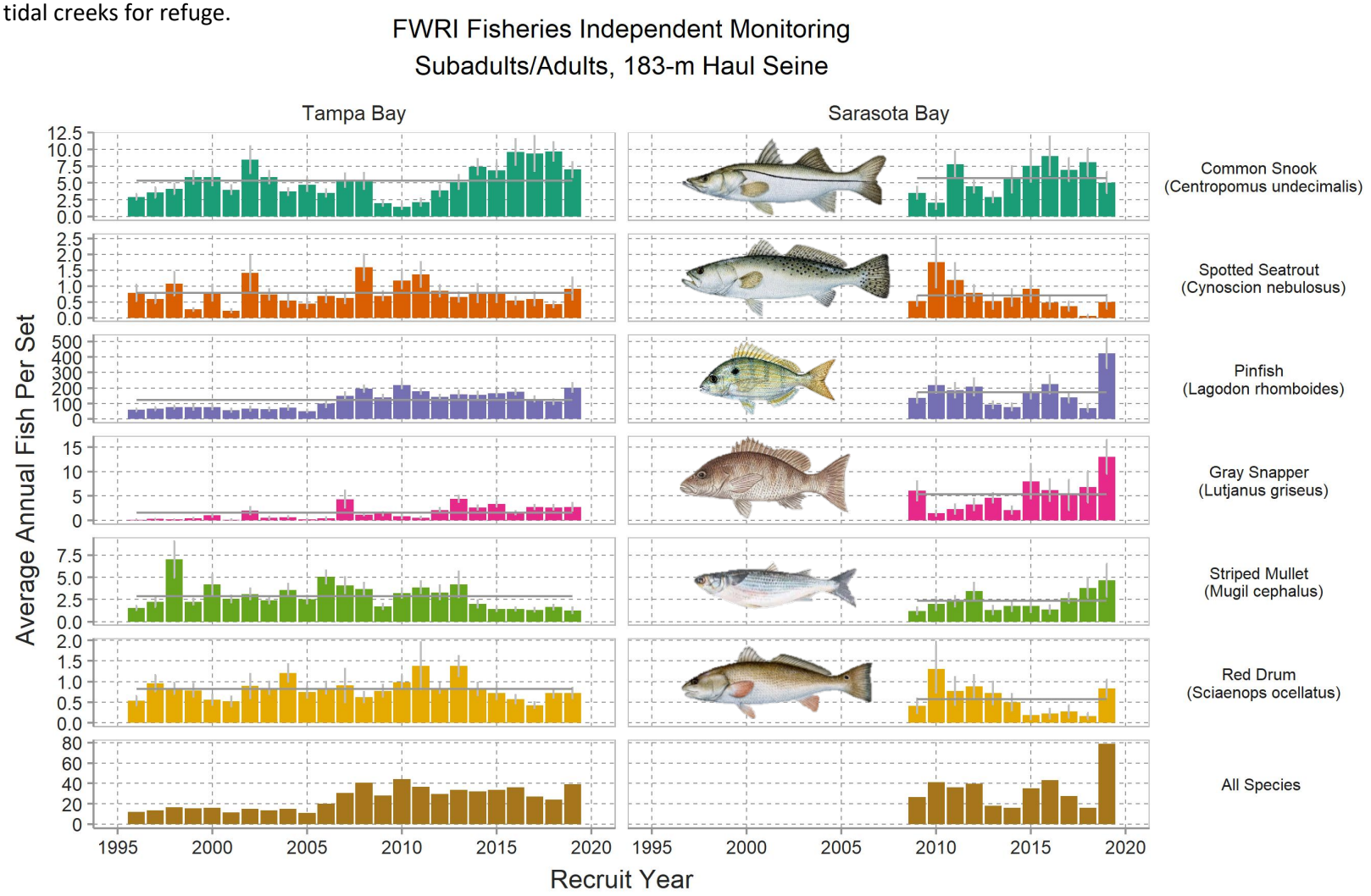
[4] Berens McCabe, E., D.P. Gannon, N.B. Barros and R.S. Wells. 2010. Prey selection in a resident common bottlenose dolphin (*Tursiops truncatus*) community in Sarasota Bay, Florida. Marine Biology 157(5):931-942. DOI 10.1007/s00227-009-1371-2

[5] Rycyk, A. M., R. B. Tyson Moore, R. S. Wells, K. A. McHugh, E. J. Berens McCabe and D. A. Mann. 2020. Passive acoustic listening stations (PALS) show rapid onset of ecological effects of harmful algal blooms in real time. Scientific Reports 10, 17863 (2020). DOI 10.1038/s41598-020-74647-z

FWC's Fish and Wildlife Research Institute Fishery Independent Monitoring (FIM) Program has conducted monthly surveys throughout Tampa Bay since 1996 and bi-monthly surveys in Sarasota Bay since 2009. Surveys use several gear types targeting different habitats and size classes in order to detect changes in relative abundance of fishes from year to year. In general, monthly catch (not shown) was down during red tide conditions, but not down year over year for many species.



Species abundance in Tampa Bay stayed within typical ranges for the year and higher than in 2005 during the last major red tide event. Total catch of adult classes and certain populations in Sarasota Bay, such as pink shrimp, spotted seatrout, pinfish, and gray snapper young-of-year, showed the lowest abundance since sampling began in 2009. Adult pinfish experienced a strong recovery in 2019 in Sarasota Bay, while pink shrimp did not. Common Snook abundance was mostly unaffected, possibly because this species can migrate to tidal creeks for refuge.

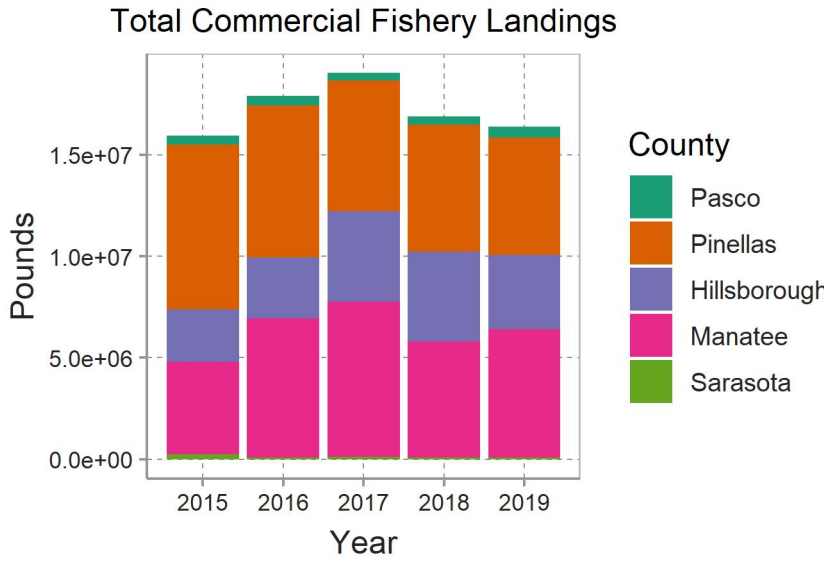


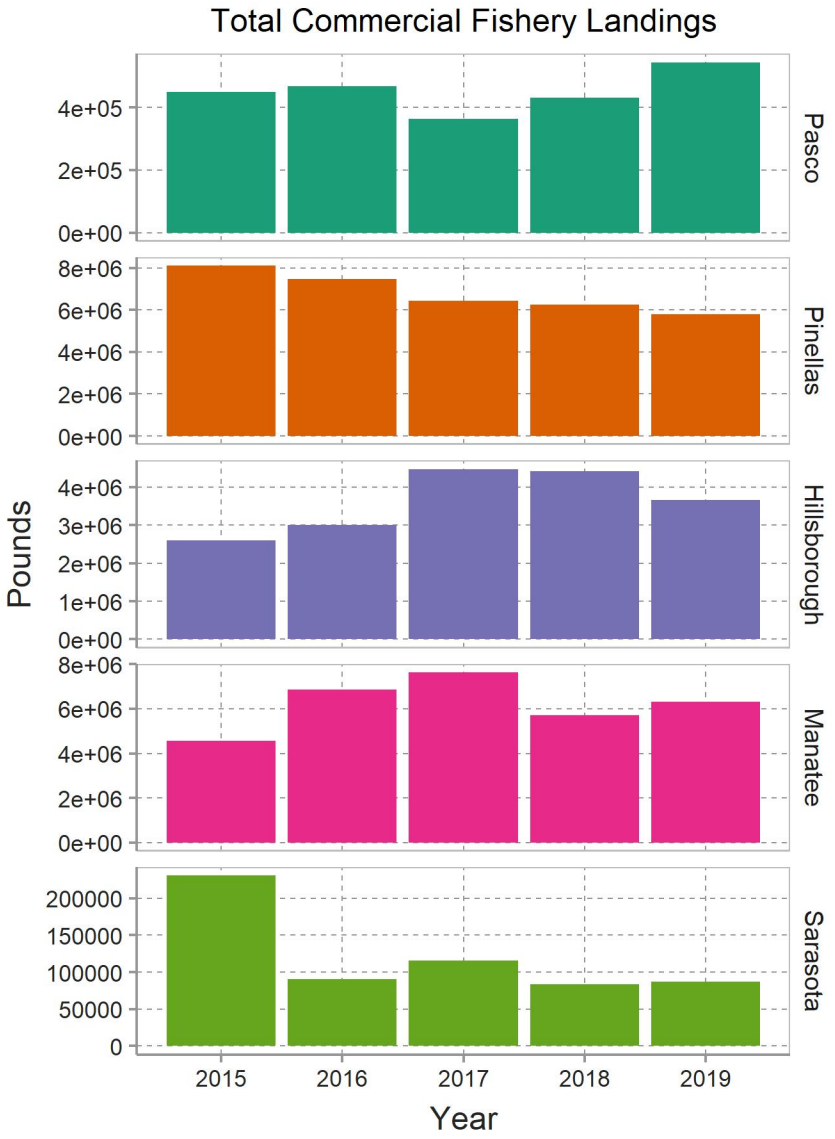

Where the months assessed cross calendar years, the Recruit Year represents the earlier of the two years. Standard error bars and series average shown in grey.

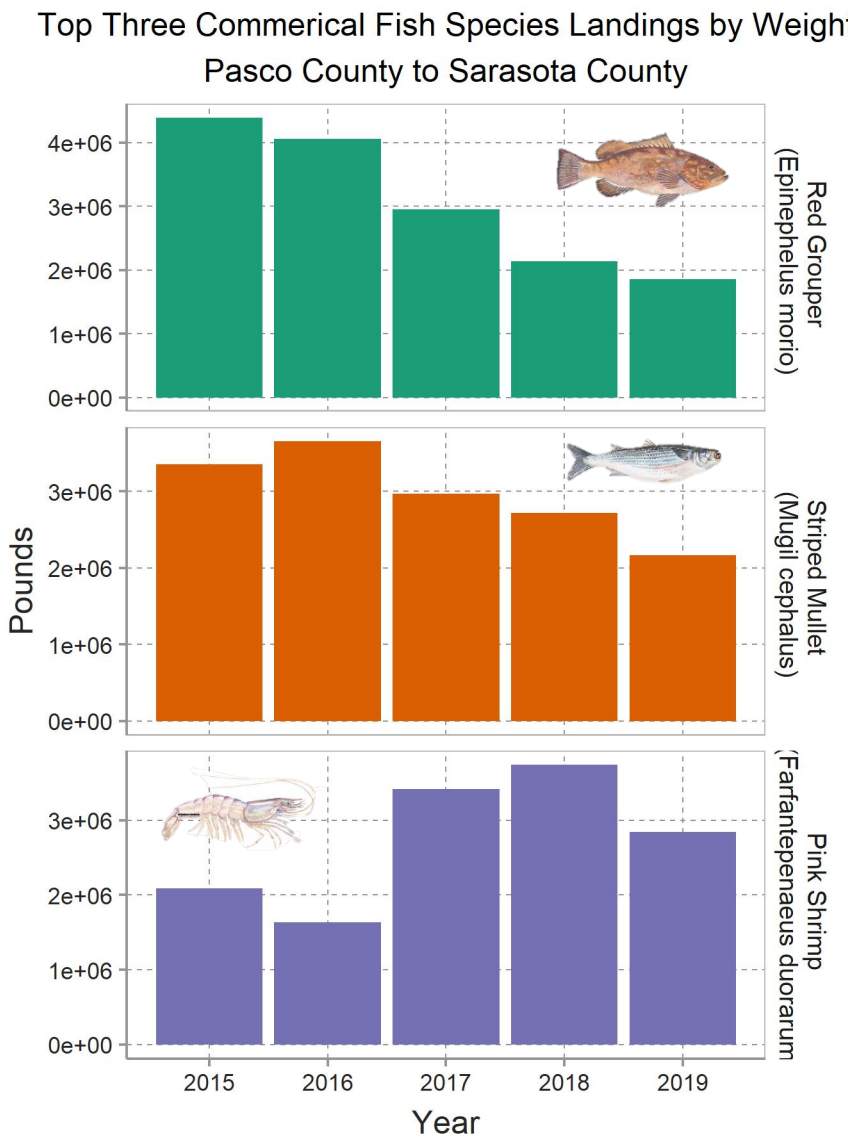
## 2.3 COMMERCIAL FISHING

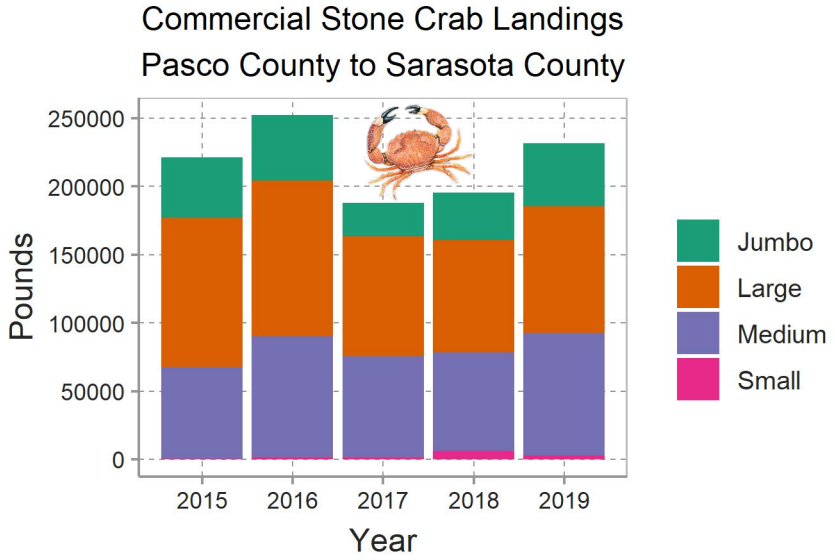
Total pounds of commercial fish landings reported to FWC were down 11% across the region in 2018 compared to 2017, along with a decrease of 8.7% in number of reported trips. Manatee County landings suffered a year over year decline of 25.3% or 1.9 million pounds from 2017 to 2018. Striped Mullet and Red Grouper landings were down 334,000 pounds and 207,000 pounds, respectively. Sarasota County commercial fishery landings were down 27.6% or 32,000 pounds mainly due to drops in Stone Crab (17,400 lbs), Striped Mullet (12,000 lbs), and Red Grouper (7000 lbs).

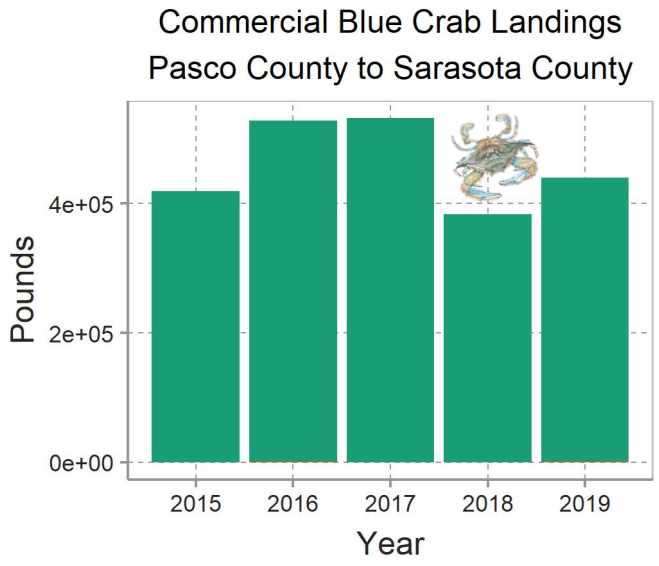
Overall, Pinellas County and Pasco County suffered greater year over year losses in 2017 than 2018. In 2018, Pinellas County's largest decline in landings for a single species was for its number one catch Red Grouper, which was down 605,000 lbs or 25% for the year.




Top Three Commerical Fish Species Landings by Weight
Pasco County to Sarasota County
Pounds
4e+06
3e+06
2e+06
1e+06
0e+00
Red Grouper
(Epinephelus morio)
Striped Mullet
(Mugil cephalus)
Pink Shrimp
(Farfantepenaeus duorarum
2015
2016
2017
2018
2019
Year


Commercial Stone Crab Landings
Pasco County to Sarasota County
Pounds
250000
200000
150000
100000
50000
0
2015
2016
2017
2018
2019
Year
Jumbo
Large
Medium
Small

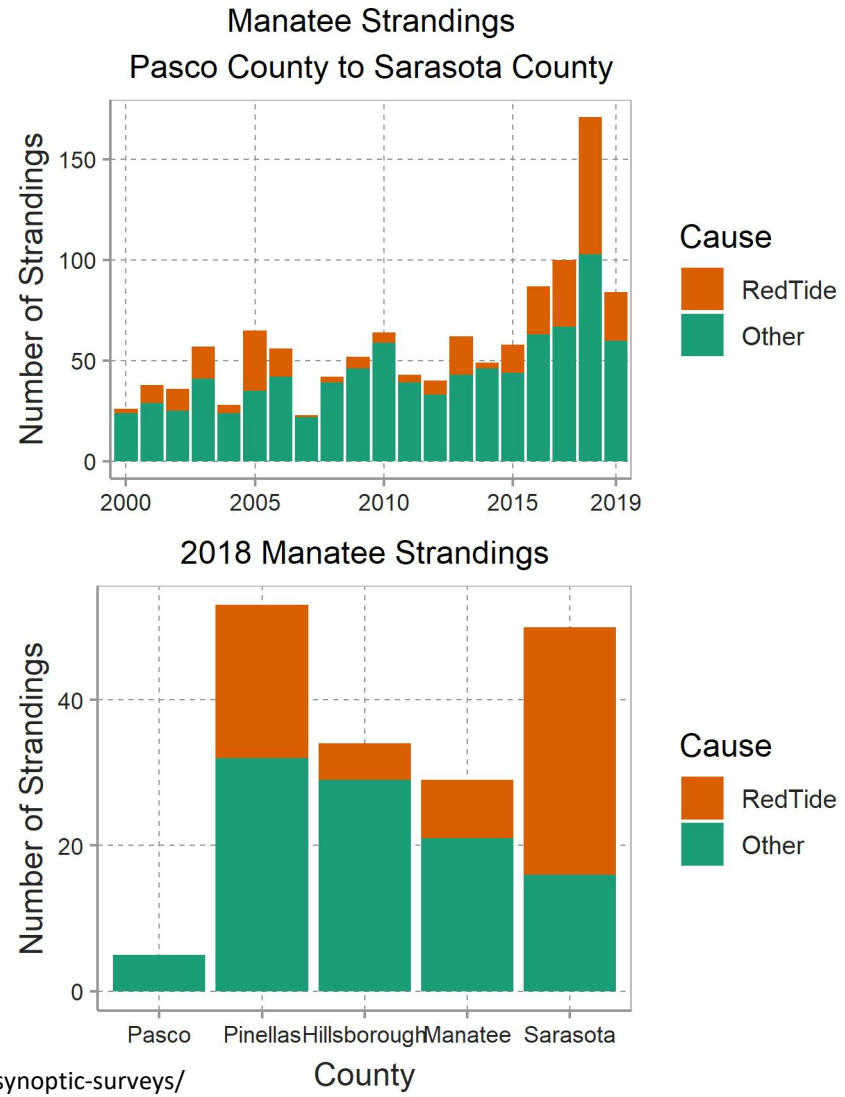

Commercial Blue Crab Landings
Pasco County to Sarasota County
Pounds
4e+05
2e+05
0e+00
2015
2016
2017
2018
2019
Year

# 3 WILDLIFE

## 3.1 MANATEES

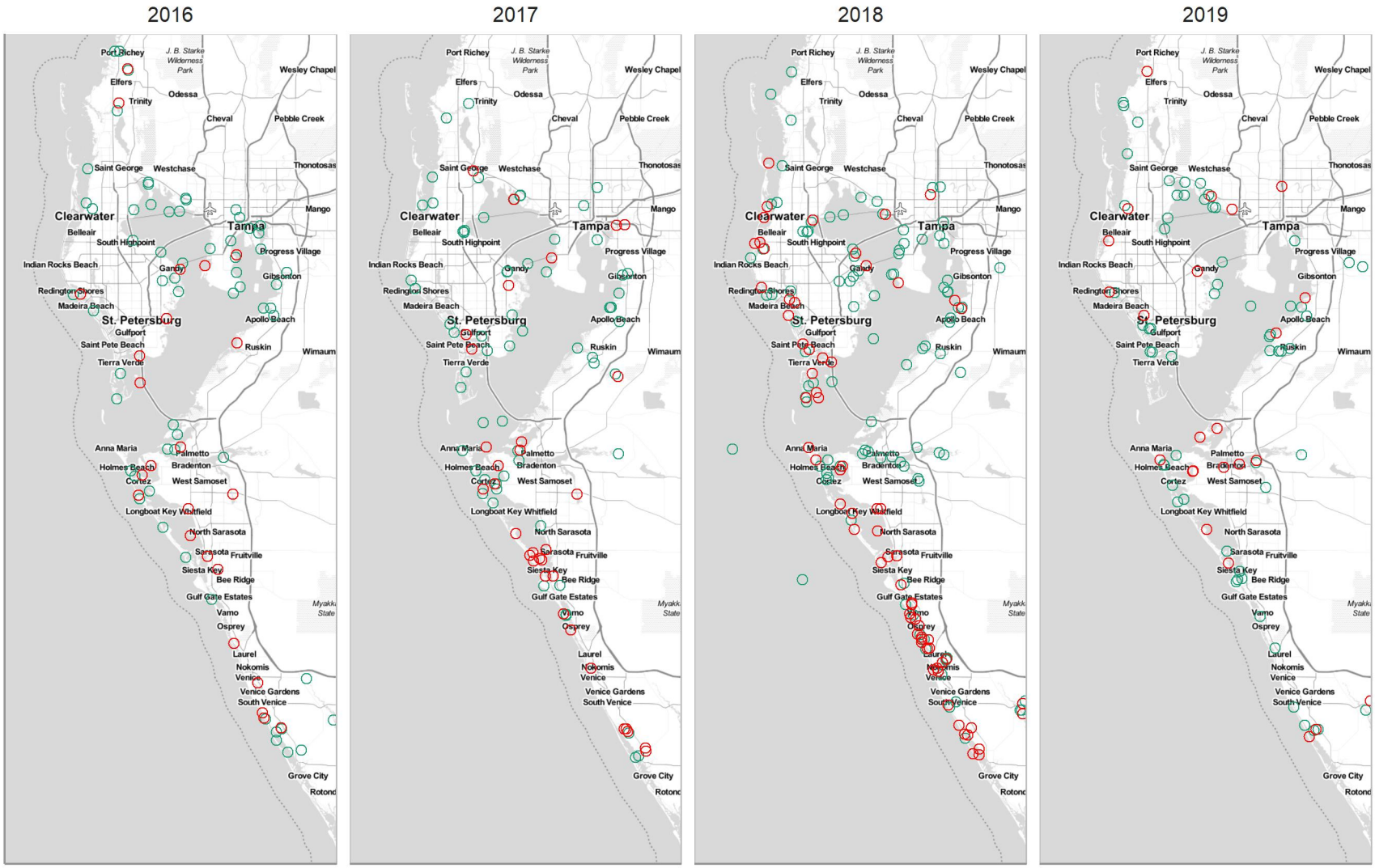
FWC maintains a reporting hotline and mobile app for stranded manatees and tracks and responds to every reported incident. Red tide toxins, especially brevetoxins, are deadly to manatees when ingested or inhaled. The neurotoxins cause seizures and loss of muscle control, and the affected manatee usually dies from drowning. When the 2017–2018 red tide spread along all of the waterways of Southwest Florida, there were few places for manatees to retreat. The red tide killed 1 out of every 12 manatees (8.6%) living on the west coast of Florida in 2018 (207[6] deaths out of 2400[7] surveyed).

Across just the five-county Tampa Bay and Sarasota Bay region, the death of 171 manatees from all causes in 2018 was unprecedented — more than three times the typical annual number from all causes in the region (about 50). Sixty-eight of those deaths were attributed to red tide, half in Sarasota County and one-third in Pinellas County. In Sarasota County during the month of August, on average one manatee died every other day; in Pinellas County in October, one manatee died every third day.




[6] https://myfwc.com/media/24282/2018finalredtide.pdf
[7] https://myfwc.com/research/manatee/research/population-monitoring/synoptic-surveys/

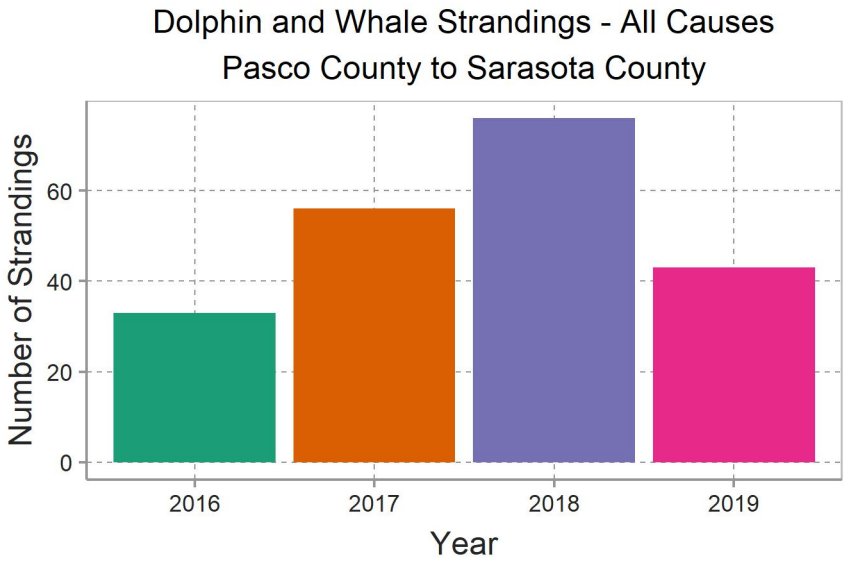
# Manatee Strandings
## All Causes



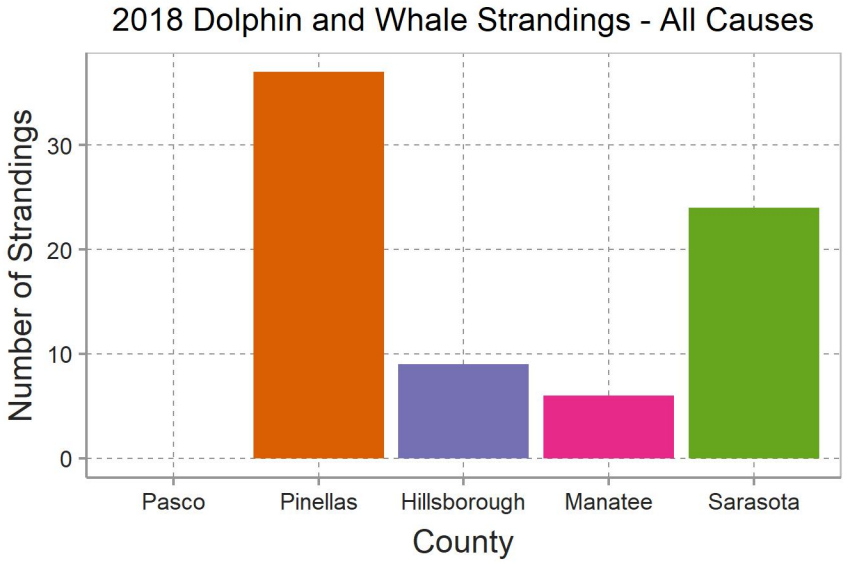

Strandings shown in red are due to red tide.

## 3.2 Dolphins and Whales

A network of organizations responds to marine mammal standings across the region, and data are archived by NOAA's Southeast US Marine Mammal Stranding Network in a national database. While the NOAA database does not provide cause of death, dolphins and whales are endangered by red tide conditions. In the short-term, they can die from eating contaminated prey and inhaling the toxins. In the long-term, their health can suffer from lack of prey (see 2.2 Fish Monitoring) and changes in their home range. In 2018, 50 out of 76 strandings in the 5-county region occurred during the peak of red tide from August to November, resulting in the declaration by NOAA Fisheries of an Unusual Mortality Event (defined as a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response). Strandings were elevated in 2017 apparently due to two unusual and isolated grounding events.




Forty-nine percent of 2018 strandings were in Pinellas County and 32% in Sarasota County, mostly bottlenose dolphins and at least 8 whales. In the Sarasota Bay dolphin population, brevetoxins were identified as responsible for the deaths of six dolphins and suspected in the deaths of four other dolphins who were well known to the Chicago Zoological Society's Sarasota Dolphin Research Program, which has been tracking the resident Sarasota Bay resident dolphin population since 1970. Two other well-known dolphins observed in Gulf coastal waters off Sarasota since 1989 died during the red tide and had tissue brevetoxin concentrations indicative of cause of death. In contrast, no Sarasota Bay resident dolphins were known to have died from brevetoxins in the 2005–06 severe red tide.

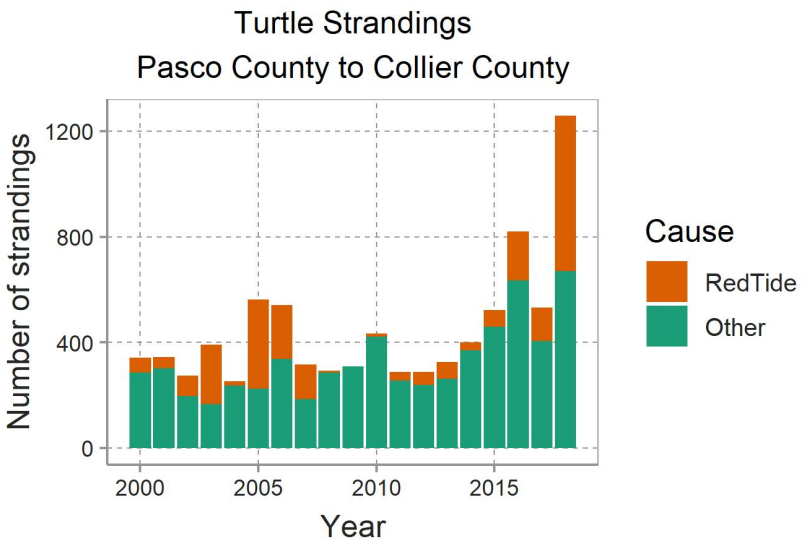


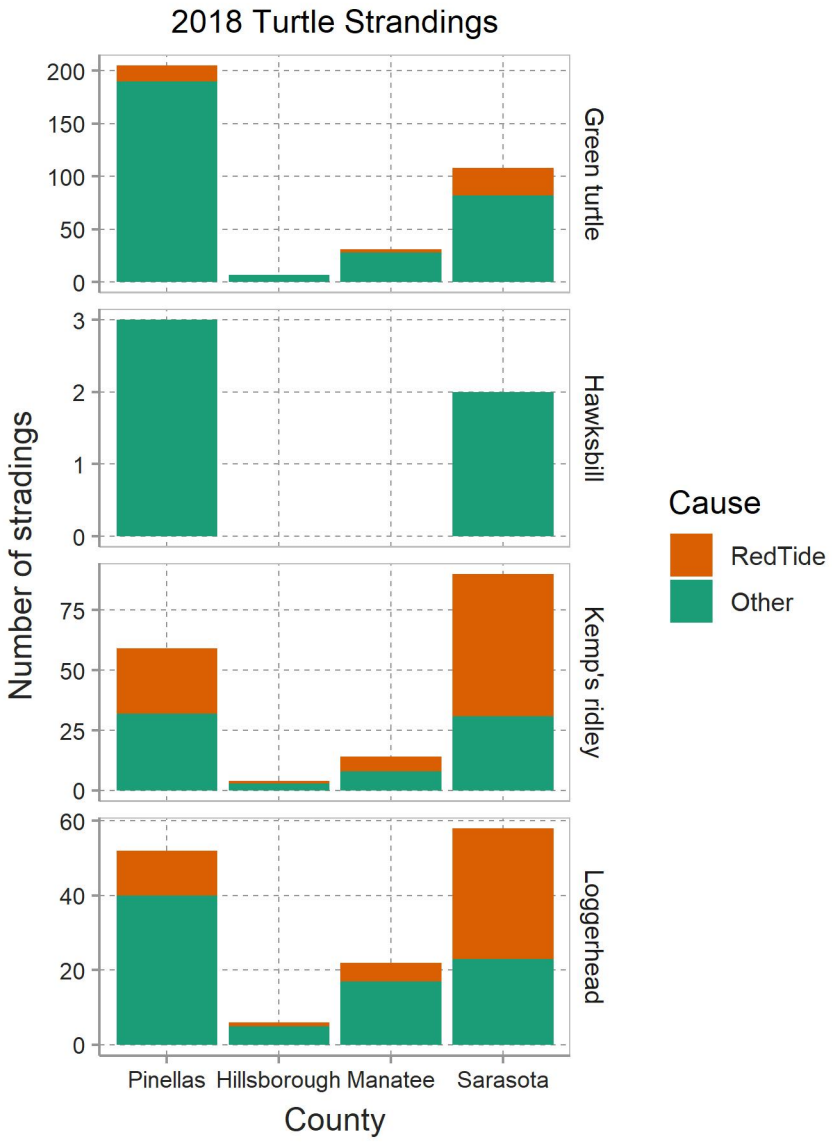
# Dolphin and Whale Strandings
## All Causes

## 3.3 TURTLES

FWC tracks and responds to every reported incident via its Sea Turtle Stranding and Salvage Network Database. Across all of central and southwest Florida from Pasco County to Collier County, the death of 1258 sea turtles in a single year was unprecedented — more than three times the typical annual number from all causes combined. In the 5-county Tampa Bay region, there were 673 turtle standings in 2018, and 190 were caused by red tide, with 120 (63%) in Sarasota County waters and 54 (28%) in Pinellas County. In the Tampa Bay area, greater numbers of turtles died from causes other than red tide and most of those were in Pinellas County.

Kemp's ridley turtles and Loggerhead turtles had the highest red tide mortality with 93 and 53 deaths, respectively, and most in Sarasota County. Overall, only 12% of green turtles died of red tide compared to 56% of Kemp's ridley and 38% of Loggerheads. No Hawksbill turtle deaths were reported as red tide strandings.



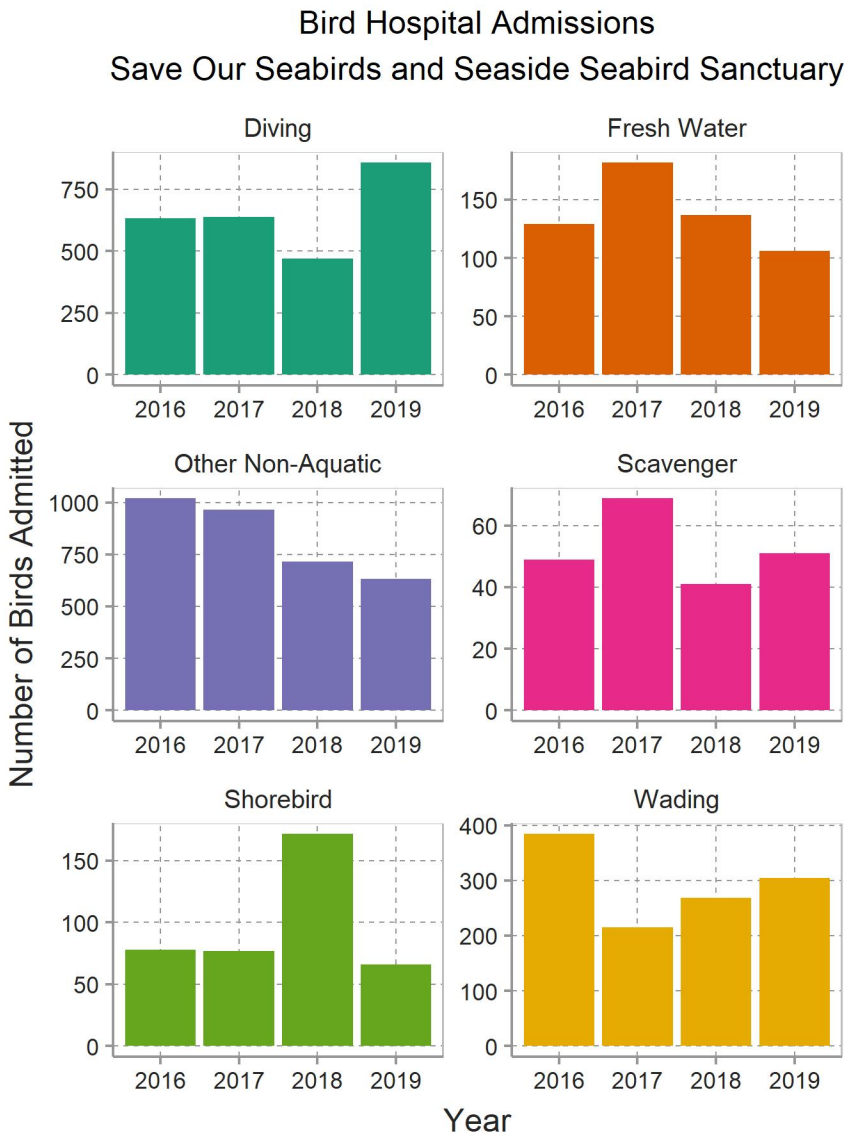



## 3.4 BIRDS

Save Our Seabirds (SOS) in Sarasota County and Seaside Seabird Sanctuary (SSS) and Birds In Helping Hands in Pinellas County are the primary intake hospitals for sick or injured birds in the region. These wildlife facilities are permitted by the State of Florida and the US Fish and Wildlife Service, which require annual reporting.

Red tide produces neurotoxins hazardous to seabirds and a variety of other marine associated birds, including diving birds, wading birds, shorebirds, and scavengers, whose habitat and prey become contaminated. The peak of the 2018 red tide event coincided with the end of the shorebird nesting season and interfered with fledgling development. The arrival of shorebirds migrating from the Arctic to South America also peaked with red tide, putting threatened bird species like the Red Knot further at risk.

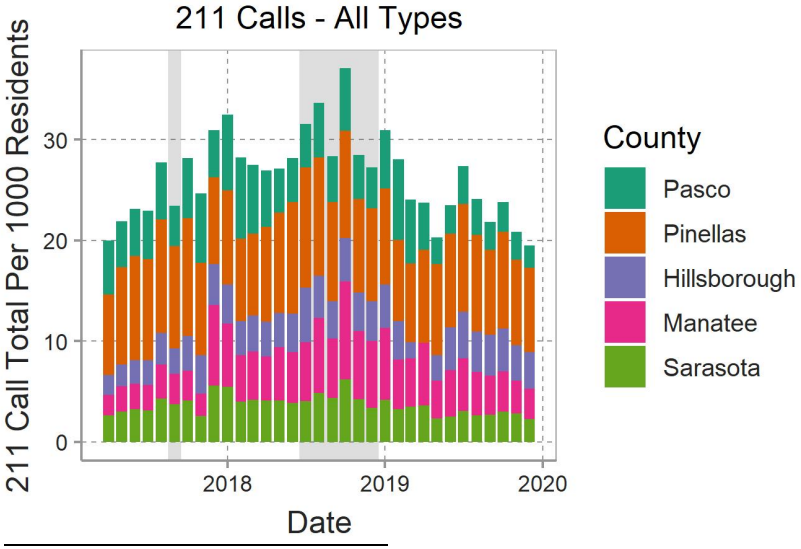
Altogether, the three hospitals admitted 1591 marine associated birds in 2018; based on red tide debris cleanup reports, the vast majority of sick birds never made it to the hospital. Bird hospitals reported unprecedented numbers of Red Knots (90), Sanderlings (76), Ruddy Turnstones (43), and Royal Terns (26). Diving birds such as the Double-crested cormorant (229) and wading birds such as the Black Crowned Night Heron (134) were also reported in high numbers. At SOS and SSS with multiple years of data available, the admission rate of shorebirds in 2018 was 300% above normal. During the peak of red tide conditions in August–September 2018, Save Our Seabirds saw hospital admissions increase 100% with record numbers of sick shorebirds — 42 birds admitted on one day alone.

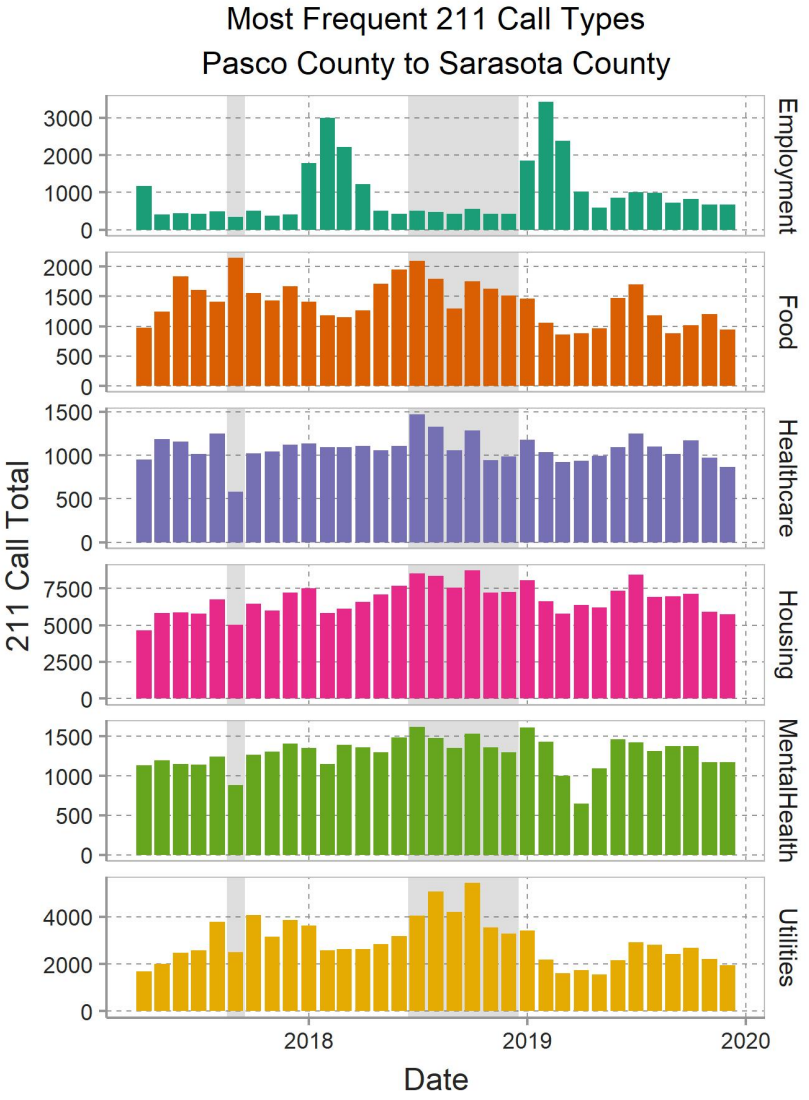


# 4 COMMUNITY

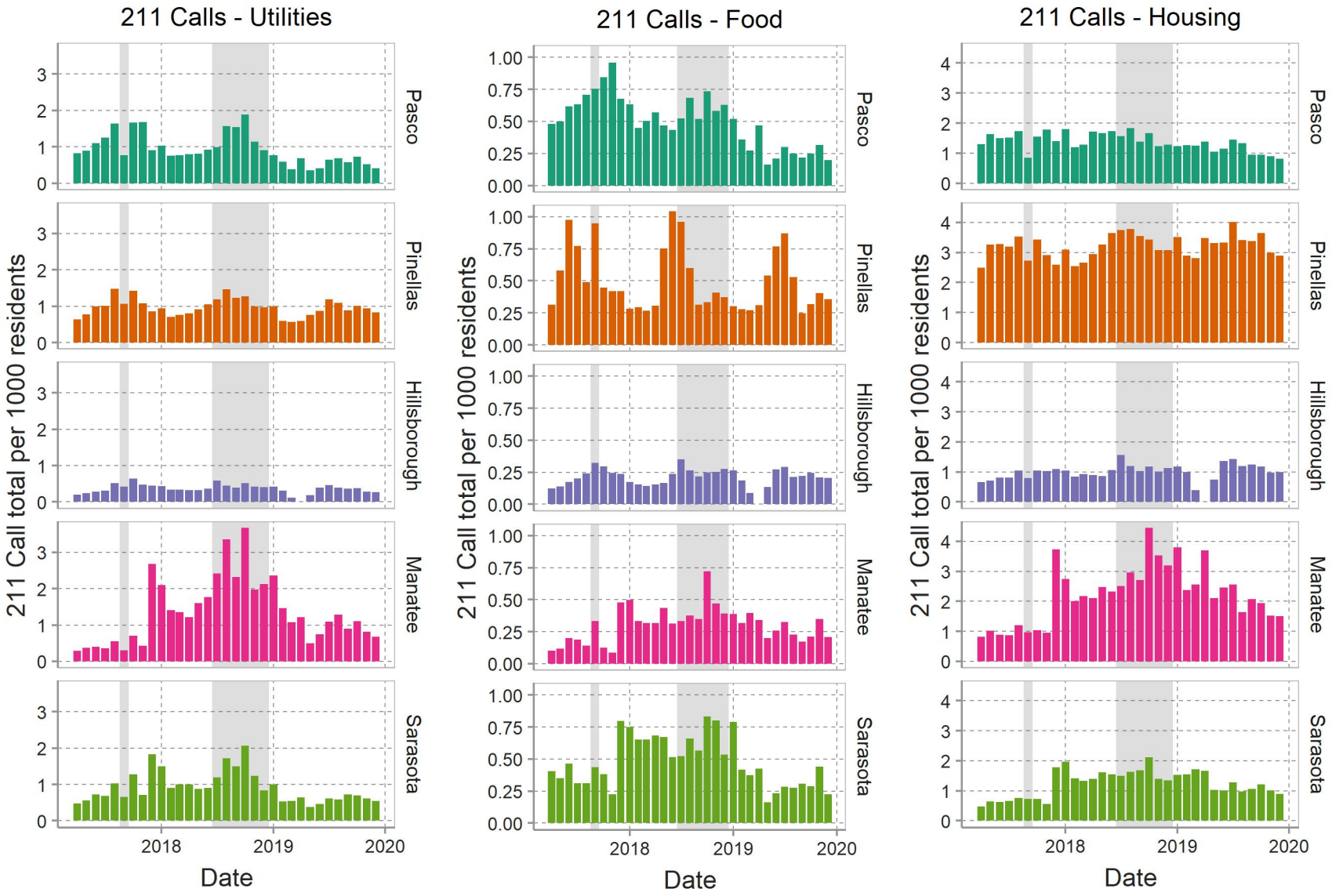
## 4.1 211 CALLS

Call activity to regional community assistance 211 hotlines is reported on web-dashboards. Total call volume reached a 3-year peak during the peak of the red tide event with 37 calls logged per 1000 residents in October 2018. September 2018 call totals exceeded those following Hurricane Irma in September 2017[8]. Requests for assistance with food, healthcare, housing, and utilities exceeded typical seasonal peaks. Calls for employment assistance were not unusually high during the red tide period. On a per capita basis, Manatee County had the highest call volume for utilities and housing requests. Sarasota County and Manatee County saw a 50% increase in calls for food assistance September–October 2018.



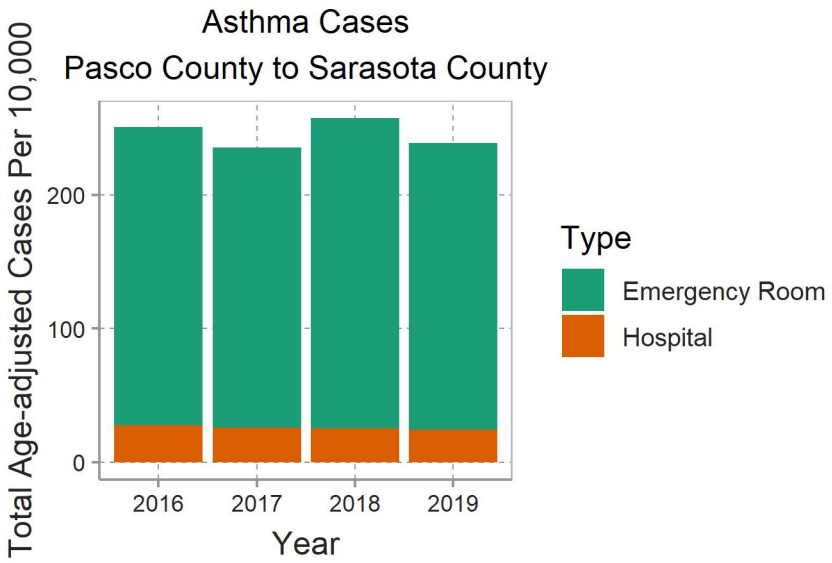



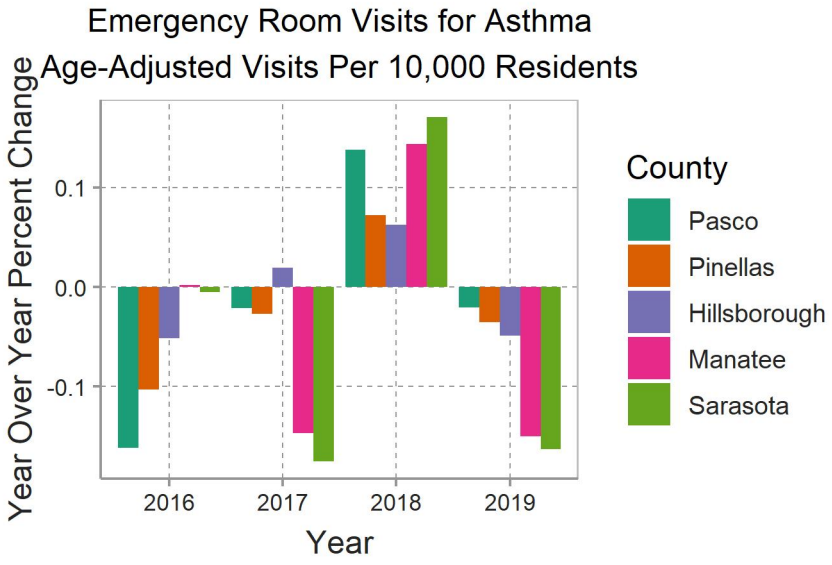

[8] Shaded areas in plots coincide with Hurricane Irma in September 2017 and peak red tide July–December 2018.


211 Calls - Utilities
211 Calls - Food
211 Calls - Housing
211 Call total per 1000 residents
Pasco
Pinellas
Hillsborough
Manatee
Sarasota
2018
2019
2020
Date

## 4.2 ASTHMA

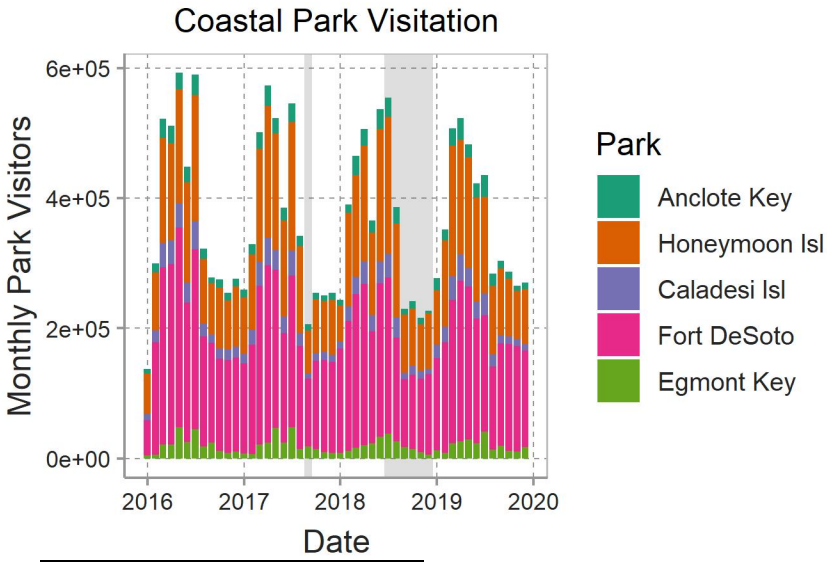
When aerosolized in sea spray, the red tide toxins, especially brevetoxins, are a respiratory irritant to humans and other mammals. Exposure results in eye, nose, throat, and lung irritation. People with asthma are particularly susceptible. Based on Florida Department of Health records adjusted for age and population, asthma cases were up in 2018. Emergency room visits for asthma were elevated, but no trend was observed for more severe asthma related hospital admissions. Compared to 2017, emergency room visits for asthma increased 6–17% in 2018 across the five counties in the region, with the largest year over year increase in Sarasota County.

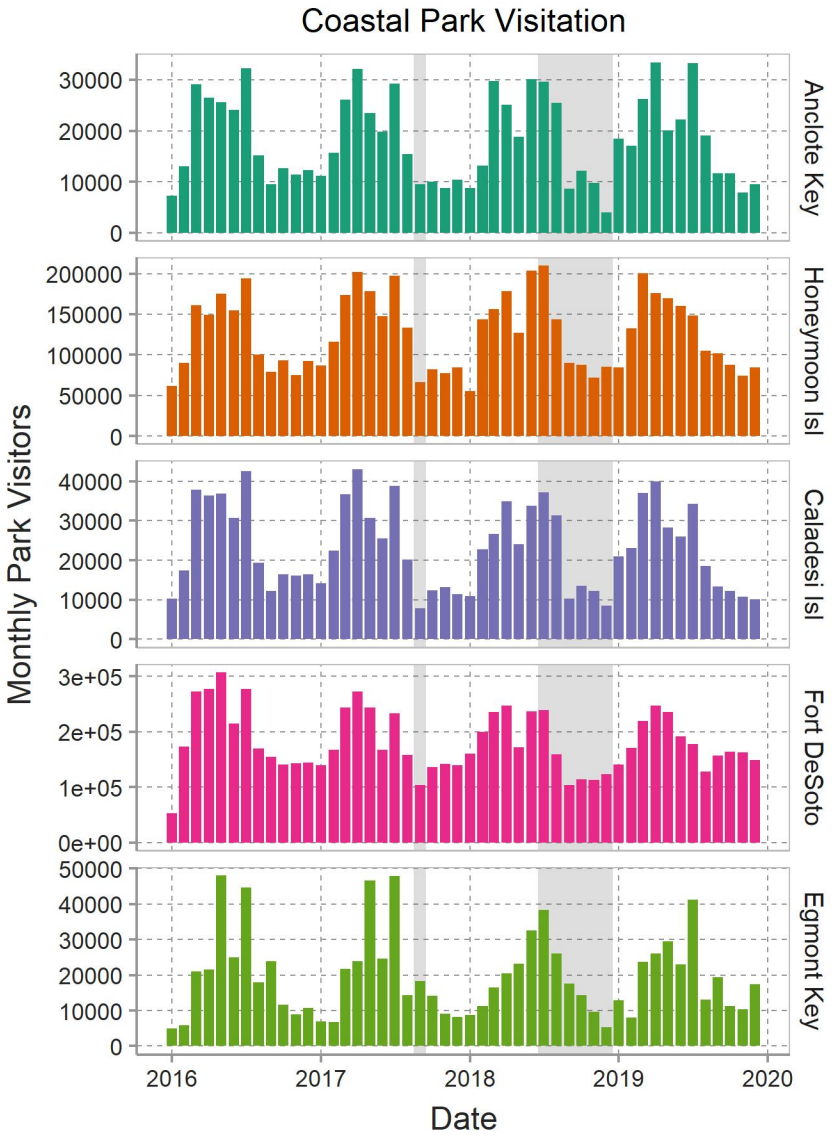


## 4.3 Coastal Parks Visitors

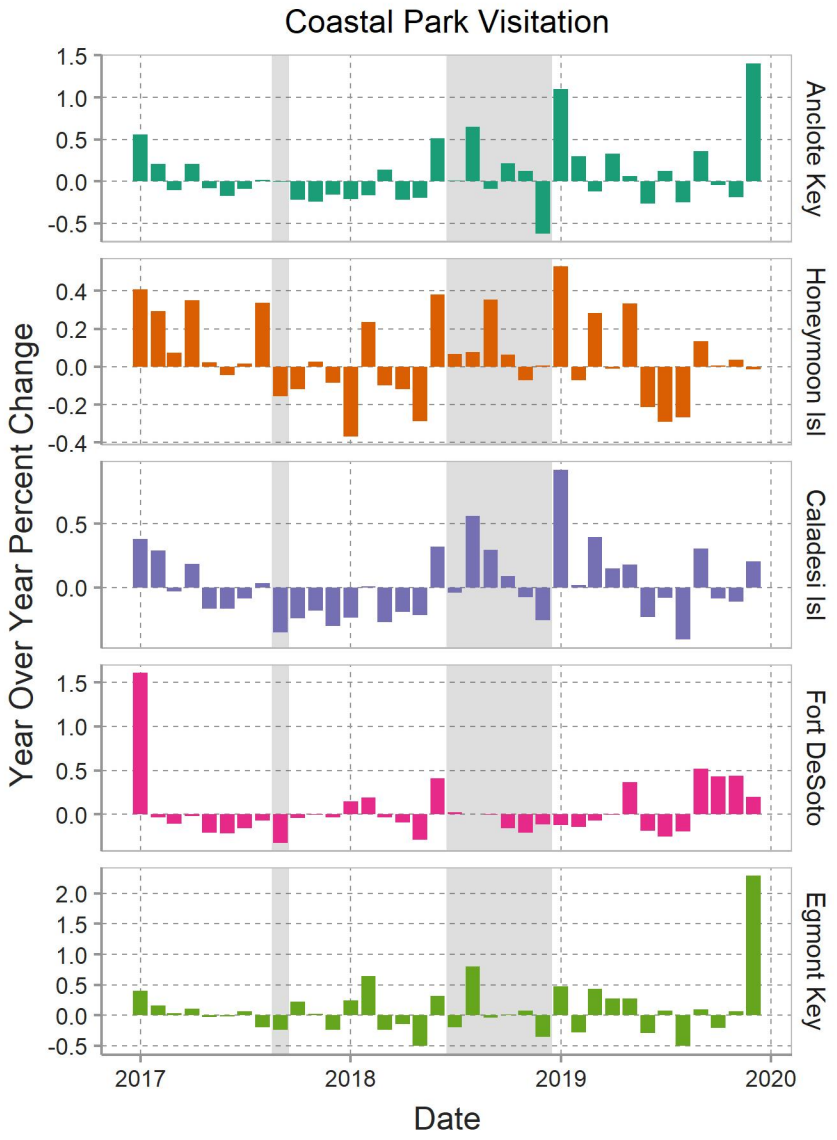
The Tampa Bay area's island parks are popular recreational destinations for residents and tourists. Florida State Parks and Pinellas County (for Fort DeSoto Park) tally daily visitors and campground reservations. Altogether, they receive hundreds of thousands of visitors every month. Visitation peaks seasonally March through July and dips in the late summer and fall. During the most severe period of red tide for Tampa Bay and Pinellas County's coastal waters (September–November 2018)[9], the total count of visitors at Fort DeSoto Park was down 23.8% compared to the 2016–2019 average for those months. For the same period, Caladesi Island visitation was down 6%, while visitor numbers for the other parks were essentially unchanged. Camping reservations at Fort DeSoto Park were also down 38.7% from September 2017 to September 2018.



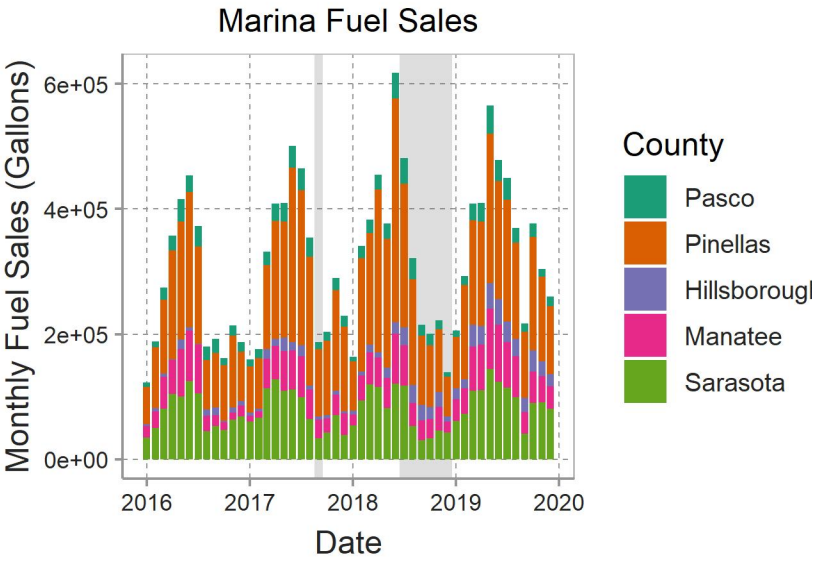

[9] Shaded areas in plots coincide with Hurricane Irma in September 2017 and peak red tide July–December 2018.

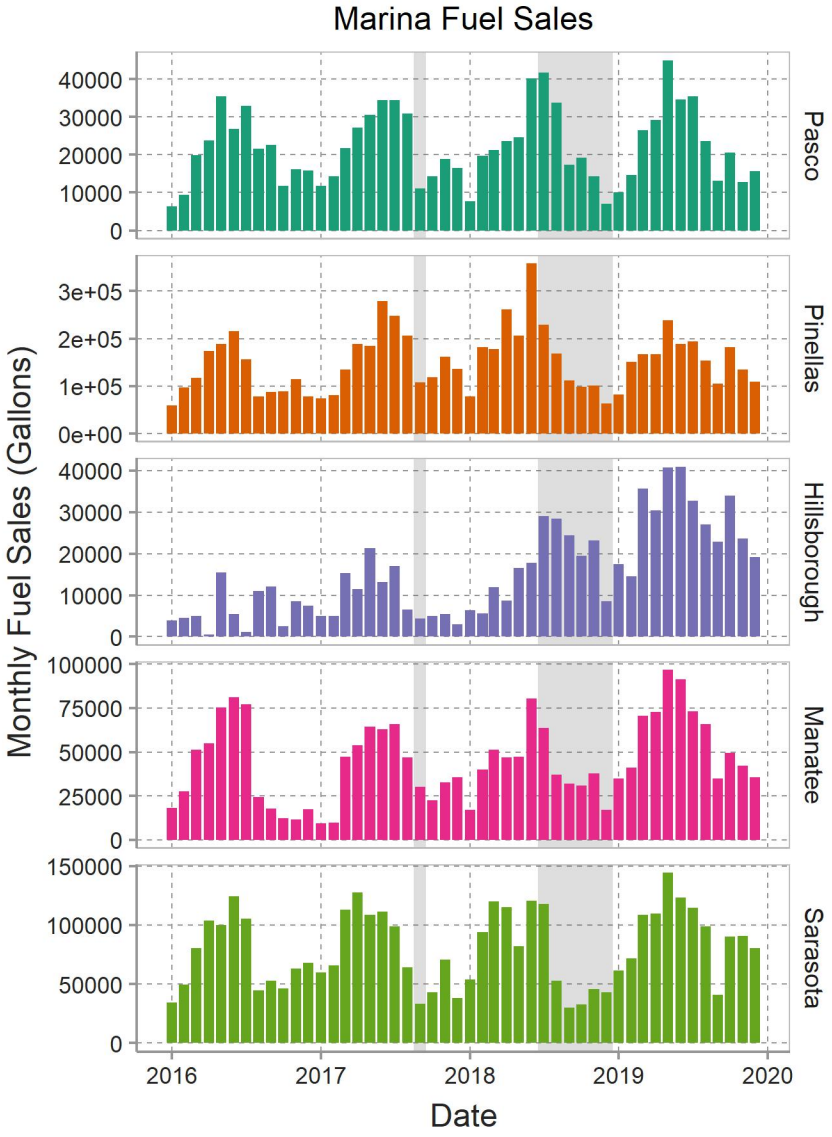
Visitation across all parks was down in the fall of 2017 likely due to Hurricane Irma, but Fort DeSoto Park received even fewer visitors in the fall of 2018 during the red tide event.



## 4.4 Boating

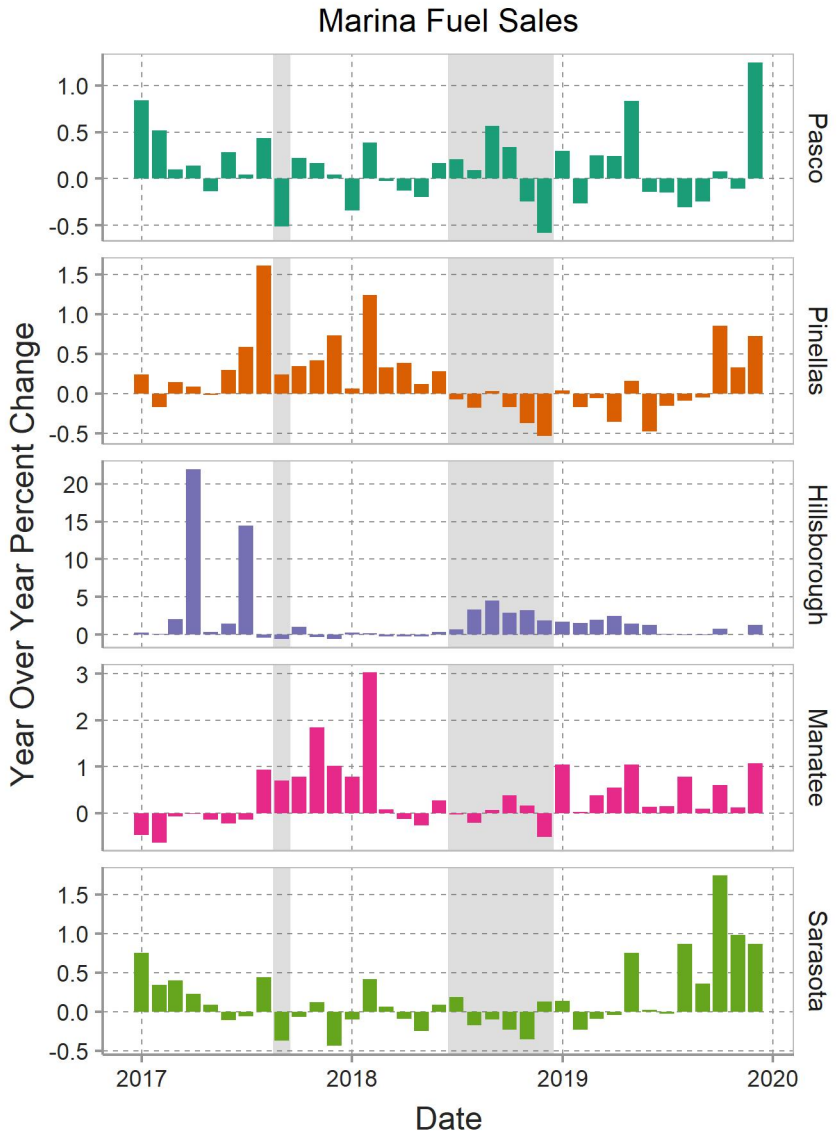
All fuel storage and service facilities report gallons sold to the Florida Department of Revenue monthly for tax purposes. Volume (gallons) of recreational fuel (non-ethanol) sold from waterfront marina locations was used as a proxy measure for boating activity, including all types of motorized recreational and commercial vessels fueling at coastal or waterfront fueling facilities. Recreational fuel sales follow a seasonal pattern similar to coastal park visitation (see 4.3 Coastal Park Visitors). Boat fuel sales peak seasonally in spring and early summer and dip in the late summer and fall. In addition to the seasonal trend, sales generally are increasing year over year, especially in Hillsborough County. Boat fuel sales were lower across the region in September 2017 during Hurricane Irma compared to September 2018 during red tide[10], except in Sarasota County.




[10] Shaded areas in plots coincide with Hurricane Irma in September 2017 and peak red tide July–December 2018.

During the most extreme conditions of the red tide event from August to November 2018, year over year boat fuel sales were down 7% across the region, led by a 24% drop in Sarasota County, and a 19% drop in Pinellas County. Meanwhile, Pasco saw boat fuel sales rise by 40% in September–October compared to that period in 2017, also reflecting a rise in tourism (see 5.2 Bed Tax).

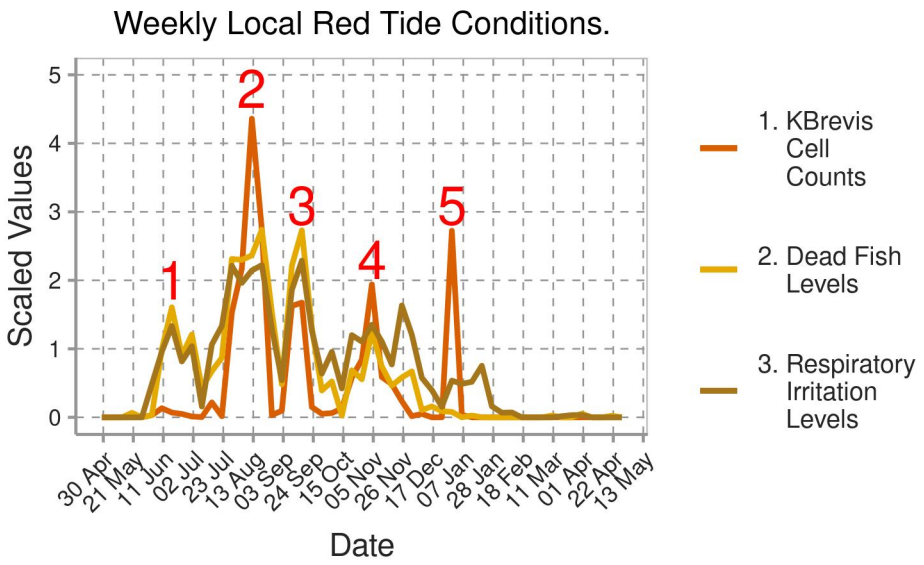


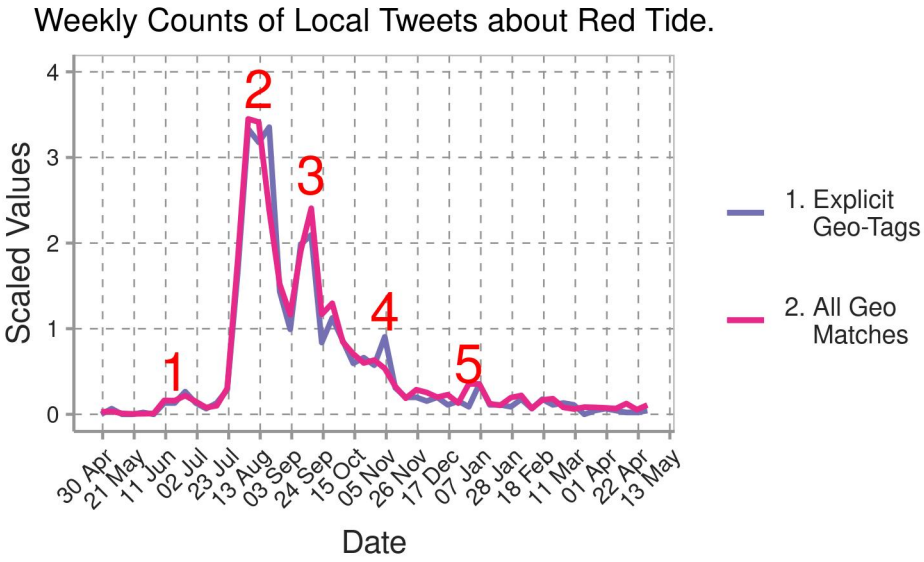
## 4.5 TWITTER ACTIVITY AND SENTIMENT

This was the first major red tide event since the ubiquitous use of social media. Twitter data were used to evaluate social awareness of red tide impacts and how they correlated with measured *K. brevis* cell counts, as well as dead fish and respiratory irritation measured at local beaches by Mote Marine Laboratory's Beach Conditions Reporting System (see 1.2 Beaches). Localized per capita Tweet counts containing the key word "red tide" were strongly correlated with local red tide conditions over multiple temporal (weekly, daily) and spatial (county, city, zip code area) scales. For example, correlation coefficients for red tide conditions versus County-level explicitly geo-tagged tweets were 0.80 for weekly and 0.64 for daily tweets[11].

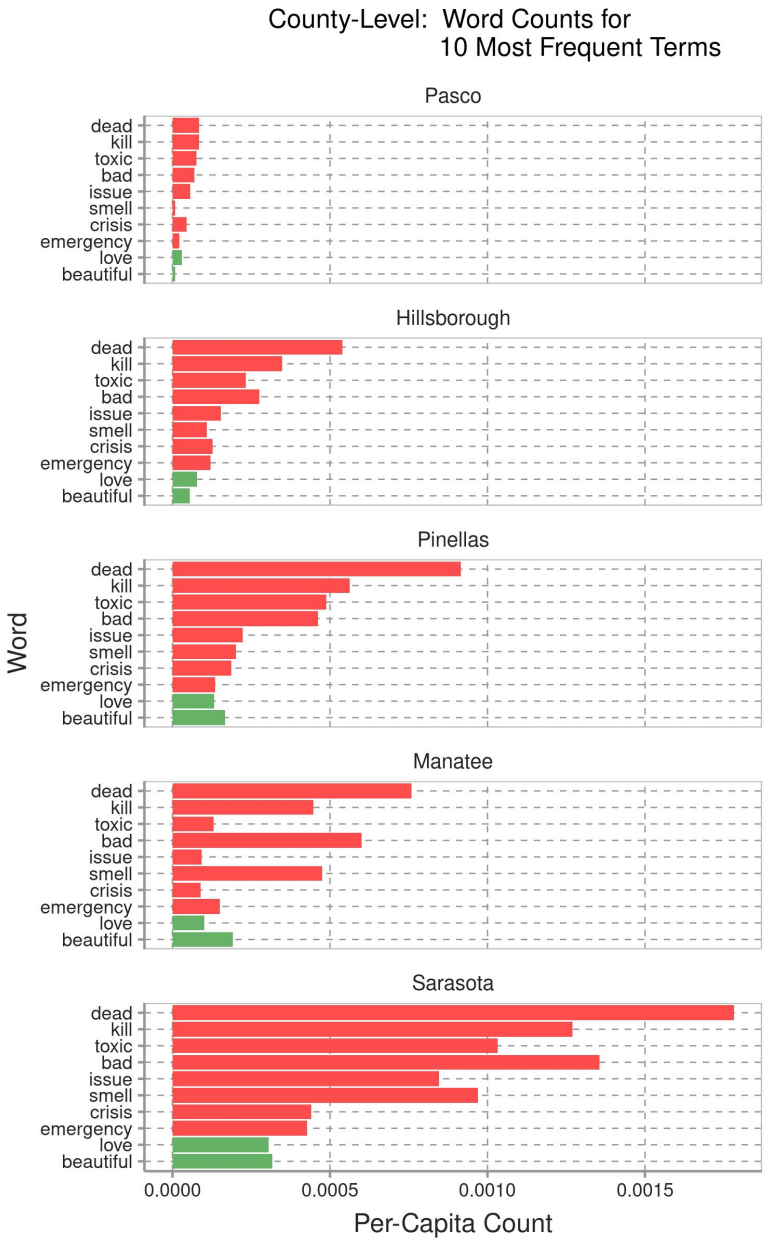
Tweet content was further studied with sentiment analysis to quantify the emotion expressed within the text. A specialized red tide lexicon was developed to evaluate the body of tweets containing the keyword "red tide" for positive or negative terms. The frequency of positive and negative sentiment of the tweets was also a highly reliable indicator of red tide conditions.

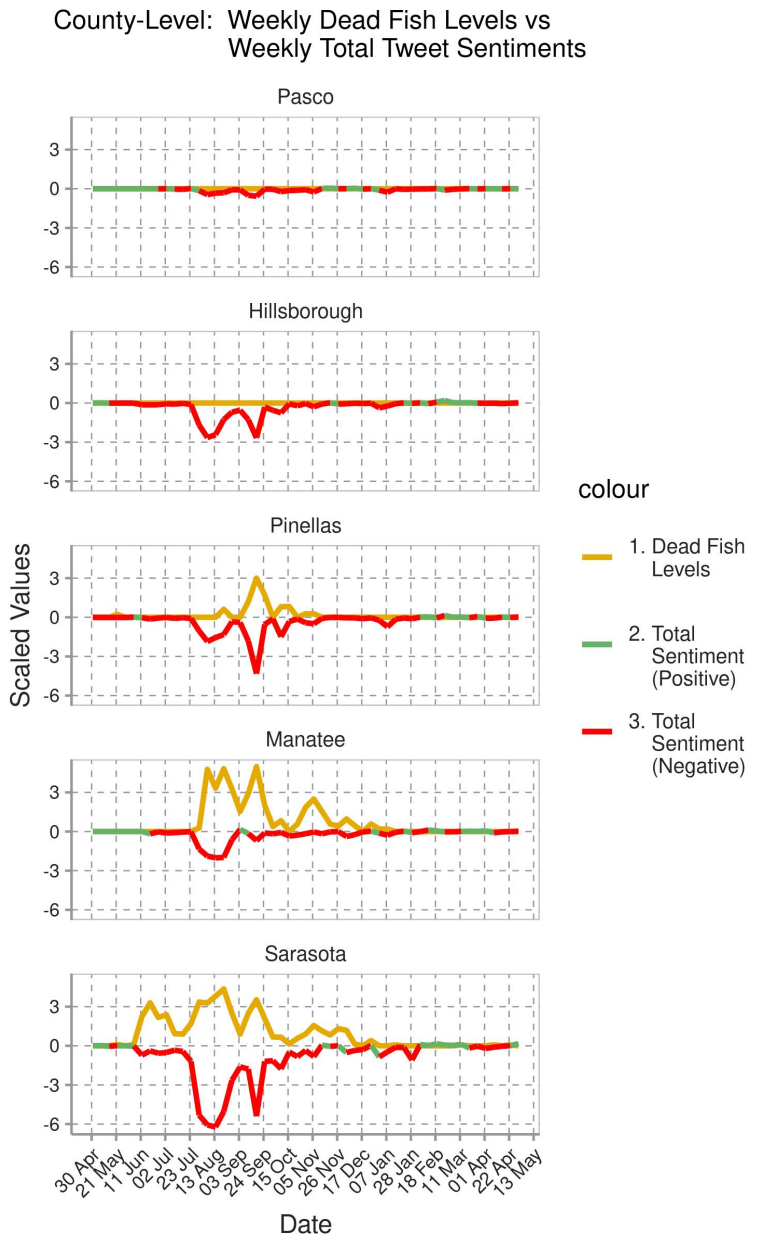
To evaluate what types of red tide impacts were of most concern, the top-1000 words used across all tweets were categorized as relating unambiguously to environment (*e.g.*, beaches, fish, water, climate, pollution), health (*e.g.*, odor, toxic, sick, harmful), or economy (*e.g.*, business, tourism, restaurant, budget). Environment was the top concern with 69% of words, followed by health (22%) and economy (9%).




[11] Skripnikov, et al. (2020) "Using Localized Twitter Activity for Red Tide Impact Assessment." 51 pp. [Manuscript submitted for publication.]

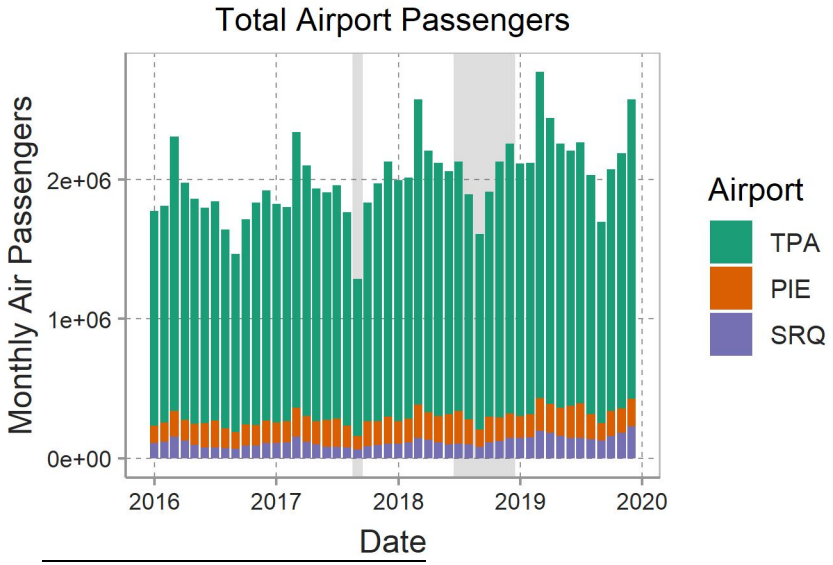

County-Level: Word Counts for
10 Most Frequent Terms
Pasco
Hillsborough
Pinellas
Manatee
Sarasota
dead
kill
toxic
bad
issue
smell
crisis
emergency
love
beautiful
Word
0.0000
0.0005
0.0010
0.0015
Per-Capita Count

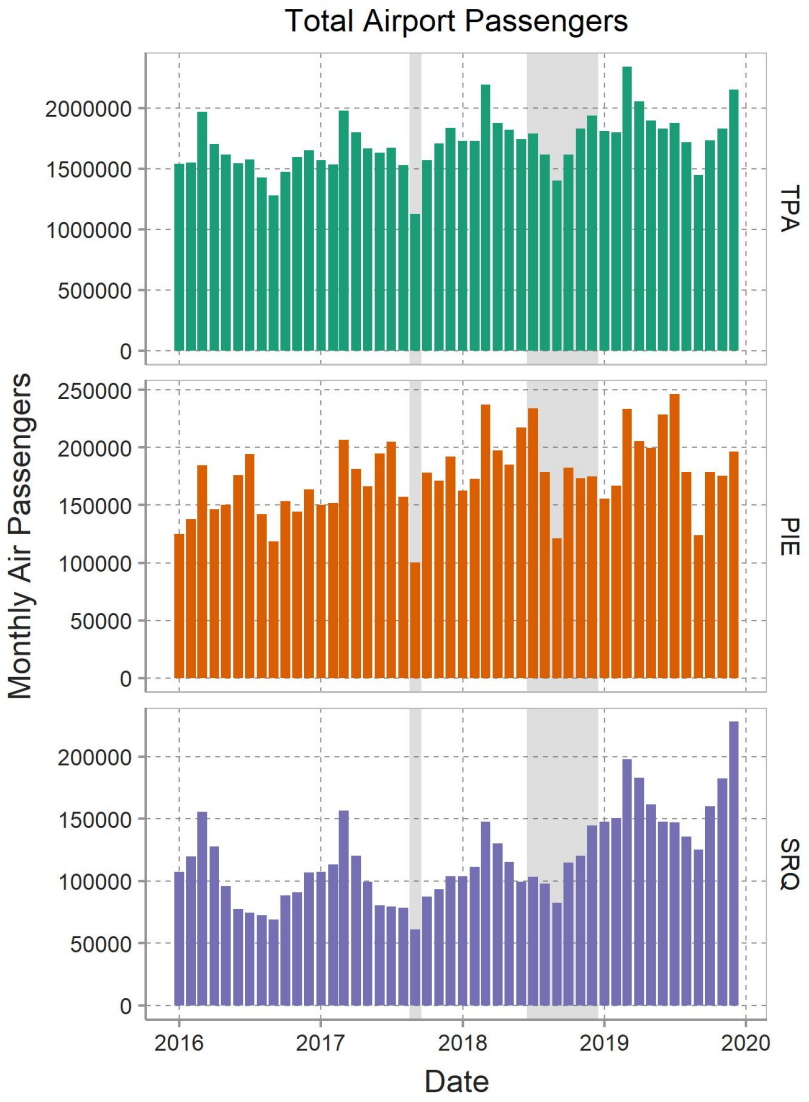

County-Level: Weekly Dead Fish Levels vs
Weekly Total Tweet Sentiments
Pasco
Hillsborough
Pinellas
Manatee
Sarasota
Scaled Values
3
0
-3
-6
30 Apr
21 May
11 Jun
02 Jul
23 Jul
13 Aug
03 Sep
24 Sep
15 Oct
05 Nov
26 Nov
17 Dec
07 Jan
28 Jan
18 Feb
11 Mar
01 Apr
22 Apr
13 May
Date
colour
1. Dead Fish Levels
2. Total Sentiment (Positive)
3. Total Sentiment (Negative)

# 5 ECONOMY

## 5.1 AIRPORT PASSENGERS

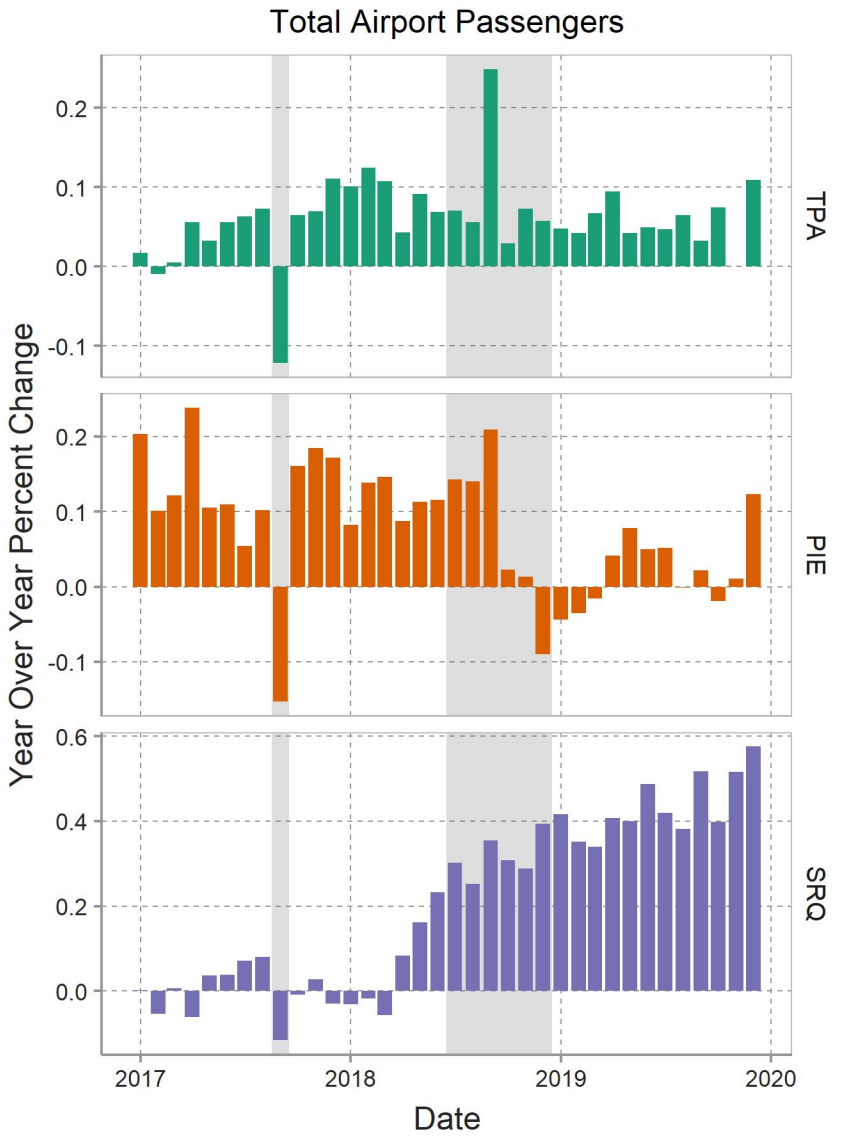
Three international airports serve the region, Tampa International (TPA), St. Pete-Clearwater International (PIE), and Sarasota-Bradenton International (SRQ). The total number of passengers arriving and departing are an indicator of tourism activity, one of the region's leading economic drivers. Air passenger traffic follows a seasonal pattern similar to recreation (see 2.3 Coastal Park Visitors and 2.4 Boating) with a strong peak in the spring and a low point in September. All airports showed year over year growth in traffic. Across all airports, total passenger count was higher in September 2018 during red tide than in September 2017, when airports were closed during Hurricane Irma[12].



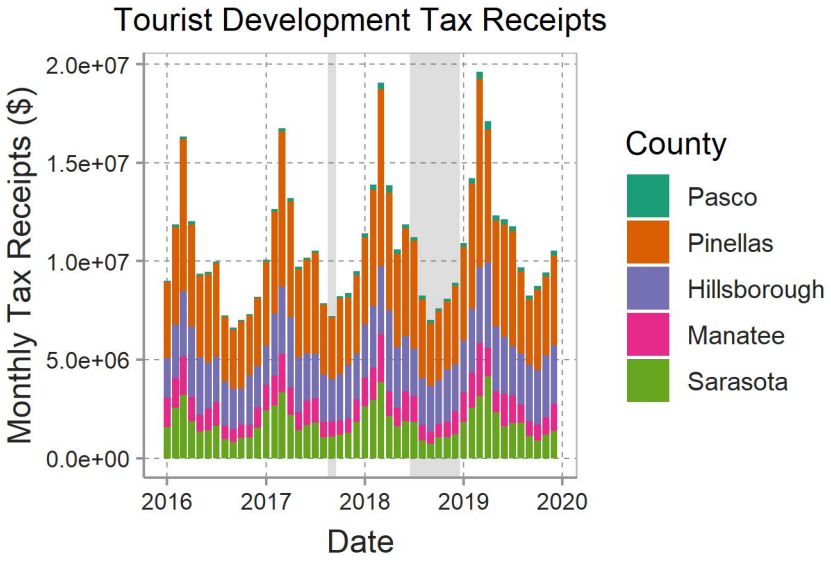

[12] Shaded areas in plots coincide with Hurricane Irma in September 2017 and peak red tide July–December 2018.

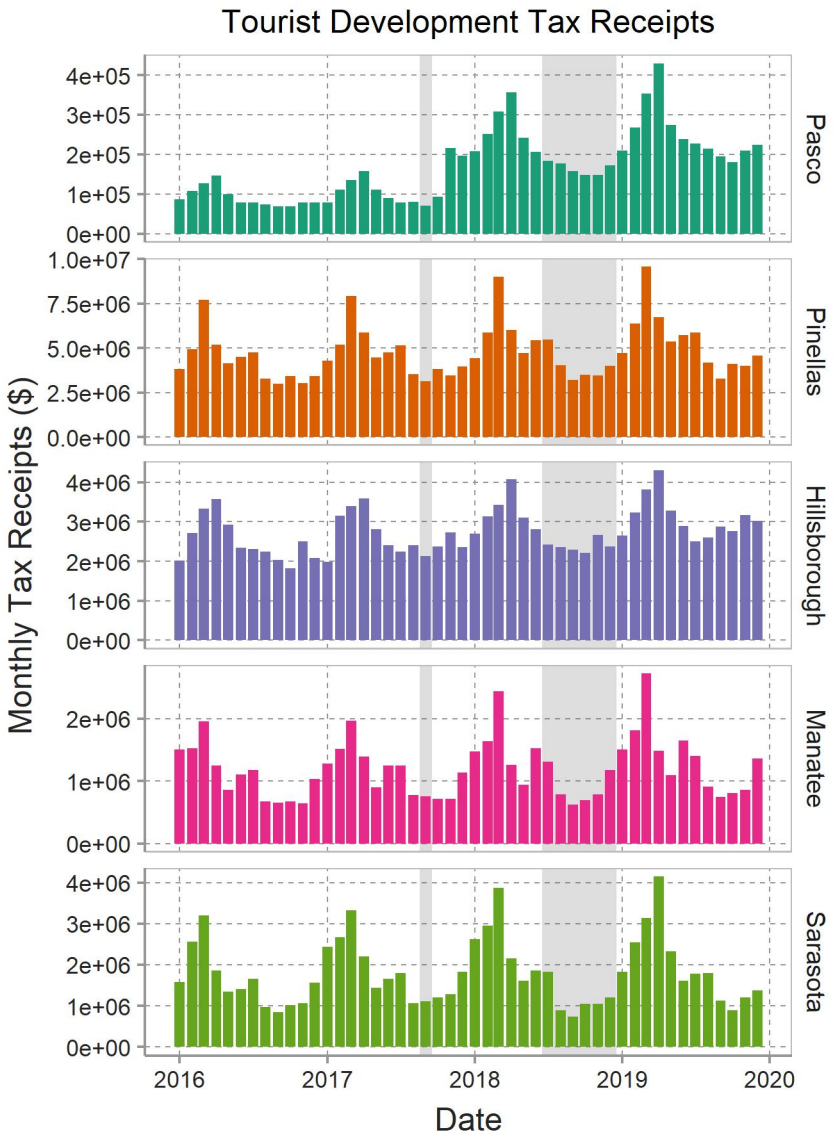
Year over year comparisons show growth during the red tide period, except for PIE which had a 2% dip in the fourth quarter of 2018. After depressed year over year passenger counts from September 2017 through March 2018, SRQ showed 32% growth from July to December 2018 during red tide conditions, part of a longer growth trend involving the addition of several new carriers to the airport.



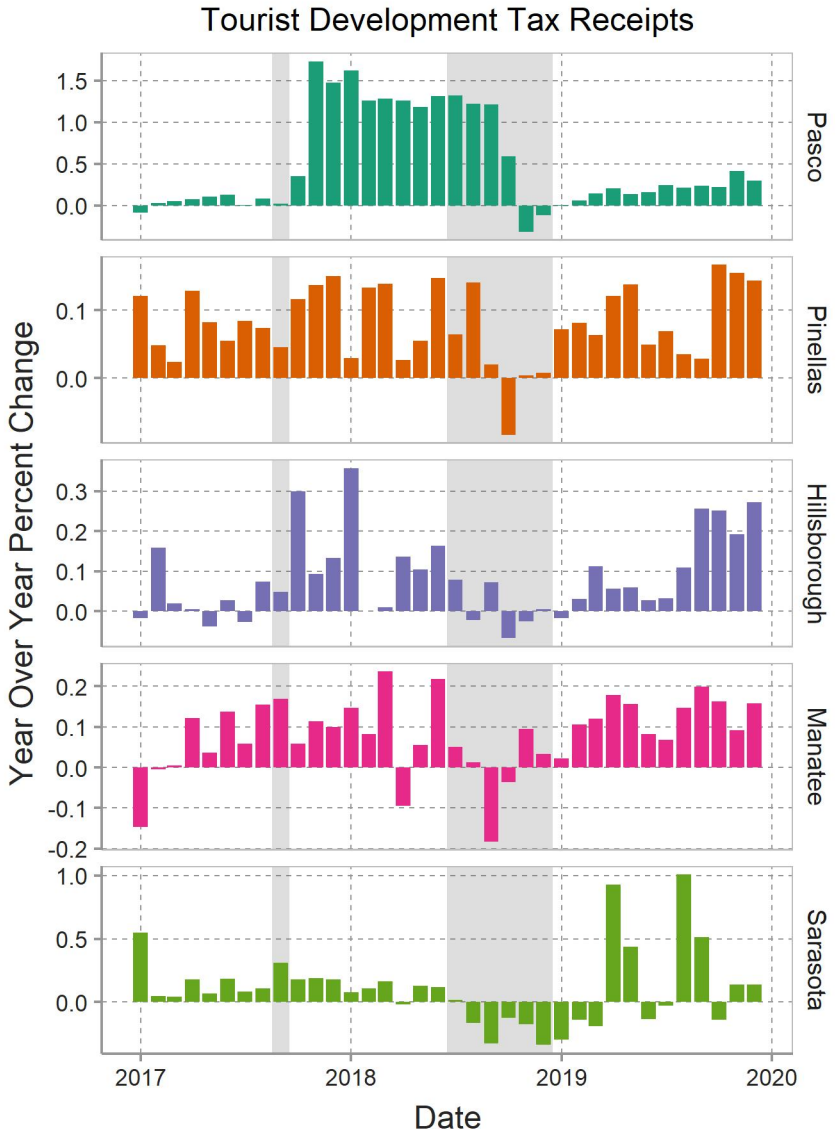
## 5.2 Bed Tax

Sales of accommodations are reported to the Florida Department of Revenue for tax purposes. The Tourism Development Tax (TDT) also known as the "Bed Tax" is a statewide tax administered by the counties on transient accommodations for periods less than 6-months, including hotel rooms and private rentals like Airbnb. It serves as a direct indicator of tourism activity through hotel occupancy. TDT collections are strongly seasonal with a peak in the spring and a low point in August and September (see also 5.1 Airport Passengers). All counties showed annual growth in total tax collected, except Sarasota County which saw a small (<1%) dip in 2018 compared to 2017. Pasco County's annual TDT collections jumped 80% from 2017 to 2018, coinciding with the launch of several new hotels and convention center and county approval to double its TDT rate.



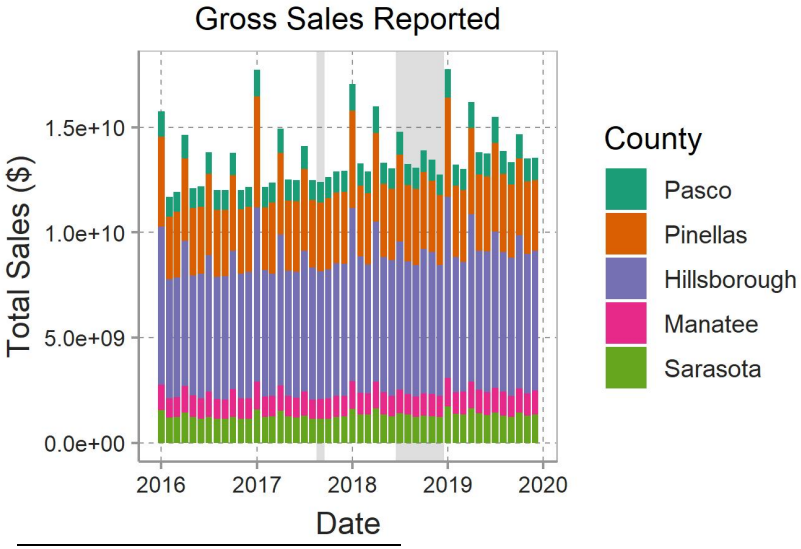
Year over year TDT collections in September 2017 were not affected by Hurricane Irma (likely because of storm refugees)[13]. However, during the red tide event July–December 2018, all counties experienced at least one month of year over year decline in TDT revenue with number of months and magnitude of decline correlated with severity of local red tide conditions. Sarasota County, which experienced the earliest, most prolonged, and most severe red tide conditions (see 1.1 Red Tide and 1.2 Beaches), saw year over year declines every month from August 2018 to March 2019 even after the red tide conditions cleared, with revenue down 22% for the period. Meanwhile, Manatee County saw a year over year decline of 11% in the period September–October 2018, while Pinellas County saw 10% increase in July–August, but an 8% decline in October.

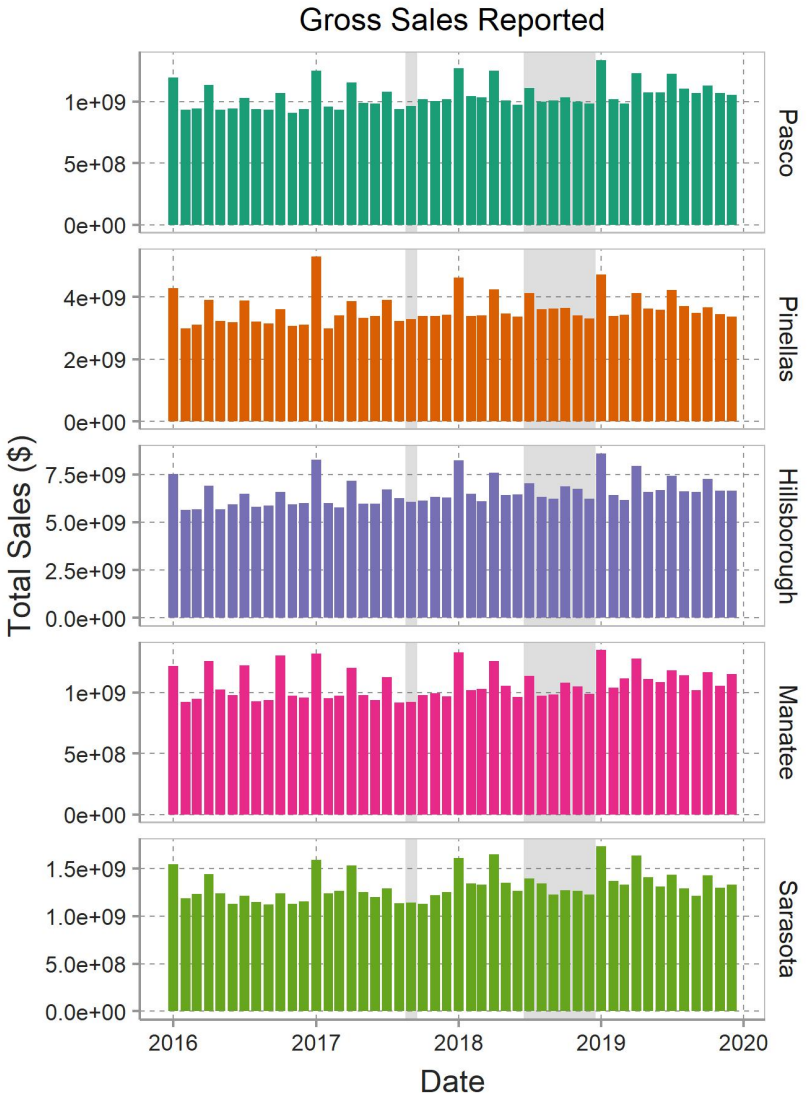



[13] Shaded areas in plots coincide with Hurricane Irma in September 2017 and peak red tide July–December 2018.

## 5.3 Gross Sales

Gross sales of all taxable goods and services is reported monthly to the Florida Department of Revenue for each county. Annual growth in revenue across the region was about 3–4% per year with no strong seasonal trends. Quarterly spikes in reported sales are due to quarterly or semi-annual reporting by small businesses. All counties experienced flat growth or slight declines in the second half of 2017 (Hurricane Irma), but not 2018 (red tide)[14]. The only notable decline in monthly gross sales in 2018 occurred in Manatee County in October when gross sales were down 17% compared to October of 2016 (but still higher than October 2017). More detailed econometric studies show county-level monthly red tide impacts mostly affected restaurants and accommodations[15] [16].



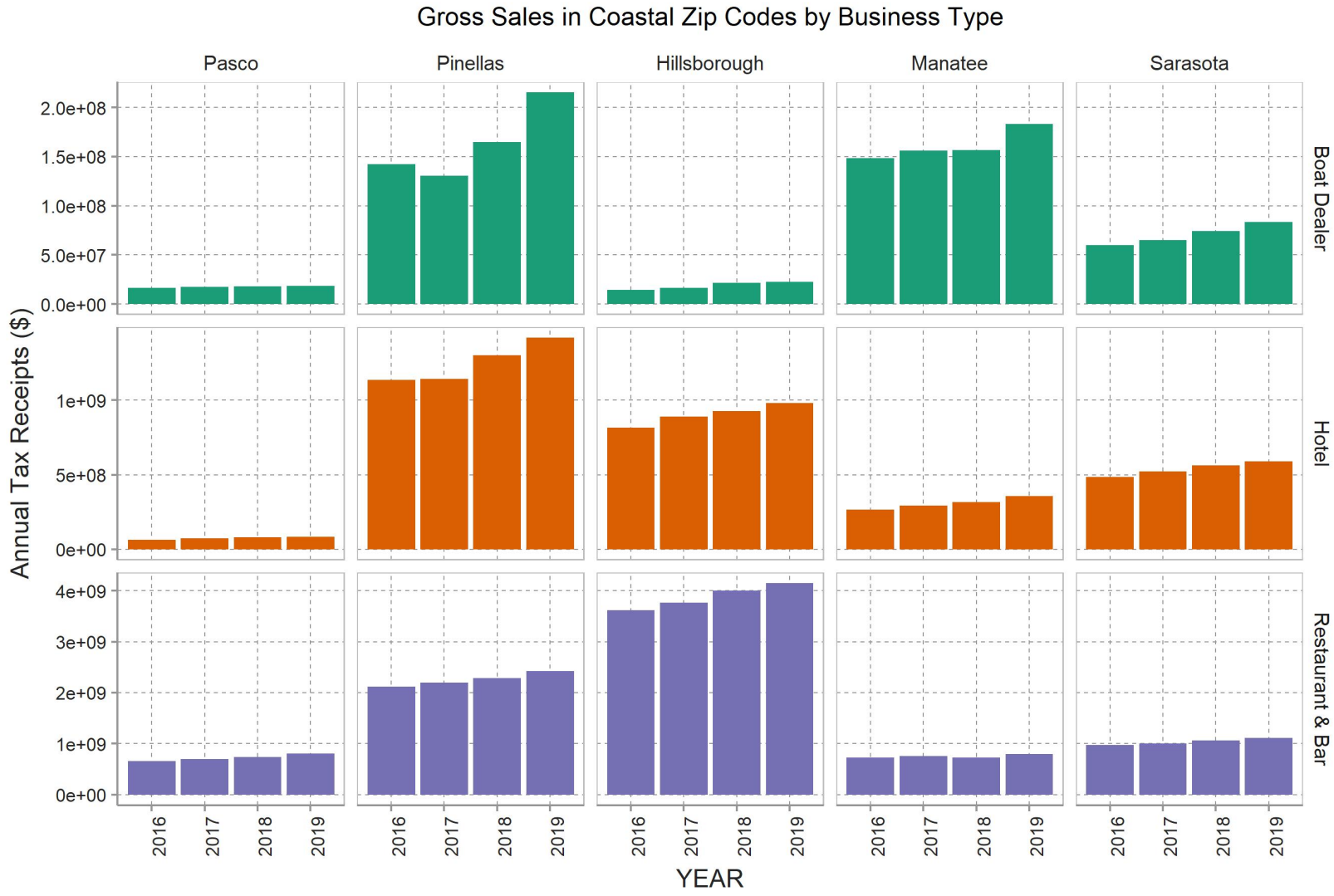




[14] Shaded areas in plots coincide with Hurricane Irma in September 2017 and peak red tide July–December 2018.

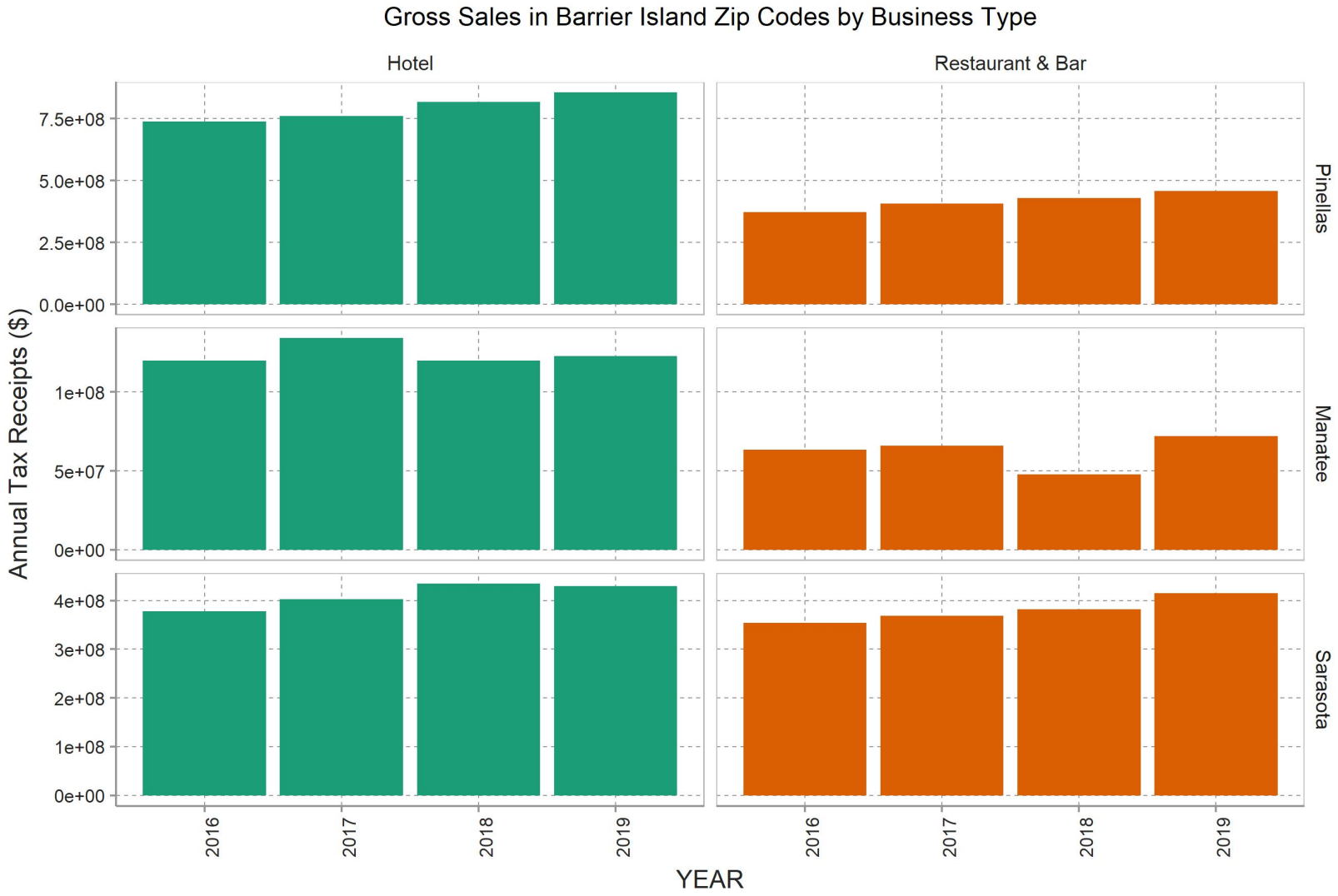
[15] Dechazo, R. 2018. The Economic Ripple Effects of Florida Red Tide. Report to the Tampa Bay Regional Planning Council. 3 pp.

[16] Bechard, A. 2019. Red tide at morning, tourists take warning? County-level economic effects of HABS on tourism dependent sectors. Harmful Algae, 85, 101689. https://doi.org/10.1016/j.hal.2019.101689

Zip code level sales data is only publicly reported on an annual basis. Annual gross sales for red tide vulnerable businesses in coastal zip codes showed no regional decline in 2018. Sales were off only in Manatee County, where restaurants sales were down 3% and boat sales were flat.



Analysis of annual gross sales trends for businesses on the barrier islands is limited in scope because a large portion of the data is masked for privacy due to the small number of businesses in those unique zip codes and business categories. Only Manatee County barrier island businesses experienced overall annual losses in gross revenue in 2018. Annual gross sales were down 27% for restaurants, 10% for hotels, and 4% across all (masked) restaurants, bars, hotels, and boat dealers.



# 6 DATA GAPS AND RESOURCES

## 6.1 RECOMMENDATIONS

The following recommendations are intended to help standardize monitoring and reporting and fill data gaps.

- Adopt standard procedures and training across the region for daily rapid beach conditions assessment, especially for qualitative indicators like smell and respiratory irritation and for estimation of volume of debris *in situ*, to ensure comparability (see Volume 2 Red Tide Response Assessment). Coordinate data collection and archiving with Mote's Beach Conditions Report System (BCRS). Increase number of locations, trained observers, and daily reporting of beach conditions especially in Pinellas County for upload to the BCRS.
- Continue improving technology and coordinating HABScope cell counts and NOAA wind forecasts to produce the HABScope-GCOOS Experimental Forecast and augment BCRS with respiratory irritation forecasts. Adopt standard procedures across the region for comparability. Recruit trained volunteers to assist.
- Open the Beach Conditions Reporting System database to web-based data queries.
- Develop standard procedures and training for open water surveillance and size estimation of dead fish patches. Adopt standard procedures across the region for comparability. Recruit civilian fishing guides, fishers, lifeguards, and licensed drone operators to assist (see Volume 2 Red Tide Response Assessment).
- Expand the existing Passive Acoustic Listening Station (PALS) network in Sarasota Bay as a near-real-time tool for monitoring ecological impacts and recovery from red tide events. Consider establishing a PALS network in Tampa Bay.
- Improve capabilities for defining with greater precision the spatial extent of red tides relative to where lethal effects are occurring and should be expected, especially in estuarine waters (simple cell counts do not accomplish this).
- Promote FWC's regional tracking and reporting mobile app (https://myfwc.com/news/all-news/sighting-app/) for more responsive public reporting of high importance red tide affected fish and wildlife and open the database to web-based data queries.
- Coordinate adoption of a standard online database for avian rescue and rehabilitation facilities that satisfies Federal Migratory Bird Treaty Act USFWS permit reporting requirements, eliminates paper records, and standardizes data collection.
- Prioritize staffing of data scientists and data system engineers at FWRI to upgrade to SQL web servers and allow open access to monitoring data. At a minimum, provide the option for download of data tables in CSV rather than PDF.
- Develop standard online business impact survey tools for deployment to waterfront and water-dependent businesses. Utilize Tourist Development Tax funds to hire laid off workers to canvas businesses and collect business survey data during major red tide events.

## 6.2 METADATA

| Topic | Monitoring parameter | Temporal resolution | Spatial resolution | Factor 1 | Factor 2 | File type | Data steward | Access | Contact | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| WATER & BEACHES | *Karenia brevis* cell counts | daily | lat / long | water salinity / temp | wind dir / speed | CSV and GIS | NOAA HABSOS, FWC | https://habsos.noaa.gov/ | public download Tide.Predictions@noaa.gov | Cell counts were spatially joined with the NOAA Respiratory Forecast Region boundary layer (tidesandcurrents.noaa.gov/hab/gomx.html) to segment samples in gulf and bay waters |
| WATER & BEACHES | beach conditions | daily | beach | dead fish | respiratory irritation | XLS | Mote Marine Laboratory | By request to Tracy Fanara | tfanara@mote.org | Dashboard: https://visitbeaches.org/ |
| FISH | fish kill reports | daily | county | cause | | CSV | FWC FWRI | https://public.myfwc.com/FWRI/FishKillReport/ | public download | Reports for red tide cause and all other causes generated and downloaded separately to disaggregate red tide. Combine datasets to analyze. |
| FISH | fish abundance in Sarasota Bay seagrass beds | monthly | Sarasota Bay | dolphin prey species | clupeids excluded | XLS | Chicago Zoological Society | By request to Randy Wells | rwells@mote.org | Sampling of dolphin prey species in seagrass beds of Sarasota Bay |
| FISH | fish abundance and diversity | annual | bay | species | gear type | CSV | FWC FWRI | By request to Tim MacDonald or Meagan Schrandt | tim.macdonald@myfwc.com | FWRI has an R work flow for preparing data for red tide updates for the Commission using QA/QC data and most recent unverified data |
| FISH | commercial fish landings | annual | county | pounds | value | XLS | FWC | https://myfwc.com/research/saltwater/fishstats/commercial-fisheries/landings-in-florida/ | public download | |
| WILDLIFE | manatee strandings | daily | lat / long | cause | | GIS and PDF | FWC FWRI | https://myfwc.com/research/manatee/rescue-mortality-response/statistics/mortality/red-tide/ | public download Andrea.Krzystan@MyFWC.com | By request to Andrea Krzystan for updated dbf GIS http://geodata.myfwc.com/datasets/manatee-carcass-recovery-locations-in-florida |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| WILDLIFE | dolphin and whale strandings | daily | lat / long | species | | XLS | NOAA SE US Marine Mammal Stranding Network | By request to Liz Stratton | elizabeth.stratton@noaa.gov | https://www.fisheries.noaa.gov/national/marine-life-distress/national-stranding-database-public-access |
| WILDLIFE | turtle strandings | weekly | county | species | | PDF and narrative | FWC FWRI | https://myfwc.com/research/wildlife/sea-turtles/mortality/archived-stranding-data/ | public download<br>Allen.Foley@MyFWC.com | By request to Allen Foley for red tide summaries by year and by species. Red Tide mortality is modeled on the percentage of a subset of turtles tested for brevetoxin that have concentrations that are believed to be lethal. Request updated dbf GIS<br>http://geodata.myfwc.com/datasets/sea-turtle-strandings-florida |
| WILDLIFE | bird hospitalizations | annual | region | species | | XLS and PDF | Save Our Seabirds<br><br>Seaside Sea Bird Sanctuary<br><br>Birds in Helping Hands | By request David Pilston (SOS)<br>By request Keith Wilkins (SSS)<br>By request Shelley Vickery (BHH) | dpilston@saveourseabirds.org<br>keith@seasideseabirdsanctuary.org<br>birdsinhelpinghands@gmail.com | Data received from Birds in Helping Hands were sparse and haphazard and could not be analyzed. These data are varied and unstructured and required considerable manual cleanup. Consider developing a common data base that also satisfies USFWS rehab permit reporting. Hospital admissions data by year and species were further coded into species guild by an experienced Audubon birder to distinguish species whose feeding or nesting behaviors exposed birds to red tide or not. |
| COMMUNITY | social services 211 calls | weekly | county | request type | | CSV | 211 Counts with custom webscraper tool | https://crisiscenter.211.counts.org<br>http://211tampabay.211cuonts.org<br>https://suncoast.211counts.org<br>https://unitedwaypasco.211counts.org | askripnikov@ncf.edu | R scripts for webscraper and CSV files at https://github.com/UsDAnDreS/Florida-Red-Tide-Event/tree/master/2-1-1 |
| COMMUNITY | asthma cases | annual | county | ER visit | hospitalization | XLS | FDOH | https://www.floridatracking.com/healthtracking/mapview.htm | public download | Effective October 1, 2015, hospital record data transitioned to a new coding system. |
| COMMUNITY | park visitors | monthly | park | | | XLS and PDF | FDEP Florida State Parks<br>Pinellas County | By request to Joe Novetzke<br>By request to Robert Browning | Joseph.Novetzke@floridadep.gov<br>rbrowning@pinellascounty.org | |

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| COMMUNITY | recreational fuel sales | monthly | lat / long | facility type | | XLS | FDOR | By request to Lee Gonzalez | Edward.Lee.Gonzalez@floridarevenue.com | Ethanol-free fuel is product code 065. Point of Destination was joined to DOR Petroleum Product Facilities to get station location |
| COMMUNITY | Twitter activity | daily | geotag | | | CSV | Twitter with Full Archive Premium Subscription | https://github.com/tbep-tech/red-tide-twitter | askripnikov@ncf.edu | Skripnikov, et al. (2020) “Using Localized Twitter Activity for Red Tide Impact Assessment.” 51 pp. [Manuscript submitted for publication.] |
| ECONOMY | airport passengers | monthly | airport | arrivals | departures | XLS and PDF | Sarasota-Bradenton International airport<br><br>St.Pete-Clearwater International airport<br><br>Tampa International airport | https://srq-airport.com/airport-statistics<br><br>http://www.tampaairport.com/airline-activity-report-and-financial-archives<br><br>https://www.fly2pie.com/news-media/passenger-statistics-reports | donald.farr@srq-airport.com<br>msavas@fly2pie.com<br>statistics@tampaairport.com | |
| ECONOMY | tourist development tax receipts | monthly | county | | | XLS | FDOR | https://floridarevenue.com/taxes/pages/colls_from_7_2003.aspx | public access | Form 3 located on the third tab of DOR page "Local Tax Receipts" |
| ECONOMY | gross sales of taxable goods and services | monthly | county | | | XLS | FDOR | https://floridarevenue.com/taxes/pages/colls_from_7_2003.aspx | public access | Form 9 located on first tab of DOR page "Florida Sales Tax Receipts" |
| ECONOMY | gross sales of coastal businesses | annual | zip code | business type | | XLS | FDOR | By request to Bob McKee | Bob.McKee@floridarevenue.com | monthly by zip not available; some records aggregated to protect privacy |