Ripples of Red Tide: Quantifying Recreational Losses from Harmful Algal Blooms in Florida

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Abstract

This paper examines the effect of the red tide event on recreation trips and values in Florida's Gulf Coast using cancelled trips data in the context of Travel Cost Method. Demand models are estimated using data on actual trips taken and cancelled trips due to Red Tide reported in a survey conducted in 15 US states. The survey gathered information from respondents on their recreational visits to Florida's Gulf Coast between 2017-2022, including detailed information on past trips and, the number of trips cancelled to the study region due to red tide. The empirical analysis involves the estimation of a random parameter negative binomial count data model. Our results suggest that red tide events have significant and negative effects on recreation visits and consumer surplus. The consumer surplus loss due to red tide is estimated to be $65 per household.

INTRODUCTION

- HABs are a significant environmental concern in the U.S. coastal waters
- In recent years, between 2000 and 2019, more than 800 algal bloom events have been recorded in the U.S
- HABs affect marine ecosystem, human health, and have socio-economic consequences.
- While the ecological and environmental causes and impacts of algal blooms are extensively studied, there has been limited research on their socioeconomic impacts
- **This paper is an effort to better understand the socioeconomic consequences by quantifying the recreational loss associated with HABs**.

What are Harmful Algal Blooms ?

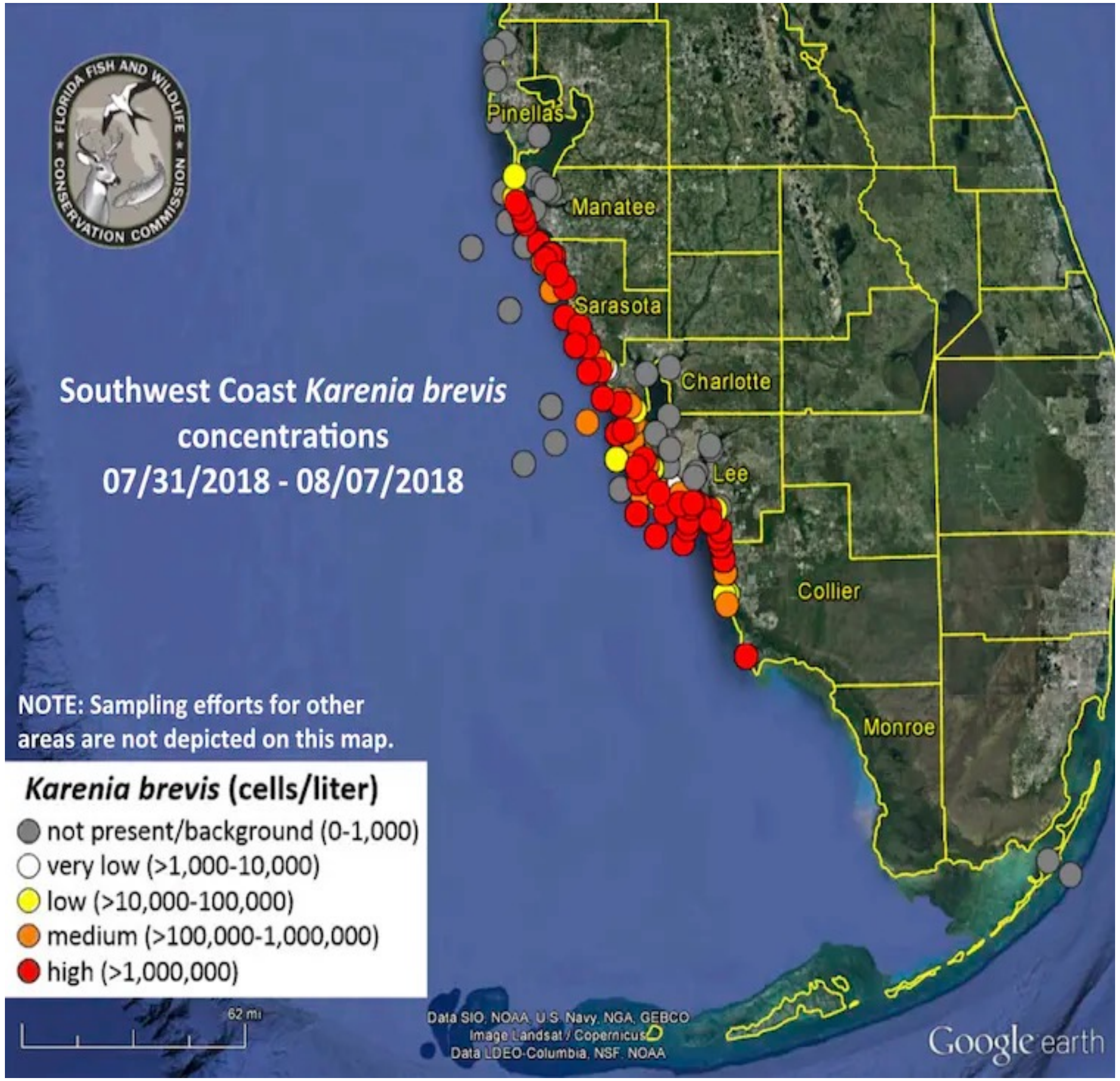
- Under certain environmental conditions, algaes can grow excessively, or blooms, and produce toxins
- Of thousands of algae species, 100+ can produce toxins that are harmful to humans and marine/aquatic life
- Multiple factors influencing the occurrence and prevalence of HABs in marine waters such as nutrient concentrations, water temperature and pH, availability of light, shape of the coastline, other organisms in water, and water current and circulation

Red Tides in Florida

- Blooms of the red-pigmented Karenia brevis algae are popularly known as ‘the red tide’
- Red Tide events frequently occurs on hundreds of miles of Florida’s coastline, with blooms lasting for days, weeks, or even months
- K. Brevis blooms results in the reddening of ocean water, kill marine life, poison shellfish, disrupt beach activities due to unpleasant smell and dead marine animals washup onshore, and affect human health due to exposure to toxins

Red Tide in Florida

Red Tide in Gulf Coast in 2018



MOTIVATION

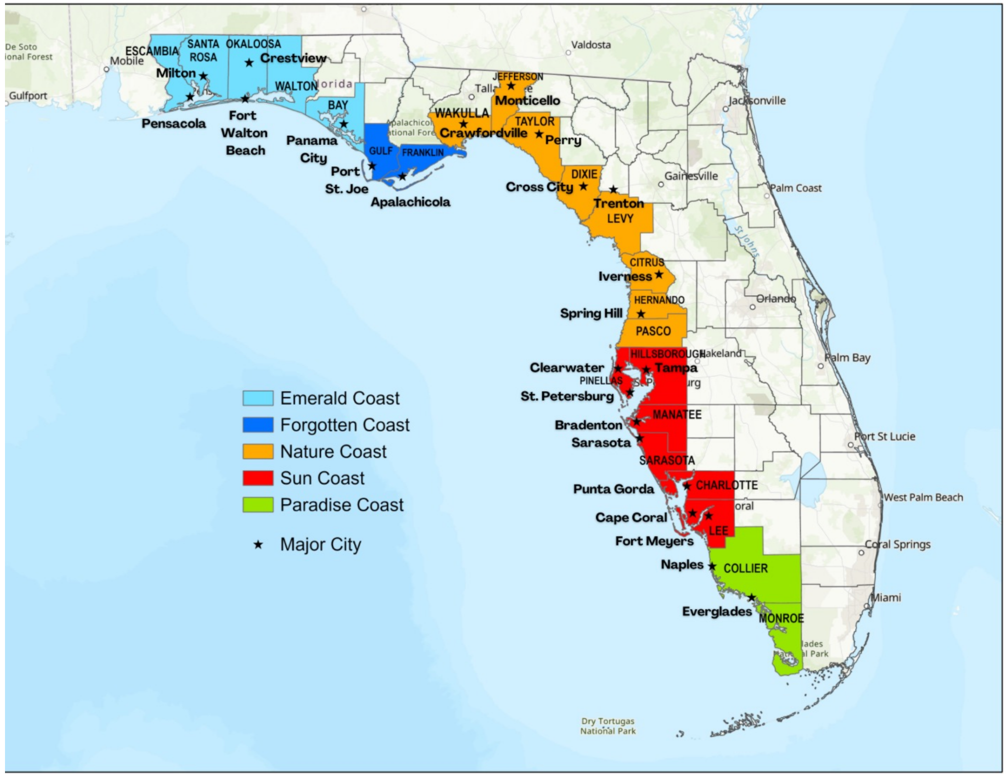
- Florida's $100+ billion tourism economy, heavily dependent on its clean coasts and healthy ocean
- The recurrence of Red Tide events causes beach closures or restrictions, unpleasant conditions, and threat to health which may deter tourists from visitation and damage tourism revenues
- Limited research exploring the impact of red tide events on beach visitation, recreational loss, and overall impact on tourism economy

RESEARCH OBJECTIVE

To quantify the recreational damages due to Red tide events in Florida, particularly focusing on changes in visitation and the associated recreation losses

SURVEY DESIGN & IMPLEMENTATION

- Designed an online survey instrument to capture beach visitations in Florida's Gulf Coast in between 2017-2022
- Survey conducted between Nov 22 – Aug 23 via Qualtrics
- Survey collected data from 2358 adults who visited Florida's Gulf Coast for saltwater recreation from 2017 to 2022 or cancelled planned trips
- 2358 adults were surveyed, including 1291 Florida residents and 1067 out-of-state visitors from 14 states that contribute the most tourists to Florida
- Survey elicited information on:
  - Visitation history
  - Trip cancellations due to red tide
  - Awareness and contingent-behaviour to red tide
  - Alternative trip location
  - Respondent socio-demographic characteristic



Study Region in Florida's Gulf Coast

EMPIRICAL MODEL

- Study uses a single-site Travel Cost Model to estimate the changes in recreation demand due to Red Tide
- The model uses data from actual trips taken and the cancelled trips to the study region due to the Red Tide event to construct a panel with a counterfactual time period without the Red Tide, and an actual time period with the Red Tide
- We utilize the pseudo-panel data to estimate random effect negative binomial count data demand model
- The change in consumer surplus per trip from the pseudo-panel data represents the loss in recreational value due to red tide

The empirical travel cost model based on a log-linear specification of Random Effects Negative-Binomial regression model is expressed as:

$$Log(TRIPS_{ij}) = \beta_0 + \beta_1 \mathrm{TC}_{ij} + \beta_3 \mathrm{Night}_{ij} + \beta_2 \mathrm{X}_{ij} + \beta_3 \mathrm{RedTi}de_{\mathrm{j}} + \varepsilon$$

where j=1 denotes actual scenario with Red Tide and j=0 denotes counterfactual scenario without Red Tide

$\boldsymbol{\beta_k}$: vector of parameters to be estimated

$\mathbf{TRIP_{ij}}$: number of trips made by individual i

$\mathbf{Night_{ij}}$: 1 if Nights > Trips, 0 otherwise

$\mathbf{TC_i}$: travel cost incurred by individual *i* per trip

$\mathbf{X_i}$: vector of demographic variables associated with individual *i*

$\mathbf{RedTide_j}$: dummy variable representing actual trip scenario (RedTide=1) and counterfactual time period without Red Tide (RedTide =0)

TRAVEL COST ESTIMATION

1. Identified four/five most visited beach in each coastal zone from *VISITFLORIDA*

	Location
Emerald Coast	Panama City Beach, Pensacola Beach, Destin, Fort Walton Beach
Forgotten Coast	Cape San Blas, Carrabelle, St. George Island, Alligator Point
Nature Coast	Crystal River, Spring Hill, Horseshoe Point, Cedar Key
Sun Coast	Sarasota, Bradenton, Tampa, St. Petersberg, Clearwater
Paradise Coast	Fort Myers, Naples, Marco Island, Cape Coral

2. Estimated the driving distance of each location from respondent's home in every coastal region; and selected the location with minimum distance as the destination for each respondent

3. We calculate travel cost as a weighted average of driving and flying costs, where the weights are based on the observed share of respondents who drive and fly (English et al. 2018)

4. Driving Cost

$$Driving\_cost_{ij} = [c * d_{ij} + \gamma * w_i (d_{ij} / mph)]$$

where c: cost per mile (c= \$0.20, American Automobile Association 2020)

d_{ij}: Round trip distance

γ: Fraction of hourly wage rate (γ=0.33, Englin and Shonkwiler 1995; Parsons 2017)

w_i: Hourly wage rate

mph: miles per hour (mph =50)

i= 1…N respondent households, and j = 1….5 site

5. Flying Cost

- Our airport selection was based on two criteria: first, mid-size airports with over 2 million enplanements; second, for states lacking such airports, the airport with the highest number of enplanements was chosen
- Estimated the distance of nearest airport from home location and destination for every respondent
- Estimated driving cost from home to home-airport and destination-airport to destination
- Airfare was obtained from the Airline Origin and Destination Survey (DB1B), a 10% sample of all airline tickets collected by the Office of Airline Information and the Bureau of Transportation Statistics (English et al. 2018)

6. Probability of Flying

	Income <70k & family size<=3	Income <70k & family size>=3	Income>70k & family size<=3	Income >70k & family size>=3
Distance <250 miles	0%	1%	1%	0%
Distance 250-500 miles	3%	10%	8%	16%
Distance 500-1000 miles	17%	25%	37%	30%
Distance >1000 miles	43%	46%	54%	57%

7. Weighted Average of Driving and Flying

$$C_{ij} = \left(1 - \rho_{ij}\right) C_{ij}^{D} + \rho_{ij} C_{ij}^{F}$$

where C_{ij}^{D} is the roundtrip cost of driving from origin i to destination j and C_{ij}^{F} denotes the corresponding roundtrip flying cost.

RESULTS

	Negative Binomial	Random Effect Negative Binomial
Travel Cost	-0.0029*** (.00045)	-0.0022*** (0.0004)
Red Tide	-	-0.022*** (0.01)
Nights	-0.82*** (0.07)	-0.79*** (0.07)
Travel Cost X Nights	0.002 (0.0004)***	0.001** (0.0003)
Income	0.002** (0.0005)	0.003*** (0.0005)
Age	0.002 (0.0012)	-0.003* (0.001)
White	0.28*** (0.06)	0.31*** (0.065)
Female	-0.26*** (0.04)	-0.26*** (0.04)
Bachelor	-0.21*** (0.04)	-0.18*** (0.04)
Visitor	-0.32* (0.13)	0.13 (0.12)
(Intercept)	1.66*** (0.095)	1.52*** (0.095)
Clustered SE	Yes	No
N	1240	1316
Time Period	1	2

- Consumer surplus per trip in a log-linear regression is equal to the negative inverse of the coefficient on the travel cost variable: CS per trip = $-1/\beta_{TC}$

- The change in consumer surplus due to Red Tide is equal to the product of the change in the number of trips and consumer surplus per trip: Δ CS per HH = $-\Delta x/\beta_{TC}$ (Whitehead et al. 2018)

	Negative Binomial	Random Effect Negative Binomial
CS per trip	$342 [279, 415]	$463 [335, 552]
Δ CS per HH /year		-$65 [33, 76]

CONCLUSION

- Households are estimated to take 8% less trips in case of Red Tide
- The effect of the Red Tide on consumer surplus is –$65 for each household/year that took trips to Gulf Coast
- Aggregate recreational damages from Red Tide can be estimated using the consumer surplus figures obtained from the model
- Sensitivity analysis should be conducted with different travel cost estimates
- Separate estimation of recreational losses for out-of-state and Florida residents