CHOICES
The magazine of food, farm, and resource issues
A publication of AAEA Agricultural & Applied Economics Association
VOLUME 40 QUARTER 2

Adapting to the Tide: Behavioral Responses to Red Tide along Florida's Gulf Coast

Ulrich Adegbola, Abhishek Rajan, Olesya M. Savchenko, Christa Court*

JEL Classifications: Q53, Q26
Keywords: Harmful algal blooms, Red tide, Risk-avoidance behaviors

Harmful algal blooms (HABs), caused by excessive growth of harmful algae, affect most coastal regions worldwide (Chapra et al., 2017). Although algae are a natural part of aquatic ecosystems, HABs can result in negative environmental, health, and economic consequences. For example, they can deplete oxygen levels in the water, making it uninhabitable for marine life; contaminate seafood; pose significant risks to human health; and disrupt local economies (Larkin and Adams, 2007; Hallegraeff, 2003). Over the past two decades, experts have increasingly linked the intensification of HABs to human-induced factors (Anderson, 2014), including climate change and increased nutrient runoff (Brand and Compton, 2007; Lapointe and Bedford, 2007; Vargo et al., 2008; Paerl and Scott, 2010; Charette et al., 2013).

In the Gulf of Mexico, the HABs (commonly referred to as red tide) are caused by high concentrations of *Karenia brevis (K. brevis),* a microorganism that produces potent neurotoxins. The frequency and persistence of red tide along the border of the United States and in the Gulf of Mexico has increased in recent years, leading to significant mortality among fish and marine species and disrupting tourism and recreation along hundreds of miles of shoreline (Kirkpatrick et al., 2004; Heil and Muni-Morgan, 2021). This presents challenges for states that border the Gulf of Mexico, like Florida, which is one of the most popular travel destinations globally, welcoming more than 143.9 million visitors in 2024 alone (Visit Florida, n.d.).

The economic losses caused by red tide vary based on the severity and duration of these events. Red tide leads to declines in tourism, closures of shellfish harvesting zones, reduction in housing values, and costly cleanup efforts to remove dead marine life from affected shorelines (Kirkpatrick et al., 2014; Bechard, 2019, 2020a,b,c, 2021). For example, the 2018 red tide event caused $317 million in lost sales revenues and nearly 3,000 job-years across Florida due to the shock to the Airbnb market (Ferreira et al., 2023). In addition, red tide can cause respiratory irritation and skin rashes that can negatively impact the experience of visiting coastal areas (Kirkpatrick et al., 2004).

In this article, we analyze data from a survey of 2,358 visitors from 15 states to Florida's Gulf Coast to understand individual perceptions and behaviors in response to red tide. We examine visitors' awareness of red tide and its impacts, risk prevention and avoidance behaviors, recreation preferences, and how the severity of red tide influences decisions to come back to the Gulf of Mexico for recreation in the future. Understanding these behavioral responses is important to inform policies aimed at minimizing human exposure and reducing related impacts.

What Draws Visitors to Florida's Gulf Coast?

Using an online survey administered through the Qualtrics platform, we collected responses from a random sample of 2,358 adults who visited Florida's Gulf Coast between 2017 and 2023 to engage in saltwater recreation or had planned a trip but canceled due to red tide. Respondents came from Florida and 14 other states that account for the largest share of tourists to Florida, including Georgia, Alabama, Tennessee, Louisiana, Texas, Maryland, Mississippi, Kentucky, Arkansas, Virginia, West Virginia, Oklahoma, South Carolina, and North Carolina (Visit Florida 2018, 2019, 2022). The sample broadly aligns with Florida's visitor demographics and includes both frequent and infrequent visitors as well as individuals who canceled trips due to red tide. However, our sample of Florida residents tends to be older (median age 52) and has a higher percentage of women (65%) compared to the general population, while out-of-state visitors skew slightly older and have a greater proportion of White respondents (78%) than the national average.

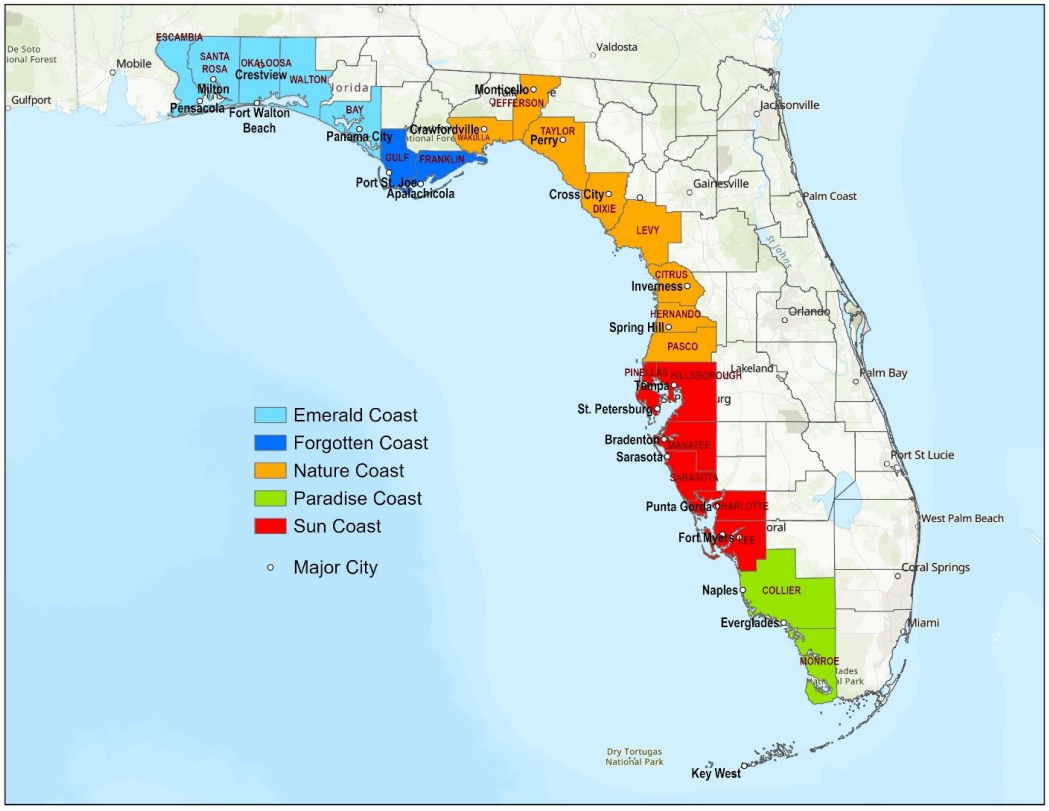
We asked survey respondents about their visitation history, awareness of and experience with red tide events, and how red tides impact their past and future travel decisions. We focused on five distinct coastal regions along Florida's Gulf Coast, depicted in Figure 1, each offering unique recreational opportunities.

The most popular destination among survey respondents was Florida's Sun Coast, a region known for its white-sand beaches and scenic coastline. This destination's appeal was particularly strong among Florida residents, 75% of whom reported visiting the Sun Coast, compared to only 47.5% of out-of-state visitors. Interestingly, this area typically experiences the most frequent and severe red tide events (Stumpf et al., 2022). The Nature Coast was also more popular among Florida residents, with 38.1% reporting visits compared to 26.3% of out-of-state visitors. The Emerald Coast was more popular among out-of-state visitors, with 59.2% reporting visits compared to only 33.8% of Florida residents. The Paradise Coast attracted similar proportions of residents (27%) and visitors (27.2%), offering a blend of natural beauty and tranquil environments. The Forgotten Coast received the fewest visitors overall, with just 17.2% of survey respondents reporting visits. Notably, out-of-state visitors (21%) were more likely to explore this region than Florida residents (14.8%).

Coastal characteristics can play a key role in individuals' decisions about which areas to visit for saltwater recreation. In Figure 2, we summarize the coastal attributes survey respondents consider important when planning trips to Florida's Gulf Coast. For all respondents, water quality and scenic beauty are the most important factors. More than 90% of Florida residents consider scenic beauty, water quality, and the absence of red tide as important when selecting a destination along Florida's Gulf Coast. These attributes are also highly valued by out-of-state visitors, with 90% and 88% rating scenic beauty and water quality, respectively, as important. In addition, 77% of out-of-state visitors considered the absence of red tide important. This finding aligns with broader concerns about the impact of environmental factors on tourism, particularly issues related to water quality such as red tide events.

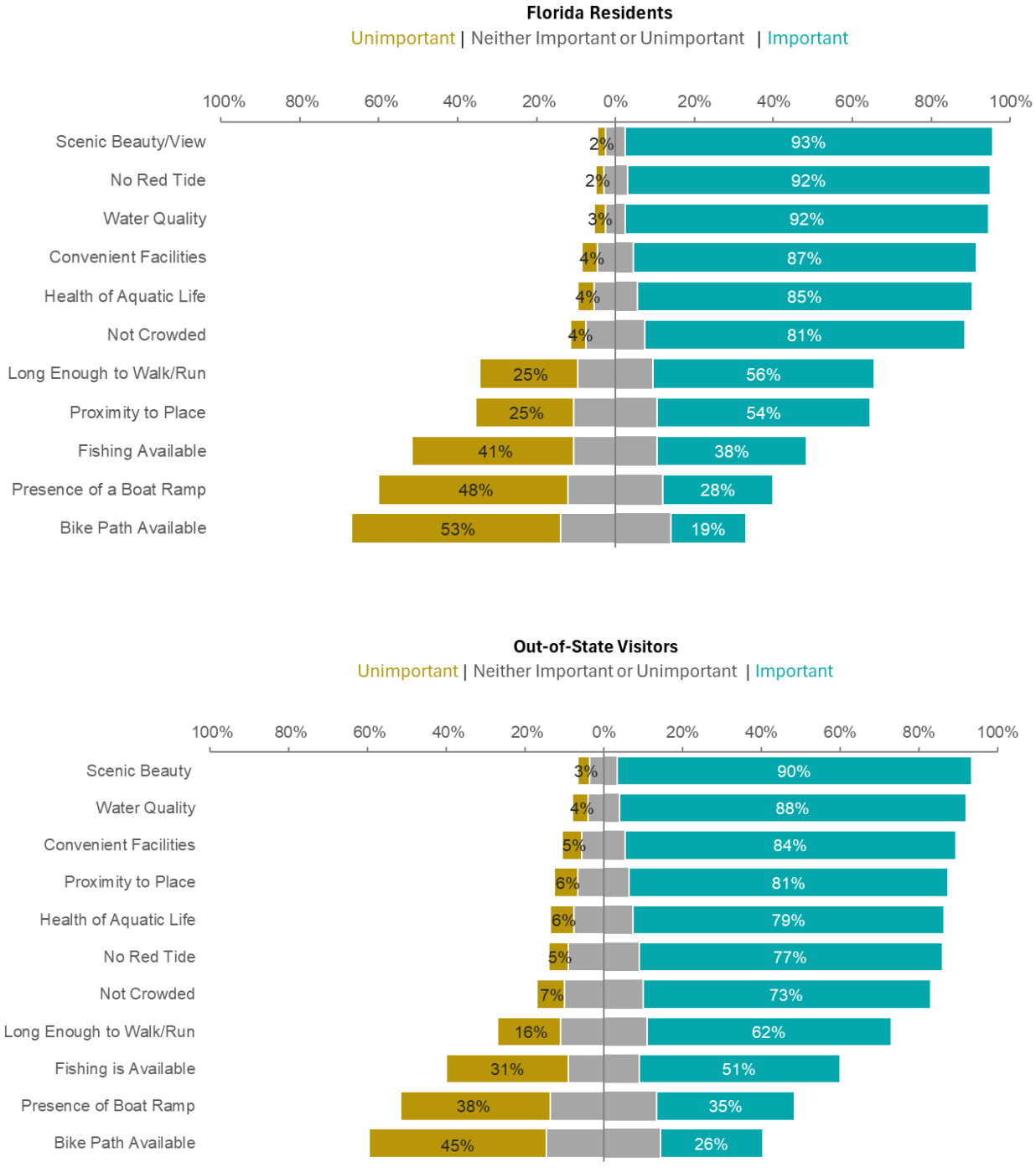
Other factors, such as convenient facilities and the health of aquatic life, are also significant considerations, particularly for Florida residents, with 87% and 85% rating them as important, compared to 84% and 79% of out-of-state visitors. Crowding levels also play a role in trip decisions, with 81% of Florida residents and 73% of out-of-state visitors considering destinations that are less crowded an important factor. While both groups prioritized environmental quality, Florida residents place greater emphasis on red tide conditions and ecosystem

Figure 1: The Five Coasts Along Florida's Gulf Coast



Source: Xiaohui Qiao, University of Florida, using data from Visit Florida (2021).

Figure 2: Key Factors Influencing Travel Choices along Florida's Gulf Coast



Note: The "Unimportant" category includes respondents who selected either "Unimportant" or "Somewhat Unimportant," while the "Important" category includes those who selected either "Important" or "Somewhat Important."
Source: Authors' depiction.

health, likely due to their greater exposure to red tide events and awareness of the associated risks. Differences also emerged in preferences for other attributes—out-of-state visitors place greater importance on convenience-based factors, such as proximity to the destination, availability of a boat ramp, and fishing opportunities.

Are Visitors to Florida's Gulf Coast Aware of Red Tide and Its Impact?

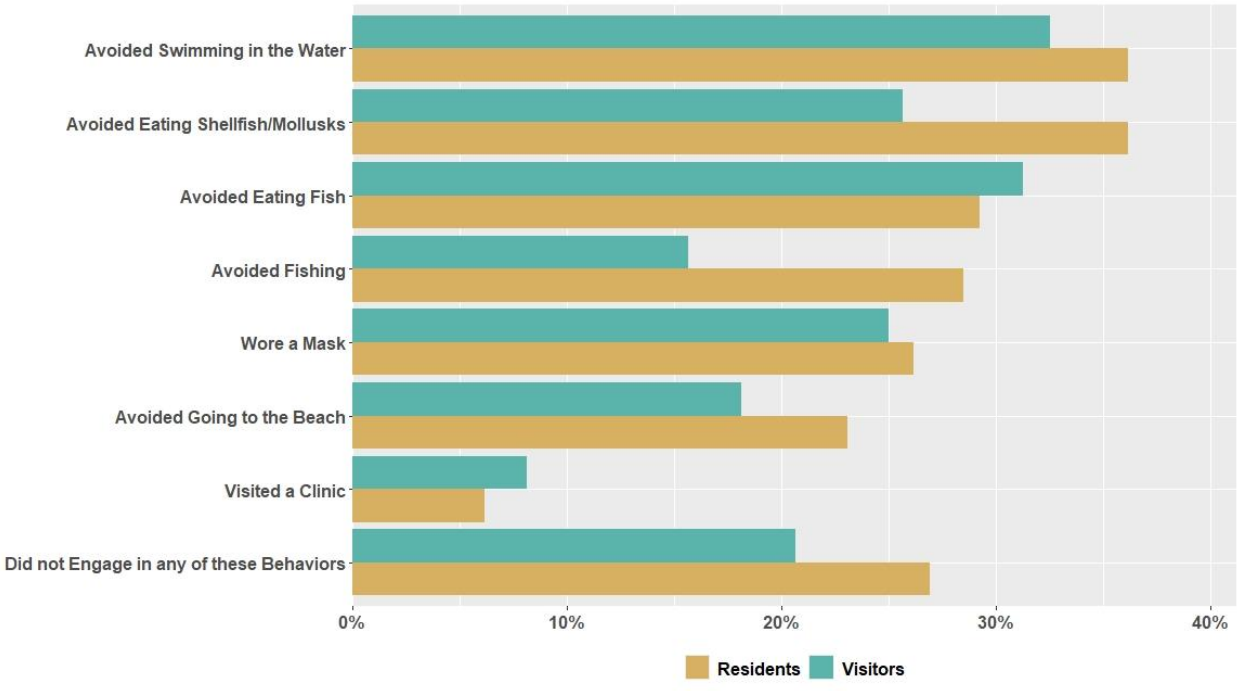
An overwhelming majority of Florida residents (94%) are aware of red tide; however, only 69% of out-of-state visitors report the same. This gap in red tide awareness likely stems from differing levels of exposure to local environmental issues. Florida residents are generally more proactive than out-of-state visitors about checking red tide advisories. Among those who are aware of red tide, 45% of Florida residents report checking red tide advisories before their most recent trip compared to 30% of out-of-state visitors. Residents' proximity to the coast and firsthand experience with red tide, such as public advisories, likely contribute to their higher awareness. Local governments and community groups in red tide–prone areas often engage in public outreach and educational campaigns to ensure that residents remain informed and prepared for potential outbreaks (Nierenberg et al., 2011). Visitors from other states, on the other hand, may not encounter red tide as frequently and are less likely to seek out or be exposed to red tide information. Their unfamiliarity with the local environment and the potential risks associated with red tide might lead them to overlook the need to check advisories, contributing to the substantial awareness gap observed in the study. Additionally, out-of-state visitors might not perceive the same level of risk as residents, especially if they are unaware of the health issues that red tide can cause.

What Risk-Avoidance Behaviors Do Visitors Exhibit in Response to Red Tide?

To evaluate the behavioral responses to red tide, we asked all survey respondents about the specific actions they engaged in to avoid the risks associated with red tide, as summarized in Figure 3. Florida residents report a greater level of risk-avoidance behavior in response to red tide, particularly when consuming seafood or swimming, likely due to their familiarity with the local environment and a better understanding of the risks posed by red tide. Out-of-state visitors also engage in preventive measures, but their overall engagement in these behaviors is lower.

Both groups report avoiding swimming (36% of residents, 33% of visitors), suggesting that these individuals recognize and act upon the risks of direct contact with water affected by red tide, which can cause

Figure 3: Behavioral Changes Due to the Presence of Red Tide



Note: The percentages are not mutually exclusive; individuals may have engaged in multiple avoidance behaviors.
Source: Authors' depiction.

skin irritation and exacerbate respiratory issues. Despite a higher percentage of out-of-state visitors (32%) choosing not to consume fish compared to residents (29%), both groups have engaged in other risk-avoidance behaviors, such as avoiding eating shellfish/mollusks (36% of residents and 26% of visitors) or fish during red tide (28% of residents and 16% of visitors). These behaviors reflect a shared understanding among residents and visitors of the potential health risks associated with consuming certain types of seafood during red tide events (Kirkpatrick et al., 2004).

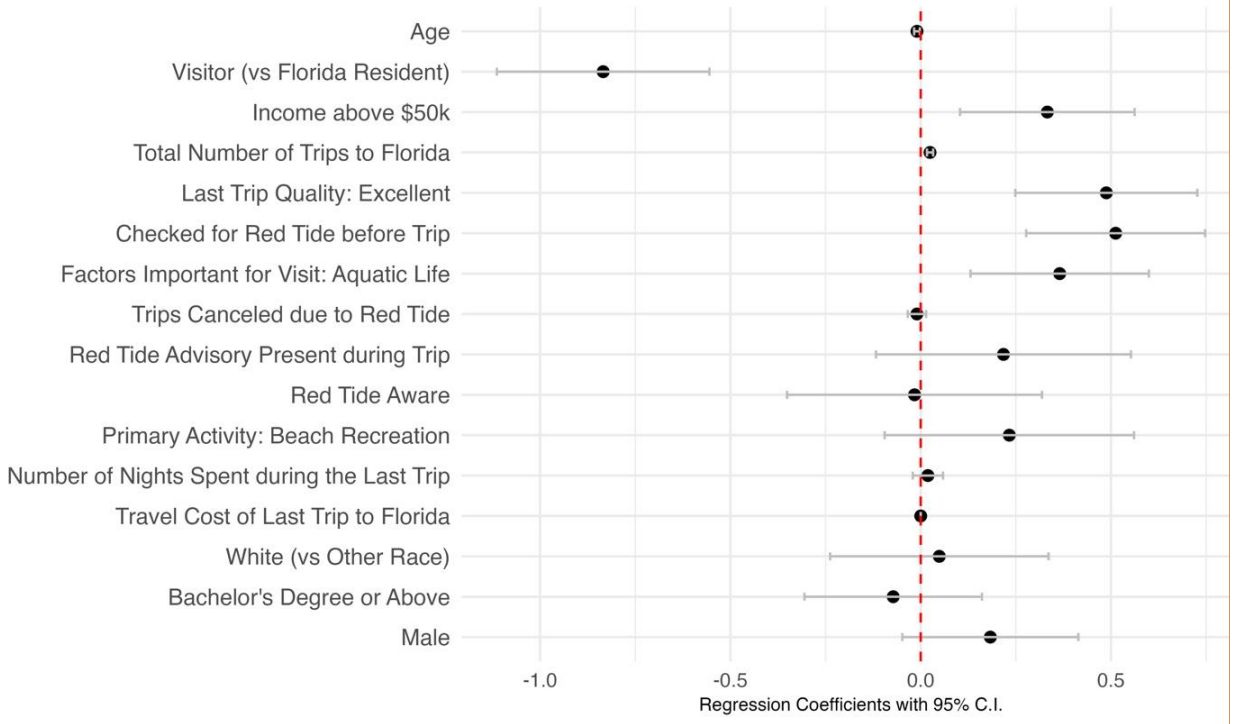
Only a small fraction of respondents sought medical attention by visiting a clinic when exposed to red tide (6% of residents and 8% of visitors). This suggests that most individuals did not experience symptoms severe enough to warrant medical attention or may have relied on self-care measures. A similar proportion of residents (26%) and visitors from other states (25%) report wearing a mask, a precaution likely taken to mitigate respiratory symptoms associated with red tide.

Do Red Tide Advisories Deter Florida's Gulf Coast Visitors?

We asked survey respondents about their experience with red tide advisories, and the majority of the sample (61%) indicated that they did not check for advisories prior to making a trip to Florida's Gulf Coast. A considerable portion of respondents who checked for red tide advisories report that they had no impact on their travel plans (39% of residents and 37% of visitors). Interestingly, among individuals who adjusted their travel plans, cancellations due to red tide were more common among residents (13%) than visitors (4%). This difference could be attributed to out-of-state visitors' commitment to a preplanned itinerary or the higher financial costs associated with canceling or modifying travel plans. Residents, being more familiar with the region, may have the knowledge and ability to choose alternative locations that are less affected by red tide.

When it comes to altering activities, out-of-state visitors were more responsive to red tide advisories than residents, with 41% of visitors modifying their activities compared to 31% of residents. This suggests that while out-of-state visitors may be less likely to change their destination, they are more inclined to adapt their activities to minimize exposure to red tide. Residents, on the other hand, may be more accustomed to red tide and the actual risk involved and therefore less likely to significantly alter their usual activities. The percentage of respondents who changed the duration of their trip due to red tide was 15% for residents and 23% for out-of-state visitors. This difference may suggest that out-of-state visitors, who typically have less flexibility and familiarity with local conditions, are more influenced than residents by environmental disruptions.

Figure 4: Factors That Influence the Likelihood of Future Visit to Florida's Gulf Coast



Note: Figure shows logistic regression coefficients of an indicator for whether individuals plan to visit Florida's Gulf Coast in the next 12 months and 95% confidence intervals.
Source: Authors' depiction.

Overall, these results show varying degrees of flexibility and responsiveness to red tide advisories between residents and visitors. Out-of-state visitors are generally more responsive to the advisories in terms of altering their activities and trip duration. Residents, on the other hand, demonstrate greater resilience and flexibility, likely due to their familiarity with the region and frequent exposure to red tide events. This resilience is reflected in their higher likelihood of changing travel locations rather than canceling trips outright. However, the significant percentage of both groups reporting no changes in travel plans suggests that red tide advisories do not warrant major adjustments for many respondents.

What Factors Influence Future Visits to Florida's Gulf Coast?

In Figure 4, we illustrate the key factors that influence the likelihood of returning to Florida's Gulf Coast within the next year. Factors positioned to the right of the dotted line indicate an increased likelihood of return, while those to the left suggest a reduced likelihood. Florida residents are more likely to take a trip to Florida's Gulf Coast next year than out-of-state visitors. This highlights the importance of local familiarity and convenience in travel decisions.

Individuals with a history of frequent trips to the Gulf Coast, annual incomes above $50,000, a strong appreciation for aquatic life, and positive experiences on their most recent trip are more likely to visit again within the next year. Interestingly, those who check red tide advisories are also more likely to return, suggesting that staying informed about environmental conditions boosts confidence in future trip planning. Our analysis shows that the other factors tested, such as past trip cancellations due to red tide, the presence of red tide advisories during the most recent visit, red tide awareness, primary recreational activities, trip duration, trip costs, and demographic factors like race, education, or gender appear to have little influence on the likelihood of future visits. We also estimate separate models for Florida residents and out-of-state visitors, and the results are largely consistent with the findings from the full sample. However, checking red tide advisories has a stronger association with the likelihood of taking future trips among out-of-state visitors compared to Florida residents. We also find that past trip cancellations due to red tide have a negative effect on decisions to take future trips, particularly among Florida residents.

Figure 5: Example of a Red Tide Scenario Presented to Survey Respondents (medium *Karenia brevis* abundance)

Suppose the abundance of *Kerenia brevis* algae that causes red tide is expected to be MEDIUM in the Gulf of Mexico, how many trips to Florida's Gulf Coast to participate in saltwater related activities would you take in the next 12 months?

Karenia brevis abundance	Possible effects
VERY LOW (> 1,000 - 10,000 cells/L)	• *possible* respiratory irritation • shellfish harvesting closures
LOW (> 10,000 - 100,000 cells/L)	• respiratory irritation • shellfish harvesting closures • *possible* fish kills
MEDIUM (> 100,000 - 1,000,000 cells/L)	• respiratory irritation • shellfish harvesting closures • *probable* fish kills
HIGH (> 1,000,000 cells/L)	• respiratory irritation • shellfish harvesting closures • *probable* fish kills • water discoloration

Source: Authors' depiction using information from Florida Fish and Wildlife Conservation Commission (FWC, 2024).

How Does Severity of Red Tide Shape Future Travel Plans to Florida's Gulf Coast?

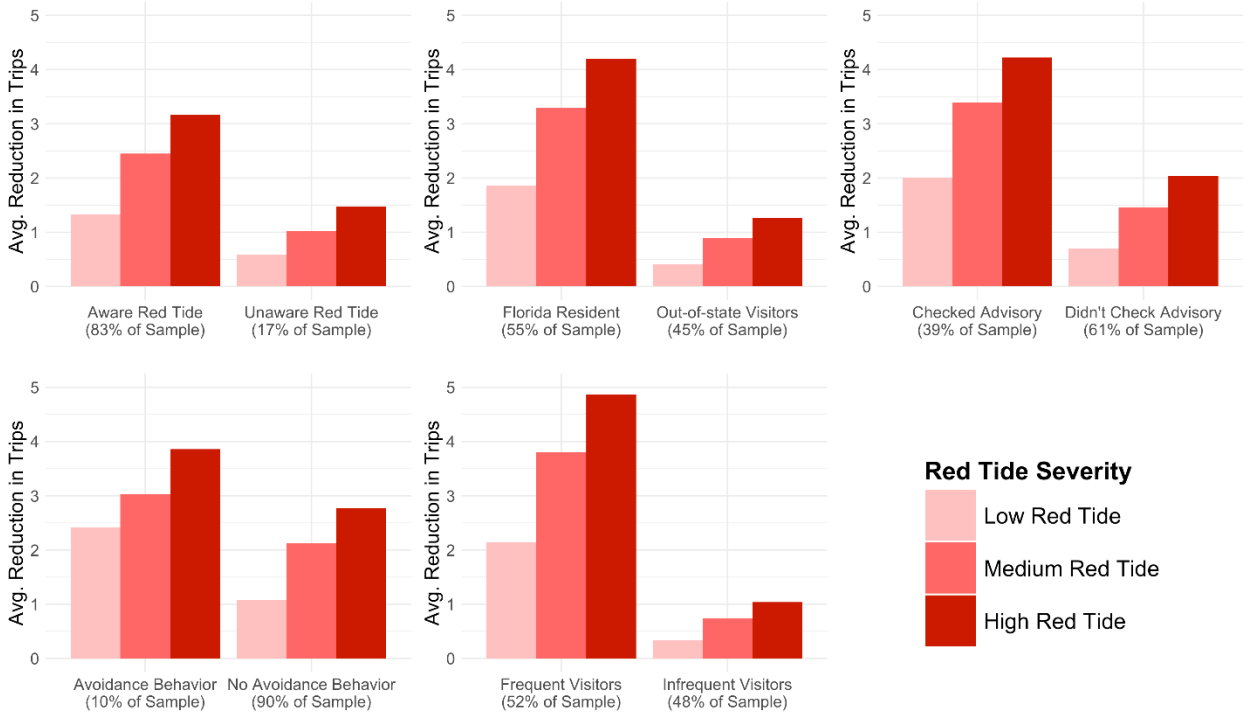
The severity of red tide conditions and their impact on human and environmental health play an important role in individuals' decisions to visit Florida's Gulf Coast in the future. In our survey, respondents who expressed plans to visit the Gulf Coast were presented with hypothetical scenarios featuring varying levels of red tide severity, characterized by low, medium, and high concentrations of red tide–causing microorganism, *K. brevis*, in the water. Each low, medium, and high *K. brevis* scenario is associated with a specific set of potential impacts on human and ecosystem health. As the concentration levels of *K. brevis* increases, the severity of red tide impacts intensifies. Figure 5 provides an example of one such scenario along with the accompanying explanatory text.

Survey participants were asked to indicate how many trips they would be willing to take under each scenario. Before responding, participants were reminded of the number of trips they initially planned to take next year and were then asked if this number would change based on the presence of *K. brevis* at varying levels of abundance.

On average, survey respondents initially planned to take 3.39 trips to Florida's Gulf Coast in the next year. This number has decreased considerably as respondents faced different red tide scenarios. When *K. brevis* abundance is high, which typically results in respiratory irritation, shellfish harvesting closures, fish kills and water discoloration, the average number of future trips decreases to 0.69. Individuals also respond to the medium and low abundance of *K. brevis*, with the average trips declining to 1.36 and 2.37, respectively.

In Figure 6, we compare different groups within our sample to examine how red tide awareness, residency status, advisory checks, avoidance behavior, and visitation frequency influence future trip reduction. On average, respondents aware of red tide reduce their future trips more than those unaware, across all levels of red tide severity. Florida residents show a greater reduction in future trips compared to out-of-state visitors, potentially due to their familiarity with red tide and its effects, which might make them more cautious in avoiding affected areas. Similarly, respondents who check red tide advisories reduce their future trips more than those who do not check, which highlights the important role that risk awareness plays in shaping travel behavior. Respondents who engage in avoidance behaviors—such as avoiding swimming, fishing, or

Figure 6: Average Reduction in Future Trips to Florida's Gulf Coast under Different Red Tide Scenarios



Note: Average reduction in trips refers to the mean difference between the expected number of trips in 12 months under normal conditions and the expected number of trips taken under different red tide conditions (low, medium, and high). All differences are statistically significant ($p < 0.001$).
Source: Authors' depiction.

eating seafood—show a higher reduction in future trips than those who do not engage in such behavior. Finally, those who visit the Gulf Coast frequently show a greater decrease in trips compared to infrequent visitors, possibly due to their more exposure and sensitivity to red tide events.

Conclusion

This article shows that while both Florida residents and out-of-state visitors are aware of red tide, their behavioral responses differ. Residents are generally more adaptable, modifying their travel plans based on past experiences and actively checking red tide advisories. In contrast, out-of-state visitors tend to maintain their original plans, demonstrating less proactive behavior, likely due to limited local knowledge or ability to change travel plans. Future visitation rates decrease dramatically in response to the severity of potential red tide conditions of various severity.

These findings suggest the need for targeted public awareness campaigns to better inform out-of-state visitors about red tide and its potential risks. Enhancing public education and encouraging proactive behaviors, such as checking advisories and planning around red tide events, particularly among out-of-state visitors, could help mitigate the negative impacts on both public health and the local economy. Moreover, understanding the factors that drive return visits can aid in developing strategies to support the tourism industry along the Gulf of Mexico, even in the face of environmental challenges like red tide.

For More Information

Allen, S.E. 2007. Florida Red Tides: Public Perceptions of Risk. MS thesis, University of South Florida, Tampa.

Anderson, D. 2014. “HABs in a Changing World: A Perspective on Harmful Algal Blooms, Their Impacts, and Research and Management in a Dynamic Era of Climactic and Environmental Change.” Paper presented at Harmful Algae 2012: Proceedings of the 15th International Conference on Harmful Algae, October 29-November 2,

Bechard, A. 2019. “Red Tide at Morning, Tourists Take Warning? County-Level Economic Effects of HABS on Tourism Dependent Sectors.” Harmful Algae 85:101689.

———. 2020a. “Economics Losses to Fishery and Seafood Related Businesses during Harmful Algal Blooms.” Fisheries Research 230:105678.

———. 2020b. “External Costs of Harmful Algal Blooms Using Hedonic Valuation: The Impact of Karenia brevis on Southwest Florida.” Environmental and Sustainability Indicators 5:100019.

———. 2020c. “Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida.” Review of Regional Studies 50(2).

———. 2021. “Gone with the Wind: Declines in Property Values as Harmful Algal Blooms are Blown towards the Shore.” Journal of Real Estate Finance and Economics 62:242–257.

Brand, L.E., and A. Compton. 2007. “Long-Term Increase in Karenia brevis Abundance along the Southwest Florida Coast.” Harmful Algae 6:232–252.

Chapra, S.C., B. Boehlert, C. Fant, V.J. Bierman Jr, J. Henderson, D. Mills, D.M.L. Mas, L. Rennels, L. Janatarasami, J. Martinich, K.M. Strzepek, and H.W. Paerl. 2017. “Climate Change Impacts on Harmful Algal Blooms in US Freshwaters: A Screening-Level Assessment.” Environmental Science and Technology 51(16):8933–8943.

Charette, M.A., P.B. Henderson, C.F. Breier, and Q. Liu. 2013. “Submarine Groundwater Discharge in a River-Dominated Florida Estuary.” Marine Chemistry 156:3–17.

Ferreira, J.P., B. Bijen Saha, G.C. Carrero, J. Kim, and C. Cour. 2023. “Impacts of Red Tide in Peer-to-Peer Accommodations: A Multi-Regional Input-Output Model.” Tourism Economics 29(3):812–834.

Florida Fish and Wildlife Conservation Commission (FWC). 2024. Red Tide Current Status. Available online: https://myfwc.com/research/redtide/statewide/

Hallegraeff, G.M. 2003. “Harmful Algal Blooms: A Global Overview.” Manual on Harmful Marine Microalgae 33:1-22.

Harowitz, B., C.C. Macdonald, and J. Wester. 2024. “Red Tide Outreach in Florida: Message Framing, Environmental Emotions, and Support for Mitigation.” Coasts 4:21–33.

Kirkpatrick, B., L.E. Fleming, D. Squicciarini, L.C. Backer, R. Clark, W. Abraham, B. Janet, Y.S. Cheng, D. Johnson, R. Pierce, J. Zaias, G.D. Bossart, and D.G. Baden. 2004. “Literature Review of Florida Red Tide: Implications for Human Health Effects.” Harmful Algae 3:99–115.

Kirkpatrick, B., K. Kohler, M. Byrne, L.E. Fleming, K. Scheller, A. Reich, G. Hitchcock, G. Kirkpatrick, S. Ullmann, and P. Hoagland. 2014. “Human Responses to Florida Red Tides: Policy Awareness and Adherence to Local Fertilizer Ordinances.” Science of the Total Environment 493:898–909.

Kuhar, S.E., K. Nierenberg, B. Kirkpatrick, and G.A. Tobin. 2009. “Public Perceptions of Florida Red Tide risks.” Risk Analysis 29(7):963–969.

Lapointe, B.E., and B.J. Bedford. 2007. “Drift Rhodophyte Blooms Emerge in Lee County, Florida, USA: Evidence of Escalating Coastal Eutrophication.” Harmful Algae 6:421–437.

Larkin, S.L., and C.M. Adams. 2007. “Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida.” Society and Natural Resources 20(9):849–859.

Nierenberg, K., J. Hollenbeck, L.E. Fleming, W. Stephan, A. Reich, L.C. Backer, R. Currier, and B. Kirkpatrick. 2011. “Frontiers in Outreach and Education: The Florida Red Tide Experience.” Harmful Algae 10(4):374–380.

Paerl, H.W., and J.T. Scott. 2010. “Throwing Fuel on the Fire: Synergistic Effects of Excessive Nitrogen Inputs and Global Warming on Harmful Algal Blooms.” Environmental Science and Technology 44:7756–7758.

Stumpf, R.P., Y. Li, B. Kirkpatrick, R.W. Litaker, K.A. Hubbard, R.D. Currier, … and M.C. Tomlinson. 2022. “Quantifying Karenia brevis Bloom Severity and Respiratory Irritation Impact along the Shoreline of Southwest Florida.” Plos One 17(1):e0260755.

Vargo, G.A., C.A. Heil, K.A. Fanning, L.K. Dixon, M.B. Neely, K. Lester, … J. Walsh. 2008. “Nutrient Availability in Support of Karenia brevis Blooms on the Central West Florida Shelf: What Keeps Karenia Blooming?” Continental Shelf Research 28:73–98.

Vilas, D., J. Buszowski, S. Sagarese, J. Steenbeek, Z. Sider, and D. Chagaris. 2023. “Evaluating Red Tide Effects on the West Florida Shelf Using a Spatiotemporal Ecosystem Modeling Framework.” Scientific Reports 13:2541.

Visit Florida. 2018. Annual Report 2018-19. Available online: https://visitflorida.app.box.com/s/5bzwnmak860ijrfilcuobu9rx3swkjh0.

———. 2019. Annual Report 2019-2020. Available online: https://visitflorida.app.box.com/s/whuwxwiouyarkp3zvp43uxcr4uc4xpy7.

———. 2022. Annual Report 2022-2023. Available online: https://visitflorida.app.box.com/s/e63t3oew26h0koeoiwr12pfcllwsaaov.

———. n.d. About Visit Florida. Available online: https://www.visitflorida.com/about-us/ [Accessed January 20, 2025].

Yehuda, L.K., J.P. Osleeb, and M.R. Viola. 2004. "Tourism-Generated Earnings in the Coastal Zone: A Regional Analysis." Journal of Coastal Research 204:1080–1088.

About the Authors: Ulrich Adegbola (ulylerich@ufl.edu) is a Graduate Student with the Food and Resource Economics Department at the University of Florida. Abhishek Rajan (a.rajan@ufl.edu) is a Graduate Student with the Food and Resource Economics Department at the University of Florida. Corresponding Author: Olesya M. Savchenko (olesya.savchenko@ufl.edu) is an Assistant Professor with the Food and Resource Economics Department at the University of Florida. Christa Court (ccourt@ufl.edu) is Associate Professor with the Food and Resource Economics Department at the University of Florida.

Acknowledgments: This work was supported by the National Oceanic and Atmospheric Administration’s National Centers for Coastal Ocean Science (NOAA-NCCOS) in partnership with the Gulf of Mexico Coastal Ocean Observing System Regional Association (GCOOS-RA) at Texas A&M University (TAMU) [AWD08253, 2020] and the Florida Department of Environmental Protection [AWD12194, 2022]. This is NOAA Social and Economic Assessment of HABS (SEAHAB) publication number 3.