ECONOMIC ANALYSES OF THE EFFECTS OF RED TIDE EVENTS ON THREE SECTORS OF FLORIDA COASTAL COMMUNITIES: RESTAURANTS, RESIDENTS AND LOCAL GOVERNMENT

By

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As scientists learn more about the effectiveness of various harmful algal bloom prevention, control, and mitigation strategies, information on local-level economic effects is needed. This study examines red-tide related economic effects across a nine-county region of Florida's Gulf Coast in three related essays, which contribute to the empirical and theoretical literature on HAB-effect measurement and mitigation. Only select specific findings are summarized here.

The first essay estimated sales reductions due to red tide events for three Southwest Florida beachfront restaurants from 1998-2005 using time-series linear regression analysis. Location-specific manager notes were used to indicate red tide, rain, and tropical storm days. Findings revealed that average inflation-adjusted sales declined by 13.7% and 15.3% for the two highest grossing restaurants on days when a red tide was present.

The second essay estimated the probability that a resident in Manatee or Sarasota County that engaged in marine-related activities was affected by a red tide. Using a sample of 569 residents, a series of discrete choice models were estimated to explain whether a resident was affected by red tide events in 2000 and, if so, how they were affected. Findings revealed that variables that can be affected by Extension activities were the only factors that affected the

probability that a resident's participation in a marine-related activity would change during a red tide. Subsequent analyses by activity and to further investigate the type of reaction revealed difference by activity that can be used to design more effective outreach materials as a means of mitigation the affects of a red tide.

The final essay provided insights into the financial and managerial impacts of a red tide event on nine county and eighteen city governments charged with management of public beaches. Two cities had 2006 budgets of $50,000 and $100,000 for red tide beach cleaning. For 2004-2007, six locations reported expenditures ranging from $11,114 to $250,000 per event and totaling $653,890. Expenditures were directly correlated with public beach length, severity of fish kills, and available beach management budgets, but should be considered conservative estimates since they did not include in-kind labor or equipment expenses.

CHAPTER 1
INTRODUCTION

Purpose of Study

The overall purpose of this study is to generate information that would provide for a better understanding of the economic consequences of red tide events on local managers, residents and restaurants located on the Gulf of Mexico in Southwest Florida, an area that has historically experienced severe red tide events. This is the first study to explore the economic impacts of red tide events across three inter-related components of Florida's economy within a region that is heavily dependent on marine water quality and related amenities. The combined use of proprietary sales information and primary survey data collected from residents and government managers is expected to provide estimates of business losses, behavioral choices, and local government expenditures on beach management resulting from the presence of harmful algal blooms (HABs).

There are three objectives of this research. Objective one is to estimate the change in restaurant sales on those days when red tide conditions were noticeable. Objective two is to predict the change in resident behaviors that are specific to their participation in marine-related activities during a red tide. To complete these examinations, other environmental, temporal, spatial, and demographic explanatory variables are incorporated in the models for comparison. Objective three is to ascertain the expenditures and specific protocols associated with public beach management during red tide events and determine the factors that affect the expenditure levels. The combined analyses are examined in turn in Chapters Two through Four and are expected to provide quantitative and qualitative evidence of the effects of a red tide event in the localized study area and contribute to the growing literature on how to measure such effects.

Florida's Gulf Coast and Red Tide

According to the 2000 National Survey on Recreation and the Environment, Florida was the first destination of choice for over 22 million American travelers that sought out marine recreation on coastal beaches, waterways and wetlands in order to swim, dive, sunbathe, boat, or fish (Leeworthy and Wiley). These travelers spent more than 177 million beach days along Florida's coast in 2000 (Leeworthy and Wiley). Non-market values estimated for Florida's marine-related recreation activities ranged from $81 million for scuba diving up to nearly $18 billion for beach users during 2000 alone (Kildow).

High-quality, sustainable marine coastal environments are crucial elements necessary to support and ensure the popularity of Florida's coastlines and associated marine sectors. The increasing movement of the population to coastal areas has emphasized coastal consumer and business reliance on predictable weather conditions, which in turn, has increased the economic impacts of naturally-occurring environmental stressors (Changnon). Similar to daily temperature, precipitation, and wind data, short-run prediction models of uncontrollable environmental stressors, such as harmful algal blooms (HABs) or other water quality measures, are necessary sources of information that impact decisions made by the public.

Harmful algal blooms are defined to have one common unique feature: "…they cause harm, either due to their production of toxins or to the manner in which the cells' physical structure or accumulated biomass affect co-occurring organisms and alter food web dynamics" (Anderson et al., 2000). When red tide algae (*Karenia brevis*) in particular become concentrated, fish and marine mammals may experience paralysis and shellfish may become toxic, resulting in massive kills of a variety of fish species and endangered manatees among other marine life (Steidinger et al.). For example, the 2003 the deaths of 98 of Florida's endangered manatees were attributed to red tide blooms (Pain), while the 2005 red tide events resulted in the documented deaths of 118 endangered sea turtles (Tomalin). Human health impacts resulting from *K. brevis* toxins released into the air in minute parts per million can include respiratory distress, nasal and eye irritations, and skin rashes, which can be particularly damaging to individuals with compromised immune systems such as the elderly and asthmatics (Flewelling et al., Backer et al.).

Red tide cell count measurements collected by the Florida Fish and Wildlife Research Institute [FWRI] and Mote Marine Laboratory can be used to indicate the location and intensity of red tide blooms from 1996 through 2005 in Southwest Florida, the main area under consideration in this study. Following FWRI's key, "very low" *K. brevis* cells per liter of seawater range from greater than 1,000 to 10,000, "low" and "medium" categories include cell counts ranging from greater than 10,000 to under 100,000 and greater or equal to 100,000 to less than a million, respectively; both categories contain cell count levels that are considered sufficient to cause human respiratory irritation and probable fish kills. The "high" category includes measurements of at least one million cells per liter. While an official cell count level that might cause either significant fish kills or respiratory distress in humans has not been established, the Florida Division of Aquaculture has mandated that waters with cell counts exceeding 5,000 per liter will result in shellfish bed closures to prevent NSP (Florida Department of Agriculture and Consumer Services).

Anecdotal evidence of the effects of red tide on human health, sea life, and marine-centric businesses is also abundant. A Google news article search for the phrase "red tide" from 01 January 1996 to 31 December 2005 found more than 1,700 days with articles in just five of the Gulf Coast's print media. Internet "web logs" such as RedTideAlert.com offer web space to individuals that want to share written or pictorial descriptions of their personal experiences with the negative aspects of red tide. This site has posts from both foreign and domestic visitors that indicate their plans to avoid vacationing, or residing, in Florida in the future. Unfortunately, testing of local waters can reveal zero or low red tide cell counts even while anecdotal evidence abounds (J. Abbott, personal communication, FWRI Harmful Algal Bloom Group, 5 January 2007). Such contradictions highlight the difficulties associated with absolute predictions of algal bloom impacts on sea life and human health (Landsberg).

Red tide event economic losses are suspected to result from a variety of impacts including those on human health (e.g., lost wages, increased sick days and medical treatment costs) and coastal communities (e.g., shellfish fishery closures, reduced recreational expenditures, and the need for beach cleaning and species rehabilitation). The Pinellas County visitor and convention bureau has stated that revenue losses approached $240 million as a result of the nearly year-long series of red tide events in 2005 (Moore). Lee County’s public tax records revealed a $100,000 commitment to red tide-related research. And, in July 2007, Florida Congress members supported a federal authorization of $30 million in each of the next three years for additional red tide research (Tibbetts).

The successful management of red tide blooms and associated negative impacts should be examined at a regional scale if the region is the affected by red tides and can contribute to successful prevention, control, and mitigation activities (Fisher et al.). This is especially the case, “if red tides and their paths could be predicted, alerted communities might have time to mobilize cleanup crews and establish warning systems before the bloom arrives” (FWRI). To that end, this research attempts to not only provide quantitative evidence of localized red tide economic impacts (if they exist), but also to contribute to the methodologies that can be used to gather credible information for the purpose of evaluating continued red tide related expenditures by the government.

Review of Applied Economic Studies

Following several recent prolonged red tide blooms and continued increases in the coastal population, it is not surprising that local, state, national, public and private agencies have been overwhelmed with demands for economic information on HAB events.

The earliest estimates found that “direct economic impacts of HABs in the United States average $75 million annually, including impacts on public health costs, commercial fishing closures, recreation and tourism losses, and in management and monitoring costs” (National Oceanic and Atmospheric Administration [NOAA]). Similar research efforts have produced estimates of average annual national losses of $46 million (Hoagland, 2000), $49 million (Anderson, Kaoru, and White, 2000), and $82 million (Hoagland and Scatasta, 2006). For the recreation and tourism sector in particular, annual losses were estimated at $4 million (Hoagland and Scatasta, 2006). For commercial fisheries, average annual losses were estimated at $19 million (2000 dollars) (Anderson, Kaoru, and White, 2000).

Regional economic analyses of red tide events are faced with limited availability of consistent information, and exacerbated by the inherently random and unpredictable nature of HABs. However, in one of the few region-specific studies, an input-output revealed that 59% of respondents indicated that negative impacts associated with red tide were reflected in their business sales and revenues, resulting in estimated direct economic impacts of $10 million to Galveston, Texas economy (Evans). Halo effects that persist over time and masking variables (i.e. weather, varied seasonal attractions, etc.) that coincided with red tide events were found to create additional difficulty in the analysis (Jensen; Hoagland and Scatasta, 2006).

In a recent study of economic impacts from red tides in Florida, the changes in business activity that occurred during red tide events from 1995 through 1999 in the Ft. Walton Beach and Destin areas of Okaloosa County were investigated (Larkin and Adams). Aggregated monthly gross taxable sales data were used to determine red tide-related losses for these two small communities located on Florida’s Northwestern Gulf Coast. A time-series regression analysis was estimated to reveal historical average losses of 29% and 35% for the restaurant and lodging sectors, respectively, during months when red tide events were measured in nearby offshore waters.

While these studies have produced some historic measurements of HAB economic costs, they collectively outline compelling reasons to expend future research efforts on the development of more precise estimates of economic consequences. First, there appears to be a current trend of increasing harmful algal blooms in both number of events and duration length (Brand and Compton), which serves to increase the important of estimates that can be used to justify continued expenditures. Second, there exists a need for empirical analyses resulting in statistically significant information at the firm level necessary to guide owners and operators of beach-dependent businesses in red tide-related loss management. Third, statistical analysis of the effects of red tide on residents that actively engage in marine-related activities may provide estimates of the scope and potential costs of residents’ decisions to avoid those activities. Finally, there is an unmet need for accurate red-tide induced expenditures incurred by public agencies that are charged with management, and dependent upon revenue streams, of beachfront destinations.

There is no doubt that an estimation of the economic impacts of red tide events would provide the necessary guidance for prioritization of financial and other types of support to those segments of the economy that are directly affected by HAB events. However, the variation of these same economic effects across currently available scientific studies tends to result in more questions, and fewer clear-cut answers. Our study provides data analyses completed at the local level of firms, consumers, and government agencies that are impacted by red tide events, which add qualitative and quantitative approaches and contributions to the existing body of literature.

Overview of Study Theory and Methods

Previous studies that have provided estimates of absolute economic losses as a result of harmful algal blooms in the United States have relied upon readily available secondary data. Three of the most recent studies (Anderson et al., 2000; Hoagland et al., 2002; Hoagland and Scatasta, 2006) used a combination of surveys from coastal state experts, literature reviews and individual calculations, to produce a seminal national review of economic implications associated with HAB occurrences from 1987-1992 on four economic sectors - public health, commercial fisheries, recreation/tourism, and monitoring/management. Available red tide loss estimates were aggregated and average annual shares were calculated for each sector. While these studies were seminal, the absence of estimates for all hypothesized losses (and measurements at different points in the value chain) will bias the absolute and relative impacts.

Losses to commercial fisheries in particular have been calculated using historical harvest levels and dockside prices (Anderson, Kaoru, and White, 2000). Most certainly, however, the magnitude of real losses will depend on such factors as the number of fishery participants, length of fishery season, and the level of fixed costs associated with participation in the fishery.

Published estimates of economic losses due to HABs have, thus, been based on a variety of case study methods and aggregated to include a wide range of economic sectors, including tourism, commercial fisheries, public health, and red tide management and monitoring. The resulting estimates from these data compilations are difficult to compare, given the information was collected for different regions using different sampling frames across such broad sectors, and therefore have limited use for future work.

As an alternative approach, comprehensive questioning of a few individuals across several sectors of a local coastal economy within a limited geographic area that had recently experienced a red tide event resulted in data that was analyzed with an input-output model (Evans). Respondents were asked to recall precise losses resulting from red tide events that varied in their duration and intensity. The inconsistency of respondent types and data recollection, and the reliance of the IMPLAN model on an underlying production function that was based on a broader geographic area and included both coastal and inland areas suggested limits to the credibility of the methodology and its results.

The field of economics provides various methods for estimation of losses based on historical data. Time series analysis with econometrics techniques in particular allow for the use of consistently collected data and bias-free estimation (versus calculations based on restrictive assumptions) of red tide impacts. For example, the empirical analysis of monthly gross taxable sales data from the Florida Department of Revenue and the FWRI cell count measurements were successfully used to estimate economic losses to the restaurant and hotel sectors in Florida's Panhandle (Larkin and Adams). The availability of primary data analyzed at the finest resolution possible (e.g., that of an individual firm) using econometric techniques may provide defensible, statistically significant evidence of the effects of red tide days.

Consumer behavior theory based on the principles of an individual's goal of selecting goods and services that maximize his or her utility has been used to predict the probability of various recreational choices. This theory has successfully produced estimation of welfare effects resulting from different management options for recreational salmon fishing (Lin, Adams, and

Berrens), measurement of the benefits of water quality improvements to marine recreational fishers in a North Carolina estuary (Kaoru), and estimation of average annual access values for recreational fishing in Tampa Bay, Florida (Greene, Moss and Spreen).

Finally, estimation of economic impacts resulting from environmental extremes such as harmful algal blooms can result from institutional analysis, as “It is important for practitioners and researchers to recognize the capacity (e.g., knowledge, power, and resources) to solve complex problems is often widely dispersed across a set of actors located at different levels of government” (Imperial). Stakeholders across Florida’s local, regional, and state levels are actively pursuing and funding red tide-related scientific and economic research, perhaps in large part due to concerns based on future lost property tax revenues, lost values of a Florida beach vacation, and lost tourist interest in Florida’s coastal activities.

CHAPTER 2
FIRM-LEVEL ECONOMIC LOSSES DURING RED TIDE BLOOMS: A CASE STUDY OF THREE BEACHFRONT RESTAURANTS

Introduction

Southwest Florida's economy is heavily dependent on its marine amenities. The value derived from marine-related business is ultimately influenced by the quality of the environment. In addition to the weather, extreme environmental conditions such as hurricanes and harmful algal blooms (HABs) can frequently occur in this region of Florida. The main species of HABs in Southwest Florida (*Karenia brevis*) is unique in that brevetoxins are produced during blooms. These specific toxins can kill marine life (Flewelling et al.), prevent safe consumption of shellfish, and cause respiratory irritation in humans (Backer et al.; Robbins et al.) and thereby cause economic losses to commercial and recreational marine-related businesses (Kusek et al.; Magana et al.; Schneider, Pierce and Rodrick; Casper et al.).

Some business sectors have been able to receive compensation for HAB-related disasters. For example, the Small Business Association provided each of 36 Florida firms with $4,832 to $81,912 in loans due to red tide events that occurred between 1996 and 2002 (Tester. P.A. Personal Communication. NOAA – National Ocean Service, 13 July 2007). Of the 36 total loans awarded to firms in Florida, only five (13.9%) went to restaurants. Overall, however, the restaurant sector fell behind only seafood markets and shellfishing (of nine total sectors) in the total sum of monies loaned. The restaurant sector is vulnerable to red tide related losses and as a service sector contributes to sustainable tourism in Florida with gross taxable sales of $17.3 billion in 1999 (Bureau of Economic and Business Research [BEBR]).

While there is an abundant and growing body of anecdotal information on the detrimental economic effects that HABs have on local economies (e.g., Glick; Huettell; Karp; Van Sant; McLaughlin and Spinner; Moore), there is a paucity of rigorous empirical analysis. Most studies have either compared changes in dockside values of harvested seafood between seasons (e.g., Tester et al., 1991), calculated average annual losses by aggregating across industries (Anderson et al., 2000; Hoagland and Scatasta, 2006), or estimating losses using recall data from businesses in a localized area (Evans). One exception is a recent study that used secondary data from the Florida Department of Revenue to estimate historical losses of 29% to 35% on average for the restaurant and lodging sectors in two small communities in Northwest Florida, respectively, during months when red tide was present in near shore waters (Larkin and Adams).

During 2005, Florida's southwest coastal areas experienced a prolonged series of red tide events in nearly every month, raising widespread concern in the business community (e.g., Glick; Huettel; Moroney; Moore). Since intense, long-lasting and far-reaching blooms are not an unusual occurrence to this area (Steidinger et al.) and red tides may be becoming more abundant (Brand and Compton), regional economic losses may increase. As a result, the demand for new and alternative prevention, control and mitigation strategies is also increasing.

Fortunately, the scientific community is advancing several alternative prevention and control strategies for red tides (Schneider, Pierce, and Rodrick; Robbins et al.; Casper et al.). This same community also has a long history of advocating the need for exploration of local and regional data to gain accurate estimates of the size and magnitude of business interruptions precipitated by HAB events (Jensen; Kahn and Rockel; Shumway; Anderson; Boesch et al.; Hoagland et al., 2002). In light of recent technological advances and an increasing number of high profile red tide events, empirical support for red tide related business losses is paramount. This need is magnified considering the potential to improve forecasting models that could support the specification of risk premiums offered by private insurance companies.

To provide the statistical evidence of the economic effects of natural disasters – and support for potential prevention, control and mitigation strategies – proprietary firm-level data is used to estimate lost sales for several beachfront restaurants. Our study offers an initial examination of the economic consequences of red tide events at the firm level. As red tide events are naturally-occurring phenomena, their presence and relative effects on specific restaurants will be compared with other environmental factors. It is the intention of our study to provide a portion of the information requested by scientists, resource managers, and business leaders. In addition, this research will further empirical analysis.

Methods

Theoretical and Empirical Model

As suggested by Nordhaus, a time-series analysis "…might be useful for examining the impact of abrupt [climate] changes, for these are similar to extreme weather events." Following this prescription, the theoretical model for our study hypothesizes that, on a daily basis, restaurant sales (*Y*) are a function of exogenous environmental conditions (*X*) and seasonal demands (*D*), such as day of the week, season, and or year. Assuming a linear functional form, which allows for the direct estimation and comparison of effects, the following empirical model is specified for each restaurant:

$$Y_t = \beta \pm \sum_j \gamma_j X_{j,t} \pm \sum_k \delta_k D_{k,t} + \varepsilon_t \tag{2-1}$$

where *t* identifies a specific day, *j* indexes the environmental variables, and *k* indexes the time-related variables (Table 2-1). Parameters β, γ_j, and δ_k will be estimated using a least squares approach for each firm. The random error, ε, is likely to be autocorrelated due to the use of time series data. Thus, empirical equations will be tested for autocorrelation, with subsequent corrections to the estimation procedure if necessary.

In our study, five *j* variables (*X*) are considered, including temperature, wind speed, rainfall, red tides, and tropical (or stronger) storm conditions. Temperature is expected to vary directly with daily restaurant sales while the remaining environmental conditions (if present or at higher levels) are expected to vary inversely with sales. The time-related variables assumed to affect daily demand for restaurant services (*D*) include holidays, days of the week, months of the year, and years. The time-related variables will be discrete and dichotomous (i.e., 0-1 dummy variables) such that directional impacts on sales will depend on which category is used as the base and included in the intercept (i.e., β). In general, however, sales are expected to increase (coefficients have a positive sign) on holidays, weekends, during the spring (when tourism and the resident population increases), and in the most recent years (due to a gradual increase in the regional population).

While estimation would be simplified by defining a single model with interactions to capture individual restaurant-level differences, it would substantially increase the number of explanatory variables and thereby complicate the presentation and analysis of results. In addition, the diversity between restaurants (especially with respect to restaurant size, type, and unique changes to each during the study period) supports a unique set of explanatory variables that would further complicate the estimation and analysis of results from a single model. Thus, separate models will be estimated for each restaurant.

Proprietary Sales Data

Daily sales were obtained for three beachfront restaurants located directly on the Gulf of Mexico in Southwest Florida. All restaurants were located within fifty feet of the water's edge. Seating capacity ranged from 360 to 500 guest chairs. Outdoor seating accounted for approximately 35 to 50 percent of total seating capacity. The data cover November 1, 1998 through December 31, 2005 and include gross sales for each day (Y_t), for a maximum of 2,032 observations. The three restaurants differed in terms of the average price of menu items; one was considered more up-scale with the highest average menu price, one was moderate, and one was relatively casual and had the lowest average prices. The restaurants are generically referred to as firm A, B, and C, respectively, to maintain confidentiality. All restaurants were open year-round with the exception of Christmas day; however, there were a few days of planned closures for maintenance and renovations.

The sales data were adjusted for inflation using the Southern region's food-away-from-home monthly consumer price index (CPI) (Table 2-2). Average daily CPI-adjusted sales (to December 2005 dollars) varied in magnitude and apparent trends between restaurants over the study period (Figure 2-1a). Daily sales for firm A, the smallest restaurant, were relatively unchanged with an average of $2,626 (Figure 2-1a). Firm B, with the highest average daily sales of $24,347, experienced above-inflation gains in daily sales due to continual updates to the facility, steadily increasing prices, and substantial market growth. The average daily sales of firm C were $6,357, although sales increased in 2004 from the addition of a 90-seat banquet area (this change in level of CPI-adjusted sales is less apparent in Figure 2-1a due to the scale of the vertical axis). The information on these infrastructure changes to firms B and C were used to create dummy variables (*D*) to allow the model to capture these exogenous effects in the model estimation.

In general, all three restaurants received the highest average daily sales in the months of February though May, and the lowest in September (Figure 2-1b). Sales of firm A, the smallest restaurant, ranged from $1,686 to $4,269 depending on the month. For comparison, sales of the largest restaurant, firm B, ranged from $16,527 to $33,895 depending on the month. To capture these seasonal effects, monthly dummy variables were included in each model. Similarly, variation is present throughout the week with peak sales being on or near weekends and the lowest sales coming early in the week. Thus, dummy variables were also included to account for these effects in the model.

Environmental Data

Information on daily environmental conditions that were believed to impact sales was obtained from the manager of each restaurant. These factors included the presence of noticeable red tide effects, whether rainfall occurred, or whether a storm of at least tropical strength was ongoing (Table 2-3). Using this data source, red tide events were noted to occur on 52, 55 and 54 days (approximately 2.7% of observations) for firms A, B and C, respectively, during the study period. The number of rainy days for all three restaurants averaged between seven to 14% of all operating days. Tropical storms or hurricanes were noted on 15, 14 and 15 days for firms A, B and C, respectively.

Temperature and wind speed data were obtained from the University of South Florida's (USF) data station. As these data were measured every six to eight minutes, the analysis used the average of measurements from 11 am through midnight to correspond with the operating hours of each restaurant. In general, seasonal variations are evident with respect to both temperature and wind speed, which are inversely related from March through October (Figure 2-2).

A supplementary source of environmental data was obtained from a monitoring station that is maintained by the National Climatic Data Center (NCDC). For the purposes of this model, the NCDC average daily temperature data were substituted for those days (73 in total or 3.6% of the 2,032 observations) when the primary USF data were missing. The absolute variation in temperatures between the two data sets over the study horizon ranged from -1.57˚ F to -0.58˚ F.

To account for this deviation, the NCDC temperature observations where adjusted by the average monthly differences in the cases where NCDC data substituted in for missing USF data.

Results

Model Estimation and Evaluation

Following Greene, condition numbers were calculated as measures of multicollinearity for each model and all were acceptable (i.e., under a value of 20), which allows for efficient model estimation. Each model was examined for evidence of autocorrelation using Durbin-Watson test statistics. The null hypothesis of no autocorrelation was rejected for all firms as autocorrelation of degree one was found. Thus, the models for all firms were estimated with generalized least squares to correct for the presence of correlated error terms in the first period. The estimated models are shown in Table 2-4. Estimated models for firms A, B, and C had adjusted coefficients of determination of 64.6%, 67.4% and 65.9%, respectively, indicating that the models appear to fit the data relatively well and consistently across locations.

The signs of the parameter estimates corresponding to the environmental variables (X) were as expected in all models, i.e. temperature was positive and wind speed, red tides, rain, and storm events were negative. The parameter estimates for all environmental variables, with the exception of red tide in firm A, were statistically significant. Of all the time-related dummy variables, only those trying to capture differences in early-week sales (i.e., Tuesday and Wednesday versus Monday) were statistically insignificant in each model. For the larger firms (B and C), sales were not found to differ in some fall months (September for firm B and August and October for firm C) from January sales, although these are considered off-peak seasons for this region. Lastly, the annual dummy variables for firm B that were intended to capture continual changes made to the menu and facility over the study period indicated that these changes did not begin to affect sales until 2000.

To facilitate discussion of model results, a base estimate of daily sales was calculated for each of the three firms using only the average daily temperature and wind speed explanatory variables. These base daily sales estimates were calculated to be $2,630, $24,361 and $6,367 for firms A, B, and C, respectively. When compared to actual average daily inflation-adjusted sales (Table 2-2), these estimated daily sales values were nearly identical. Therefore, the results discussed in this study are compared to the actual average daily inflation-adjusted sales.

Effect of Red Tides

For two of the three restaurants, the estimated models revealed a statistically significant reduction of daily sales when a red tide was present. Firm A, the lowest-grossing, was the only restaurant where the red tide parameter estimate was not statistically significant during the study period (Table 2-4). Firm B, the highest-earning restaurant with CPI-adjusted average daily sales of $24,347 (approximately 4 to 10 times larger than the other two restaurants), experienced the largest absolute and relative decline due to a red tide event. Firm B incurred a statistically significant decline of $3,734 (15.3%) each day that red tide conditions were noticeable enough for the manager to document. Daily sales for firm C also experienced a decline during a red tide event, with an $868 (13.7%) reduction when a bloom was present. Given the number of days of reported red tide events for each restaurant (Table 2-3), total losses during the seven year time horizon are calculated to total $252,242 for firms B and C, respectively.

Effect of Red Tides Relative to Other Environmental Factors (X)

All of the other four environmental factors were statistically significant in each model. For the continuous variables (temperature and wind speed), relative changes in inflation adjusted sales were measured assuming an increase equal to one standard deviation. Average daily sales were found to increase by 3.0% to 6.3% due to a one standard deviation increase in temperature and decrease by 4.4% to 4.7% from a one standard deviation increase in wind speed. In absolute value, these effects of temperature and wind speed are approximately one-quarter to one-third (i.e., the ratio of the effects to the red tide coefficient ranged from 0.22 to 0.35) the magnitude of effects on sales from red tides for firms B and C that had a statistically significant red tide parameter estimate.

If the restaurant manager recorded rain, daily sales fell 23.0% to 27.0% across restaurants. The size of this effect is larger (with coefficient ratios of 1.52 and 1.98 for the rainfall to red tide coefficients, or one and a half to two times larger) than that caused by red tides. Calculation of the effect on an annual average basis revealed that the heavy rainfall caused lost revenues of approximately ten times those caused by red tides. This is not surprising, given that a subjective measurement of a rainy day is more liberal as rainfall events are a more common weather occurrence.

Tropical storms or hurricanes had relatively larger effects on daily sales, i.e., a 20.8% to 40.1% decrease in sales. The ratios of the storm to red tide coefficients were 1.35 and 1.65, indicating storm effects exceeded red tide effects, on average, by approximately one-third to two thirds each day. When calculated on an annual average basis to factor in incidence, the effect of tropical storms or hurricanes on firms B and C was approximately one-third to one-half that of red tides. Given the number of days of reported tropical storms and hurricanes for each restaurant (Table 2-3), total losses due to storm events during the seven year time horizon were calculated to be $65,728 and $20,034 for firms B and C, respectively.

Effect of Time-Related Factors (D)

Holidays generated increased sales of 21.4% to 29.9% across firms. An average of six holidays per year resulted in annual revenue increases of $3,378, $33,090, and $11,412 for firms A, B and C, respectively. `The highest average daily sales occurred on Saturdays for each firm, when sales increased by $1,469 to $15,283 or 55.9% to 62.8% for firms A and C, respectively, above early-week sales (i.e., Monday through Wednesday). For comparison, the peak winter month (i.e., March) generated daily sales increases of $1,957 to $17,732, which translates into increases of 71.9% to 74.5% across firms. The seasonal demand has a much larger relative impact on sales than any other factor.

Firm B was the only restaurant that experienced a noticeable increase in inflation-adjusted sales in the long run, that is, across the seven-year time horizon. Compared to 1998 and 1999, sales increased from $3,165 in 2000 to $13,753 in 2004. Thus, the menu price increases and infrastructure improvements resulted in substantial increases in real gross revenues. Similarly, the renovations to firm C in 2004 increased average daily sales by $1,103 (17.4%); over the course of a year, the renovations contributed to increased sales of $402,595.

Discussion

The regression analyses revealed that red tide events reduced daily receipts at the two highest priced beachfront restaurants in the study. This result was found using environmental data observed by the manager of the restaurant that was on duty during business hours. Like the data on rain and storm days, the designation of the presence of red tide conditions that were sufficient enough to affect sales as perceived by the manager are essentially subjective data. The benefit and uses of such data are becoming increasingly common, most notably the use of beach conditions data with respect to water recreational activities (Caldwell). In the case of red tides, the observations are likely conservative because the notes were only made when the red tide conditions (e.g., noxious airborne toxins and/or dead fish washed up onto the beach) were indisputable. Moreover, the negative effects of red tide blooms on restaurant patrons can vary rapidly (due in part to the influence of wind speed and direction), suggesting that off-site monitoring by state officials may not provide relevant data necessary to capture economic effects of the restaurant sector.

In the absence of routine, on-site, red tide monitoring stations, direct observations (subjective determinations) were used. To provide comparison, all red tide observations noted by the restaurant managers were found to correspond with cell counts that averaged 180,853 cells per liter within seven days and six miles of the western edge of the County (as measured by Fish and Wildlife Research Institute [FWRI]). When FWRI recorded cell counts and managers noted a red tide on the same day (13 in total), FWRI cell counts averaged 585,183 cells per liter. These average cell count measurements greatly exceed the 5,000-threshold level that is used to close commercial shellfish harvesting areas (Florida Department of Agriculture and Consumer Services). Thus, cell count measurements may need to be much higher to impact beachfront restaurant patrons when compared to the shellfish closure threshold levels, particularly in light of corresponding wind speed and wind direction (Backer et al.). If these thresholds are supported in other studies, they could be used to estimate red tide effect thresholds for any beachfront business and, thereby, provide support for the future use of subjective red tide data in empirical analysis. Firm-level analysis is, however, essential since red tides were not found to affect all restaurants in our study despite their close proximity to one another.

The economic sustainability of beachfront restaurants, as with any natural resource-related firm, is dependent on the condition of the natural environment, which is largely uncontrollable. Recent scientific advances have, however, suggested a suite of potential prevention, control and mitigation strategies for red tides (e.g., Casper; Robbins; Pierce et al.; Schneider, Pierce and Rodrick). One result has been improved forecasting models (e.g., Stumpf). The cost of such strategies will need to be compared with potential benefits, which could be proxied with preventable losses to affected businesses, such as the restaurants measured in this research. These estimated benefits also provide support to the hypothesis that the restaurant sector is affected during red tides along with the traditional commercial fisheries or marine-related recreation and tourism sectors which seem to have received the most media attention (e.g., Glick; Huettel; Karp; Moroney; Moore). Like the fishery sector, the restaurant sector could demonstrate its eligibility for disaster assistance, such as loans offered by the Small Business Administration, using the empirical approach developed in our study.

Conclusions

Red tides have occurred in the Southeastern U.S. for more than 150 years of recorded history (FWRI) and have been anecdotally accused of causing a suite of negative economic effects. Our study used proprietary data on a more fine geographic, temporal, and industry sector resolution to provide empirical evidence of the magnitude and relative size of economic losses from red tides. Results were generally consistent with the available scientific literature (e.g., Larkin and Adams). Statistically significant daily sales losses due to a red tide day are relatively close to the minimum Small Business Administration (SBA) loan values provided to Florida restaurants in 2006 (Tester. P.A. Personal Communication. NOAA – National Ocean Service, 13 July 2007). Each of the restaurant managers' observations had notations of up to six consecutive red tide days, which suggests that cumulative sales losses based on duration of a red tide event may have driven SBA loan values to the maximum end of the range.

These results indicate that onsite record-keeping of weather events by individual firms represented a valuable source of data for determining statistically significant support for the absolute and relative effects of extreme environmental events. These records are of primary importance should waterfront firm owners consider appealing to state or federal governments, or private industry, for financial loss reimbursements. For example, the SBA Economic Relief Funds are a potential source of revenue replacement in the case where a firm demonstrates that red tide blooms diminished daily sales. Some Florida counties are reimbursing cities for the beach clean-up costs incurred during a red tide, and evidence of beachfront firm losses may encourage such tourism-dependent county governments to reimburse businesses for their private clean-up expenditures. In addition, private- or publicly-underwritten hazard or business disruption insurance could use forecast and associated probability of bloom estimates to include red tide events as they currently do for hurricane or flood policies offered in the market.

The methodology and results may also provide a means to extrapolate findings to a regional level for the restaurant sector using the cell count thresholds, number of days, and number and type of beachfront restaurants. Such losses can be compared to estimated costs of any proposed red tide prevention, control and mitigation strategy for other business dependent on the economy's tourism sector. This methodology could be applied to other businesses sectors (commercial fishing, lodging, beach attendance, etc.) to get a better estimate of regional costs and benefits associated with proposed red tide control, mitigation and management.

Table 2-1. Variable descriptions and definitions

Variable	Definition (units of measure)
Y_{i}	Inflation-adjusted gross sales for firm *i* ($)
$X_{j\,=\,TEMP}$	Average temperature from 11am – midnight (ºF)
$X_{j\,=\,WIND}$	Average wind speed from 11am – midnight (meters/second)
$X_{j\,=\,RTIDE}$	Red tide (1 if yes; 0 if no)
$X_{j\,=\,RAIN}$	Heavy rainfall (1 if yes; 0 if no)
$X_{j\,=\,STORM}$	Tropical storm or hurricane conditions (1 if yes; 0 if no)
$D_{k\,=\,HOL}$	Holiday, with the exception of Christmas Day (1 if yes; 0 if no)
$D_{k\,=\,DAY1\text{-}DAY7}$	Sunday through Saturday, respectively (1 if yes; 0 if no)
$D_{k\,=\,MTH1\text{-}MTH12}$	January through December, respectively (1 if yes; 0 if no)
$D_{k\,=\,YEAR98\text{-}YEAR05}$	Years 1998 through 2005, respectively (1 if yes; 0 if no)
$D_{k\,=\,EXPAND}$	Expanded seating area for firm C in 2004 (1 if year 2004 or 2005; 0 if not)

Table 2-2. Descriptive statistics for continuous variables

Variable	N	Mean	Standard deviation	Minimum[a]	Maximum
$Y_{i\,=\,Firm\ A}$	2,023	$2,626	$1,312	$0	$7,947
$Y_{i\,=\,Firm\ B}$	2,025	$24,347	$11,677	$0	$80,868
$Y_{i\,=\,Firm\ C}$	2,023	$6,357	$2,918	$0	$16,589
$X_{j\,=\,TEMP}$	2,032	72.0 ºF	9.2 ºF	36.4 ºF	87.5 ºF
$X_{j\,=\,WIND}$	2,032	4.6 m/sec	2.7 m/sec	0 m/sec	18.4 m/sec

[a] A zero CPI-adjusted daily sales corresponds to closures during hurricanes, which are captured with the $X_{j\,=\,STORM}$ variable. The incidence of tropical storms and hurricanes as noted by the manager are shown in Table 2-3.

Table 2-3. Environmental data by firm reported as the number of days observed

	Red tide ($X_{j = RTIDE}$)			Rain ($X_{j = RAIN}$)			Tropical storm/hurricane ($X_{j = STORM}$)		
Year	Firm A	Firm B	Firm C	Firm A	Firm B	Firm C	Firm A	Firm B	Firm C
1998[a]	0	0	0	2	2	2	1	1	1
1999	1	1	1	32	35	36	2	2	2
2000	0	0	0	39	40	39	1	1	1
2001	8	11	8	26	25	25	2	2	2
2002	4	5	5	48	51	51	1	0	0
2003	1	1	1	32	35	37	1	1	1
2004	1	1	1	50	49	51	4	4	5
2005	37	36	38	44	44	45	3	3	3
1999-05:									
Total	52.0	55.0	54.0	271.0	279.0	284.0	14.0	13.0	14.0
Mean	7.4	7.9	7.7	38.7	39.9	40.6	2.0	1.9	2.0

[a] Only November and December were included in the 1998 data.

Table 2-4. Estimation results by firm

	Firm A		Firm B		Firm C	
Variable	Coef.	Pr > |t|	Coef.	Pr > |t|	Coef.	Pr > |t|
Intercept	907***	0.0004	-268	0.9044	2,636***	<.0001
$X_{j\,=\,TEMP}$	18***	<.0001	114**	0.001	21**	0.0182
$X_{j\,=\,WIND}$	-44***	<.0001	-397***	<.0001	-111***	<.0001
$X_{j\,=\,RTIDE}$	-88	0.5808	-3,734**	0.0086	-868**	0.0118
$X_{j\,=\,RAIN}$	-604***	<.0001	-5,693***	<.0001	-1,719***	<.0001
$X_{j\,=\,STORM}$	-1,052***	0.0001	-5,056*	0.0296	-1,431**	0.0166
$D_{k\,=\,HOL}$	563***	<.0001	5,515***	<.0001	1,902***	<.0001
$D_{k\,=\,DAY1}$	923***	<.0001	7,624***	<.0001	2,013***	<.0001
$D_{k\,=\,DAY3}$	-72	0.2719	-401	0.4728	-74	0.6355
$D_{k\,=\,DAY4}$	-33	0.6146	279	0.6186	117	0.4562
$D_{k\,=\,DAY5}$	152*	0.0206	2,184***	<.0001	511**	0.0012
$D_{k\,=\,DAY6}$	844***	<.0001	9,874***	<.0001	2,162***	<.0001
$D_{k\,=\,DAY7}$	1,469***	<.0001	15,283***	<.0001	3,607***	<.0001
$D_{k\,=\,MTH2}$	1,024***	<.0001	9,397***	<.0001	2,703***	<.0001
$D_{k\,=\,MTH3}$	1,957***	<.0001	17,732***	<.0001	4,572***	<.0001
$D_{k\,=\,MTH4}$	1,625***	<.0001	16,639***	<.0001	4,433***	<.0001
$D_{k\,=\,MTH5}$	527***	<.0001	10,690***	<.0001	2,387***	<.0001
$D_{k\,=\,MTH6}$	-329*	0.0117	7,346***	<.0001	1,041***	0.0003
$D_{k\,=\,MTH7}$	-338*	0.0112	8,643***	<.0001	1,181***	<.0001
$D_{k\,=\,MTH8}$	-798***	<.0001	3,268**	0.0047	-107	0.7148
$D_{k\,=\,MTH9}$	-776***	<.0001	320	0.7853	-811**	0.006
$D_{k\,=\,MTH10}$	-271*	0.0259	4,895***	<.0001	500	0.0591
$D_{k\,=\,MTH11}$	217*	0.0326	5,153***	<.0001	654**	0.0032
$D_{k\,=\,MTH12}$	-315***	0.0006	1,895*	0.0205	-410*	0.0403
$D_{k\,=\,YEAR98}$			1,400	0.1971		
$D_{k\,=\,YEAR00}$			3,165***	<.0001		
$D_{k\,=\,YEAR01}$			4,854***	<.0001		
$D_{k\,=\,YEAR02}$			6,548***	<.0001		
$D_{k\,=\,YEAR03}$			8,194***	<.0001		
$D_{k\,=\,YEAR04}$			13,753***	<.0001		
$D_{k\,=\,YEAR05}$			13,566***	<.0001		
$D_{k\,=\,EXPAND}$					1,103***	<.0001

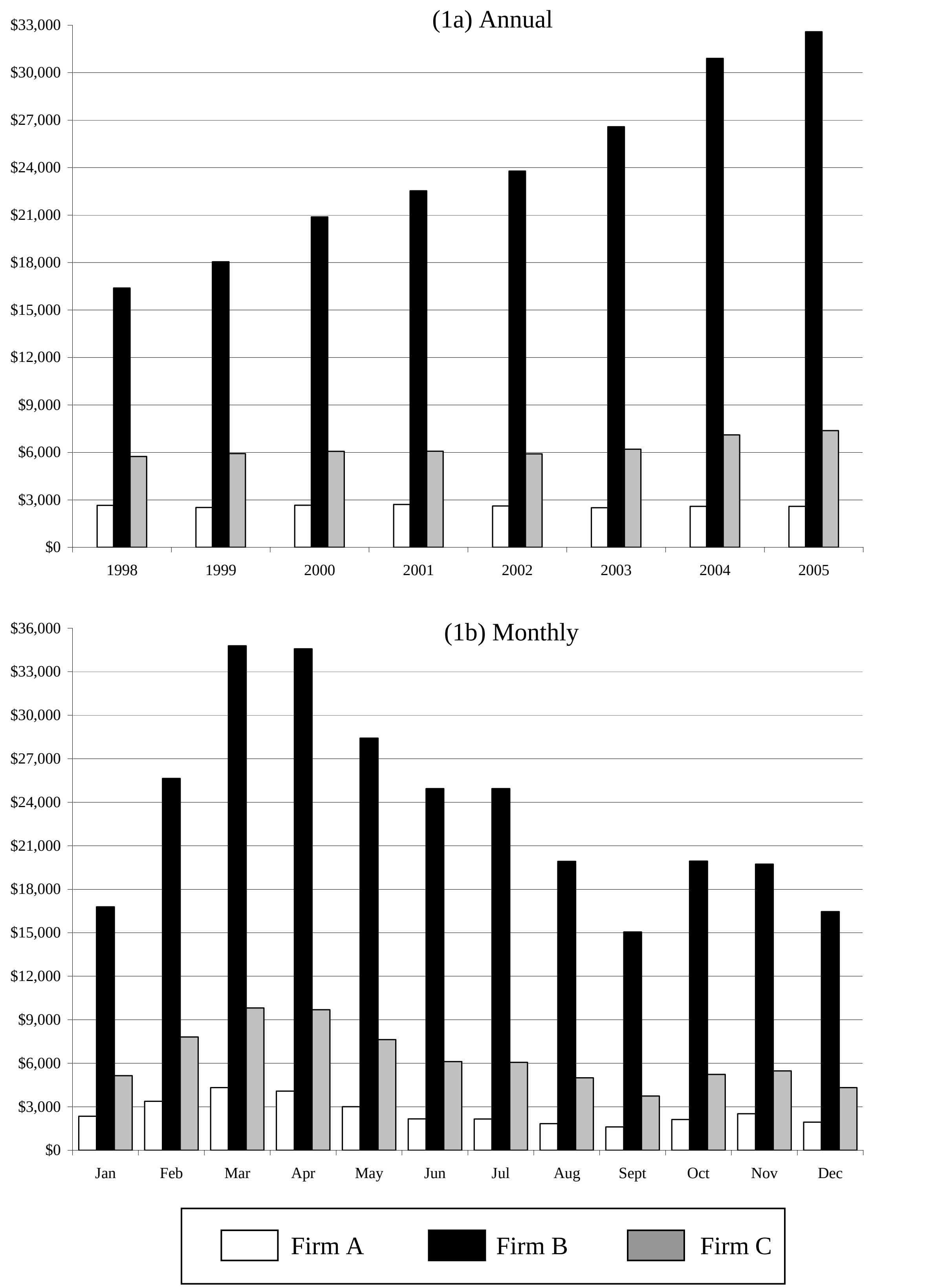


Figure 2-1. Average daily CPI-adjusted sales for each firm by year (a) and month (b), 1998-2005

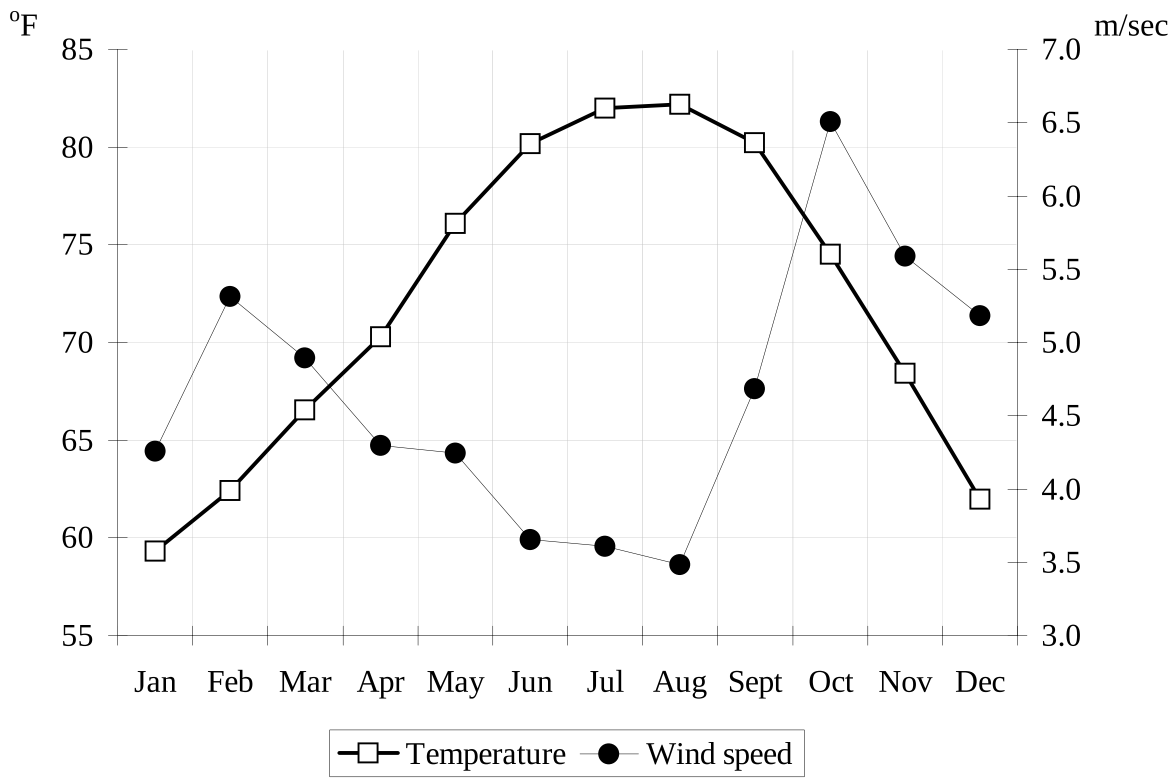


Figure 2-2. Average daily temperature and wind speed by month, Southwest Florida.

CHAPTER 3
RED TIDES AND PARTICIPATION IN MARINE-BASED ACTIVITIES: ESTIMATING THE RESPONSE OF SOUTHWEST FLORIDA RESIDENTS

Introduction

With over 22 million people participating in 2000, Florida was the number one destination for marine recreation in the United States (Leeworthy and Wiley). In particular, Florida led the nation as the number one saltwater fishing destination, with 4.7 million individuals spending 56 million days in 2000 (Leeworthy and Wiley). A review of literature provided a range of values from $60 to $100 for a day of recreational saltwater fishing day in Florida's Gulf Coast, generating potential annual non-market values ranging from $3.4 to $5.6 billion in 2000 (Kildow). Florida offers more than 4,500 marine fishing access points and more than 2,300 beach and shoreline access sites (Divers et al.). Aside from supporting a relatively large marine-based tourism industry, 77% of Florida's population resides in coastal counties (Kildow).

The continued attraction of Florida's marine recreational areas is predicated on the supply of high quality marine ecosystems that provide healthy beach and recreational experiences. For beaches in particular, poor water quality has been found to reduce the value of a trip to the beach (Freeman). For example, visitors to 23 beaches in the United Kingdom indicated that the scenery, bathing safety, and environmental quality (e.g., water quality and absence of sewage debris, litter and unpleasant odors) were the most important factors determining beach choice (Morgan). Ballance, Ryan, and Turpie found that cleanliness was the primary factor behind beach choice in Cape Peninsula, South Africa, and that up to 97% of the beach value could be lost by a decline in standards of cleanliness. While these results are likely not surprising, Pendleton, Martin and Webster found that residents of Los Angeles, California, predominantly viewed the ocean as a place of pollution, not for swimming despite several heavily advertised and successful clean-up campaigns; the authors concluded that the perceptions of coastal water quality may be influenced more by the media than with current coastal education campaigns.

Using a combination of travel cost surveys and public opinion polls, these studies confirm the importance of high-quality water and beach conditions to participants in marine-related activities. They also revealed the potential power of perception over proof with respect to residents' knowledge of local water conditions.

In perhaps the only study of the effects of red tide on recreation, Nunes and van den Burgh assessed the economic value of a program intended to prevent harmful algal blooms (HABs) at a famous beach resort in Holland. Following a joint travel-cost and contingent valuation approach, the program would be feasible if costs did not exceed 225 million Euro ($302 million in 2007). Their results also indicated that residents living closer to the beach placed a higher value on the HAB prevention program as compared to those that had relatively higher travel costs, which highlights the value of nature-based recreation to local residents.

While non-market valuation studies are necessary to evaluate policy proposals that improve environmental quality and, thus, recreational opportunities, information on actual behavioral responses is needed to accurately estimate any change in use values. For red tides in particular, this information is needed to justify continued expenditures on prevention, control and mitigation strategies.

Behavioral responses can be evaluated with choice modeling. In particular, random utility modeling (RUM) has been used extensively for this purpose, as evidenced by a recent summary of several recreational fishing site choice models that have been published over the last twenty years (Hunt). The majority of these models rely solely on the characteristics of the sites to explain the choice decision. Such a model specification entails the estimation of a conditional logit model (e.g., the choices are contingent upon the choice set, which complicates the estimation). If the choices are also hypothesized to depend on characteristics of the individual making the choice, then a mixed logit model is estimated. Alternatively, if the choices are believed to be driven solely by characteristics of the individuals, then it is most appropriate to estimate a multinomial (or generalized) logit model.

The underlying RUM methodology can be used to examine the behavioral response to a red tide event, which are either to cut short the activity (i.e., decide the conditions are too unpleasant and go home early), delay the activity (e.g., postpone it from today to tomorrow), or relocate by deciding to go further up or down the coast. Since these alternatives are not correlated in terms of their characteristics, the choice is assumed to solely depend on the preferences and constraints of the individual. Thus, multinomial logit modeling is used to examine behavioral response to red tide events in this paper.

This paper examines the behavioral response of individuals when faced with red tide conditions. Specifically, we want to know what factors affected the underlying decision of whether an individual reacted to a red tide event and, if they did, what factors determined whether they cut short, delayed, or relocated their participation in each activity. Using data from residents of two Southwest Florida counties that have experienced the most red tides, probability based models are used to examine behavior both across all marine-based activities and for four specific activities, namely: beach going, fishing from a boat or pier, and patronage of coastal restaurants.

Results are important since resident responses are needed to estimate losses in recreational values associated with marine-based activities and to guide extension efforts. For red tide research in particular, results will be timely since red tides may be occurring with more frequency (Brand and Compton), and several potential control and mitigation strategies are currently under consideration (e.g., Casper et al.; Robbins et al.; Pierce et al.; Schneider, Pierce, and Rodrick). Red tide cell count measurements collated by scientists at the National Oceanic and Atmospheric Administration (NOAA) that were within six miles the shorelines of Manatee and Sarasota Counties revealed positive (greater than zero) cell counts in January, March, August and September of 2000. However, a search of five local newspapers revealed 75 articles which included the terms "Florida red tide", in the study area. These news articles appeared in every month of 2000 and ranged from three daily items each in March, July, August and November, up to 12 and 13 daily pieces in January and June, respectively.

Theoretical Model of Behavioral Choice

The theoretical models developed in our study are based on previous work concerning the rational choice perspectives of consumer behavior (McFadden, 1972). The underlying utility theory assumes individual i is faced with a set of K mutually exclusive choices. Following Gujarati (1995), the decision of the i^{th} respondent to make choice k depends on an unobserved utility index, U_{ik}, which is determined by the set M of explanatory variables. The larger the value of index U_{ik}, the greater the probability the respondent makes choice k. If individual i selects alternative k over alternative l, then we know that their utility from the former must have been larger than from the latter (i.e., $U_{ik} > U_{il}$). From this, we can assume that they would choose alternative k such that U_{ik} is the maximum utility choice among K choices, and therefore the statistical model is driven by the probability that choice k is made:

$$Pr[U_{ik} > U_{il}] \text{ for all other } k \neq l \qquad (3\text{-}1)$$

To represent actual consumer behavior we compute the probability that $U_{ik} > U_{il}$ from the cumulative logistic distribution function. Assumption of logistic distribution of the disturbances produces a logit model, which provides parameter estimates and reveals information on the unobservable utility. Logit transformations are linear in the explanatory variables, while the probabilities are nonlinear, which allows for dichotomous response variables that take values ranging from 0 to 1. The multinomial logit model for a consumer's choice is, then:

$$Y_{i,k}^{*} = \sum_{m=1}^{M} \beta_{i,m} X_{i,m} + \varepsilon_{i,k} \qquad (3\text{-}2)$$

where Y^* represents the choice k made by the i^{th} respondent. As specified, the utility received by individual i from selecting k is composed of a deterministic and random component (βX and ε, respectively). The random error term is included to capture any unobserved characteristics that might have influenced the probability and is assumed independent of the remaining probabilities. Parameter estimates are computed by maximizing the log-likelihood function such that the probability of observing the actual choices is maximized. For ease of determining the effect of a change in one of the explanatory variables on the likelihood of a choice, the marginal effects were calculated for both continuous and dummy variables. Following Greene, marginal effects for dummy variables "…generally produce a reasonable approximation to the change in the probability that Y equals 1 at a point such as the regressor means."

An Application to Red Tide Events

Data

A total of 1,006 households in Sarasota and Manatee Counties in Southwest Florida were selected by random digit dialing in early 2001. One adult within each household was then randomly selected by asking to speak with the person over the age of 18 whose birthday was closest to the day of the interview. A call back procedure was employed to speak only with the selected adult. Of those 1,006, 894 were aware of the term “red tide” and, as such, represent the population of residents potentially impacted by such events.

Respondents were asked about their general awareness of red tide events and their level of participation in four activities during the previous 12 months, namely: (1) saltwater fishing from a boat, (2) saltwater fishing from a pier or beach, (3) beach-going, and (4) patronage of restaurants located near the beach or bay front areas. Several questions where asked to ascertain their level of knowledge concerning red tides in addition to traditional socio-economic information. Collectively, these variables will be used to explain how (if at all) a resident reacted to a red tide in terms of altering their participation in, or their reaction to, such events.

A total of 755 respondents reported participating in at least one of the four activities during the previous year and, thus, constitute the sample used in this analysis. Of this total, 80% reported being full-time residents in the study area and the average length of residency in Florida was 16 years (Table 3-1). Seventy percent of all interviewees spent at least some time in college, while 18% reported a gross annual household income of at least $75,000. Respondents averaged 55 years old, but the range of reported ages reveals significant variation (i.e., 18 to 89 years old).

Of the 755 respondents with complete information (with the exception of income), 663 residents or 88% indicated that they frequented restaurants located near coastal waters at least once per month. A majority of residents (76%) indicated that they had spent at least one day engaged in beach-going activities during the previous 12 months. Thirty-one percent and 28% enjoyed saltwater fishing from a pier or boat, respectively, of all residents interviewed in the two counties.

Overall, 66% of the sample indicated that the presence of a red tide event impacted their participation in at least one of the four marine-based activities during the previous 12 months.

Residents' reactions to a red tide bloom were relatively minimal among restaurant patrons and much stronger for beach-goers, ranging from 37% to 70%, respectively (Figure 3-1). Respondents who reacted were asked to identify how red tide altered their participation in each activity. For those engaged in beach-going, boat or pier fishing, respondents were asked if they "cut short", "delayed", or "relocated" when a red tide event occurred, while restaurant patrons were asked only to specify whether they "delayed" or "relocated" their dining experiences.

Overall, across the beach going and fishing activities, the majority of respondents (56% to 58%) delayed their participation. An additional 18% to 26% stated that they relocated to another area when faced with a red tide occurrence at their original destination. Another 17% to 24% indicated that a red tide bloom forced them to cut short their participation. For restaurant patrons, 64% stated they relocated and 36% chose to delay their dining experience.

Empirical Models

The empirical analysis began with the specification of the underlying dichotomous choice model to explain the probability that an individual's participation in any one of the four marine-based activities will change during a red tide. Since we are using stated behavior data, the model will explain the probability that individual i reacted to a red tide ($REACT_i$) by either cutting short, delaying, or re-locating any of the four activities in the past 12 months. To further refine the results, the model was re-estimated for each of the four activities to test whether specific explanatory factors had a unique affect on an individual's participation in a given activity during a red tide ($REACT_{i,j}$). Lastly, a multinomial logit model was estimated for each activity to explain the choice of reaction, which could be either to cut short the trip, delay the trip, or relocate ($REACT_{i,j,k}$). We hypothesize that certain individual characteristics constrain the behavioral choice (i.e., reaction) and the relative importance of such characteristics is likely to differ by activity.

A total of 15 explanatory variables were hypothesized to affect the reaction (X) and are categorized into three types of variables: those designed to capture differences in demographic characteristics (D), levels of participation in the various activities (A) and levels of knowledge with respect to red tides (K). The seven demographic variables included whether the individual was a full-time resident of the study area (D_FULL), the number of years they have lived in Florida (D_YRS), whether they were male (D_GEND), whether they had any college education (D_COLL), how old they were (D_AGE), whether they were Hispanic (D_HISP), and whether their household income was at least $75,000 last year (D_INC). Given that information on income was only available from a sub-set of the sample (569 of the 755 total), the first model that explains whether the respondent reacted (regardless of the activity) was estimated with and without income.

Whether an individual reacted (or not) to a red tide event, especially for each activity (j), is also hypothesized to depend on how often they participated in each activity. Thus, the initial model to explain a reaction across all activities is assumed to depend on the number of activities (J = 4) that they participated in during the previous year (A_NUM). In the subsequent models for each activity, this total was replaced with the average monthly level of participation during the previous year ($A\_{j\ activity}$).

Finally, three variables were created to capture each individual's knowledge level with respect to red tide. The first, K_INFO, is the number of distinct red tide information sources; it is essentially the modes of information (e.g., television, newspaper, workshops, Internet, etc.) that the respondent has used for red tides. The second, K_DESC, is the number of red tide effects that the respondent could list. It was an open-ended question and all answers were unprompted. It is assumed to be a proxy for what the individual thinks s/he knows about red tides. In contrast, the third and final variable, K_REDT, is the number of correct true-false questions on the biology and human health impacts of red tide events. This variable tests for actual knowledge about red tide events.

All models were analyzed using the LIMDEP statistical software package. LIMDEP develops starting values from the average of an initial ordinary least squares regression. The Newton-Raphson iterative algorithm was then used to calculate maximum likelihood estimators that were unbiased, consistent, and asymptotically normal (Amemiya). Parameter estimates are presented in terms of the marginal effects, where the partial derivatives of the cumulative distribution function with respect to the vector of characteristics were computed at the means of the explanatory variables.

Hypotheses

Since red tide blooms vary greatly in their extent, location, duration, and unpleasant side effects, full-time residents or those that have lived in Florida longer were expected to have a higher probability of a reaction (e.g., decide not to participate in a marine-related activity). Having college experience or being in the highest income category could identify full-time employees with the ability to pay for a change in plans (i.e., react) but not the time (do not react since cannot reschedule), so the expected signs of the coefficients are ambiguous. As individuals age, increased health concerns are expected to increase the probability of a reaction since this demographic is likely to have a more sensitive respiratory system. Those individuals that participate in more activities are expected to have an increased likelihood of reacting to the presence of a red tide since they are more likely to encounter red tides. Higher values for all three of the knowledge variables were expected to increase the probability that a resident would change their behavior and deviate from their normal participation levels in an activity during a red tide. This is because what has been written about red tide, especially in the popular press, has traditionally focused on the negative economic consequences.

Empirical Results

A general review of overall model test statistics revealed satisfactory levels of statistical significance. For all models, (reactions across activities, reactions within each activity, and type of reactions within each activity), convergence was achieved within five iterations. The coefficient estimates for each model maximized the value of the log-likelihood functions, *ln L*, which ranged from -91.80 to -307.55 across all models. Overall, the estimated models correctly predicted respondent reaction choices of 0 and 1 between 56% and 75% of the time (where predicted values equal to one when the probability exceeded a threshold level of 0.500 and zero otherwise) indicating reasonable performance across models. Marginal effects expressions for the parameters were computed at the sample means of the explanatory variables.

Reaction Across Activities

The dependent variable REACTi represented whether respondent i's participation in at least one of the four marine-based activities in the study had been affected by a red tide event. To determine whether missing income data was an empirical problem, two models were estimated: one with and one without income (D_INC). The results indicated that the coefficients were robust to the inclusion of income as a regressor (Table 3-2). Nevertheless, as income is theoretically expected to affect response, and since there are a sufficient number of observations remaining, we retain the use of the D_INC variable in lieu of increased observations.

One of the most notable results was the lack of statistical significance of any of the demographic variables, including income, in this model. The only statistically significant variables were those that indicated either the number of activities the respondent participated in, the number of red tide effects they could list, or the number of accurate red tide statements the respondent identified. These results highlight the importance of a respondent's participation in multiple activities and his/her ability to describe the effects of a red tide event, both unprompted and the correct responses to a set of questions. There was a 13.5% increase in the probability (in absolute value) that a resident was affected by the presence of red tide for each increase in the total number of marine-related activities s/he participated in during the previous year. For a resident that was able to accurately recall an additional red tide effect, that individual was 10.1% more likely (in absolute value) to have their participation impacted by a red tide bloom (i.e., they decide to either cut short, delay or relocate). Correct identification of an additional true-false statement resulted in a 2.5 percentage point increase in the likelihood that this resident altered their marine-related activity involvement during a red tide.

Reaction by Activity

Replacing the total number of activities (A_NUM) with the level of participation for a given activity (A_j activity), allows us to explain differences in choice regarding whether to react (i.e., change participation) for each activity during a red tide. Estimation results are in Table 3-3.

Only three of the demographic variables were statistically significant in any one of the four models: the number of years residing in Florida (D_YRS), whether the respondent was a full-time resident of Florida (D_FULL), and whether gross household income was at least $75,000 in the previous year (D_INC) (Table 3-3). Overall, each additional year of residence increased the probability of a reaction by 0.4 percentage points (or 4 percentage points for each 10 years of residence). Residents in the higher income group had a 28.6 percentage point lower probability of having their pier fishing activities affected by a red tide event. Restaurant patrons that lived in the area year-round were 13.4 percentage points more likely to respond that red tide events affected their patronage of beach or bayside restaurants.

As hypothesized, the level of participation in each activity affected the probability that respondents were affected by red tide events, with the exception of boat fishing. This is, perhaps, obvious as boats can easily be moved to better conditions. In contrast, each additional day of pier fishing per month increased the probability of a red tide affecting their pier fishing activities by 4.1 percentage points, or 9.0, at the average participation level.

As was evident in the overall model, those individuals that were able to accurately describe red tide effects without prompting had a higher probability of having their beach-going, boat fishing and restaurant patronage affected by a red tide; probabilities increased by 7.1 to 9.7 percentage points for each effect they provided. The more knowledgeable the respondent, the higher probability their beach-going activities would be affected by a red tide. At the average number of correct responses (compared to someone that knew nothing), the probability of an effect on beach-going increased 37.4 percentage points. Finally, restaurant patrons that reported having more red tide information sources had a 5.1% higher probability (in absolute terms) of having their participation altered during a red tide for each source.

Type of Reaction by Activity

The dependent choice variable in these models represented the multiple options for how respondents reacted to red tide events for each marine-related activity. The choice of reactions included “delay”, “cut short”, or “relocate” for the beach-going, boat fishing, and pier fishing activities. The restaurant patrons were limited to two choices, either delay or relocate, as it was assumed that most consumers would not leave a restaurant once the dining location had been selected and food or drinks ordered. Results are presented in Table 3-4.

Beach-going residents who were able to accurately recall red tide effects without interviewer prompting were 5.0 percentage points more likely to cut short their day at the beach for each effect described, while male residents were slightly more likely (8.4 percentage points) to relocate to another beach that was unaffected by a red tide. Saltwater boat fishers that lived in the study area year-round were 35.8 percentage points less likely to cut short their excursion, as compared to part-time residents. Those residents with more knowledge of red tide effects were 11.2 percentage points more likely to delay their boat-fishing trips. Pier fishing residents with some college had a 21.7 percentage point increase in probability that they would cut short their fishing pursuits relative to those without college experiences. Restaurant customers with more red tide information sources were 5.7 percentage points more likely to select another location as compared to the option of delaying their dining experience when a red tide bloom was evident.

Summary and Discussion of Results

Using a model to explain a respondents overall reaction (or lack thereof) to a red tide event in terms of their participation in any one of four marine-based activities, revealed that the probability of a reaction (i.e., that an individual would react negatively by cutting short, delaying or relocating) increases with the number of activities they participate in and their knowledge level regarding red tides (measured either one of two ways). None of the demographic variables were found to have a statistically significant affect on this overall probability.

Better refinement of the analysis was accomplished through estimation of the probability of any reaction for each activity by replacing the number of activities with the average monthly level of participation in each activity. These results supported the conclusion that the probability of a reaction (and the associated factors) varies by activity.

The probability of a reaction for boat fishing was only affected by how many red tide effects the individual could describe: the more effects listed (such as fish kills and offensive odor) the higher the probability an individual will react (i.e., cut short, delay, or relocate). For beach or pier fishing, on the other hand, the more years of residence, lower income levels, and higher participation levels were statistically significant in explaining whether an individual would react. Higher probabilities of losses to restaurant patronage were supported for year-round residents, those that frequented restaurants more often, those that could describe more effects, and for those that had more information sources. Lastly, for the beach going activity, the residents who have lived in Florida the longest, spent more days at the beach on average, were able to recall accurate red tide effects, and were more knowledgeable of red tide effects were more likely to react.

In terms of what can be done to help mitigate potential losses from red tide events, the knowledge-related variable results are further evaluated using figures to facilitate comparisons and highlight the magnitude of the results. The number of red tide effects that respondents could describe without being prompted (K_DESC) serves as a proxy for what the they believe they know about red tides. Figure 3-3 shows that the probability of an effect on beach-going and the probability of boat fishing being affected (Figures 3-3a and 3-3b, respectively) are similar; the probabilities increase from about 50% to over 90% when individuals can list more than five red tide effects. The effect on probability for restaurant patronage reveals the same magnitude of increase, but at a lower overall probability (Figure 3-3c), which is to be expected given that restaurant patronage is lower overall.

These results (Figures 3-3a-c) can be contrasted with those of the variable that best describes what the individuals actually know as ascertained from their ability to correctly answer 17 true and false questions about the nature and health effects of a red tide bloom (K_REDT). Although the overall probability of a reaction is less sensitive (Figure 3-2c), the probability of beach-going being affected during a red tide (by individuals choosing to cut short, delay, or relocate) was only approximately 30% with one correct answer, however, this probability increased to over 60% with six correct answers and exceeded 90% with 15 correct answers

(Figure 3-2f). Continued comparison of the overall and beach-going models revealed similar sensitivity with respect to a resident's mention of red tide effects, where individuals that described one to five red tide effects resulted in higher probabilities of reacting of 50% to 90%, respectively (Figure 3-2b and 3-2e). Respondents engaged in at least one activity had a 50% probability of reacting to a red tide that increased to over 90% with participation in all four activities (Figure 3-2a), and those that spent a single day on average at the beach had a 70% probability of reacting to a red tide (Figure 3-2d).

The final empirical analyses estimated the probabilities of specific reactions, namely, whether an individual would cut short, delay or relocate their participation in response to a red tide. Notably, some additional demographic variables were statistically significant at this finer level of resolution (Figure 3-4); males had a higher absolute probability of relocating their beach-going activities and a higher probability of relocation away from a waterfront restaurant. Individuals that were over age 55 had a slightly lower probability of relocating to another restaurant. Those individuals that had attended some college were more likely to cut short fishing from a pier. Full time residents were, perhaps the least impacted; the probabilities of cutting short a boat fishing trip or of relocating patronage of a restaurant were less. Figure 3-4 also shows the impact of red tide information sources and how much residents think they know; the former increased the probabilities of delaying a boat fishing trip or relocating restaurant patronage, the latter increased the probability of cutting short a beach trip.

Conclusions

This paper examined how red tide effects have influenced Sarasota and Manatee county residents' participation in four marine-related activities. The findings suggest potential areas where public management prescriptions may be used to influence how a resident engaged in marine-related activities chooses to react to the presence of a red tide. This is especially relevant since such information could serve to mitigate losses caused by red tides.

The share of residents surveyed that were affected by red tide events ranged from a low of 37% for restaurant patronage to a high of 70% for beach going; this is not surprising as beach going entails more interaction with affected waters and aerosolized toxins. The more information sources an individual had, the more likely they were to delay their patronage or go somewhere else during a red tide. A respondent’s existing knowledge of red tide effects (whether true or not) was associated with a higher probability of being affected across activities, and especially for beach-going. What a respondent actually knew, however, had no affect on the probability of a reaction for restaurant patronage. The boat fishers that live in the area year-round were less likely to cut short their trip, perhaps due to their familiarity with these naturally-occurring red tides, and/or their ability to drive the boat away from affected waters into better fishing territory.

These findings offer strong support for provision of extension materials targeted towards residents engaged in marine-related activities. Public managers may affect awareness and, therefore, participation decisions by providing information where conditions are optimal for beach-going as opposed to information on where conditions may be unpleasant or even harmful. Such reports are analogous to daily alpine ski reports, although providing them for red tides is more complicated in that bloom effects are not limited to a single, isolated beach location. That said, coastal communities offer a variety of nature-related activities that could be included such reports. These types of education activities may foster an atmosphere where coastal populations are protected from the negative aspects of a red tide bloom, while simultaneously encouraging residents to frequent alternative, unaffected, local marine-related businesses and therefore retain consumer spending in the area.

Table 3-1. Variable names, descriptions and statistics (n = 755)

Variable	Description	Min	Max	Mean	Std dev[a]
REACT	Participation altered in any marine activity due to the presence of a red tide? (1 if yes, 0 if no)	0	1	0.66	N/A
Demographic:					
D_FULL	Full time resident (1 if 12 mo./year, 0 if not)	0	1	0.80	N/A
D_YRS	Duration of residency (years)	1	76	16.24	13.20
D_GEND	Respondents gender (1 if male, 0 if female)	0	1	0.41	N/A
D_COLL	Formal education includes at least some college (1 if yes, 0 if no)	0	1	0.70	N/A
D_AGE	Respondents age (years)	18	89	55.00	16.58
D_HISP	Respondent is Hispanic (1 if yes, 0 if no)	0	1	0.04	N/A
D_INC[b]	Annual income $\geq$ $75,000 (1 if yes, 0 if no)	0	1	0.18	N/A
Activities:[c]					
A_NUM	Participation in marine-related activities (number)	1	4	2.24	0.98
A_*j activity*	Participation level in activity *j* (number per mo.)				
	A_BCH: *j* = *beach-going* (avg. days/mo.)	0.1	30.4	3.45	5.52
	A_BFSH: *j* = *boat fishing* (avg. days/mo.)	0.1	30.4	2.06	4.44
	A_PFSH: *j* = *pier fishing* (avg. days/mo.)	0.1	30.4	2.19	4.32
	A_REST: *j* = *restaurant patronage* (meals/mo.)	1	52	3.44	5.16
Knowledge:					
K_INFO	Information sources about red tide (number)	0	7	2.41	1.27
K_DESC	Description of red tide (number of effects listed)	0	6	2.12	1.08
K_REDT	Knowledge of red tide (number correct of 17)	0	16	9.35	2.59

[a] N/A indicates that the statistic is not applicable to this variable.
[b] As a result of non-responses or refusals, n = 569 for this variable.
[c] Beach going, boat fishing, pier fishing, and restaurant patronage were enjoyed by n = 576 (76%), 215 (28%), 236 (31%), and 663 (88%) of the respondents, respectively.

Table 3-2. Marginal effects for factors hypothesized to influence whether a resident's participation in a marine-based activity is affected by a red tide ($REACT_i$)

	Marginal effects (n = 569)		Marginal effects (n = 755)	
Variable	Coefficient[a]	Standard error	Coefficient[a]	Standard error
Constant	-0.503*	0.153	-0.484*	0.131
Demographic:				
D_FULL	0.063	0.060	0.050	0.050
D_YRS	0.0001	0.002	0.001	0.002
D_GEND	-0.045	0.043	-0.037	0.038
D_COLL	-0.001	0.045	-0.000	0.041
D_AGE	-0.002	0.002	-0.002	0.001
D_HISP	0.033	0.102	0.007	0.095
D_INC	-0.087	0.053	N/A	N/A
Activities:				
A_NUM	0.135*	0.024	0.147*	0.022
Knowledge:				
K_INFO	0.011	0.017	0.015	0.015
K_DESC	0.101*	0.022	0.085*	0.019
K_REDT	0.025*	0.009	0.021*	0.008

[a] A single asterisk (*) indicates statistical significance at the 5% level.

Table 3-3. Marginal effects and standard errors (in parentheses)[a] for factors hypothesized to influence whether a resident's participation in each marine-based activity is affected by a red tide ($REACT_{ij}$)

Variable	Activity *j*			
	Beach-going (n = 438)	Boat fishing (n = 173)	Pier fishing (n = 187)	Restaurant patronage (n = 495)
Constant	-0.366 (0.149)*	-0.086 (0.281)	-0.574 (0.287)*	-0.595 (0.156)*
Demographic:				
D_FULL	0.008 (0.062)	0.199 (0.141)	0.226 (0.130)	0.134 (0.059)*
D_YRS	0.004 (0.002)*	0.002 (0.003)	0.008 (0.003)*	0.002 (0.002)
D_GEND	-0.051 (0.046)	-0.070 (0.078)	-0.094 (0.083)	-0.004 (0.046)
D_COLL	-0.021 (0.050)	-0.017 (0.084)	0.083 (0.099)	0.028 (0.052)
D_AGE	-0.002 (0.002)	0.002 (0.003)	0.003 (0.003)	0.001 (0.002)
D_HISP	-0.034 (0.118)	0.017 (0.146)	-0.155 (0.179)	0.152 (0.118)
D_INC	-0.076 (0.055)	-0.134 (0.101)	-0.286 (0.087)*	-0.054 (0.052)
Activities:				
$A\_{j\ activity}$	0.019 (0.006)*	0.018 (0.012)	0.041 (0.016)*	0.0003 (0.0001)*
Knowledge:				
K_INFO	-0.002 (0.018)	-0.002 (0.033)	0.019 (0.032)	0.051 (0.019)*
K_DESC	0.097 (0.022)*	0.076 (0.039)*	0.066 (0.040)	0.071 (0.023)*
K_REDT	0.040 (0.009)*	-0.019 (0.016)	-0.005 (0.017)	0.003 (0.010)

[a] A single asterisk (*) indicates statistical significance at the 5% level.

Table 3-4. Marginal effects and standard errors (in parentheses)[a] for factors hypothesized to influence the reaction of a resident (*k*) for activity *j* whose participation has been affected by a red tide ($REACT_{ijk}$)

Activity *j*	Reaction *k*		
Variable	Cut-short	Delay	Relocate
Beach-going (n = 312):			
Constant	-0.243 (0.179)	0.450 (0.205)*	-0.207 (0.154)
D_FULL	-0.057 (0.074)	-0.054 (0.089)	0.112 (0.075)
D_YRS	-0.001 (0.002)	0.001 (0.002)	-0.0003 (0.002)
D_GEND	-0.036 (0.052)	-0.048 (0.059)	0.084 (0.043)*
D_COLL	-0.044 (0.058)	0.055 (0.067)	-0.010 (0.051)
D_AGE	0.0004 (0.002)	-0.001 (0.002)	0.001 (0.002)
D_HISP	0.030 (0.133)	-0.138 (0.153)	0.108 (0.094)
D_INC	-0.005 (0.060)	-0.042 (0.068)	0.047 (0.050)
A_BCH	-0.006 (0.006)	0.003 (0.006)	0.003 (0.004)
K_INFO	-0.023 (0.020)	0.032 (0.023)	-0.009 (0.017)
K_DESC	0.050 (0.024)*	-0.035 (0.028)	-0.014 (0.021)
K_REDT	0.019 (0.011)	-0.012 (0.013)	-0.007 (0.010)
Boat fishing (n = 109):			
Constant	0.374 (0.325)	0.002 (0.400)	-0.375 (0.332)
D_FULL	-0.358 (0.156)*	0.310 (0.215)	0.048 (0.181)
D_YRS	0.003 (0.003)	-0.001 (0.004)	-0.002 (0.004)
D_GEND	0.013 (0.086)	-0.170 (0.107)	0.167 (0.094)
D_COLL	0.024 (0.088)	-0.106 (0.113)	0.082 (0.099)
D_AGE	-0.004 (0.003)	0.003 (0.004)	0.001 (0.003)
D_HISP	0.085 (0.169)	-0.214 (0.217)	0.129 (0.165)
D_INC	-0.224 (0.140)	0.095 (0.149)	0.130 (0.113)
A_BFSH	-0.016 (0.016)	0.018 (0.015)	-0.002 (0.011)
K_INFO	-0.069 (0.037)	0.112 (0.045)*	-0.043 (0.037)
K_DESC	-0.018 (0.041)	-0.028 (0.049)	0.045 (0.040)
K_REDT	0.022 (0.018)	-0.029 (0.023)	0.007 (0.019)

Table 3-4. Continued.

Activity *j*	Reaction *k*		
Variable	Cut-short	Delay	Relocate
Pier fishing (n = 101):			
Constant	-0.373 (0.253)	0.630 (0.393)	-0.257 (0.373)
D_FULL	0.075 (0.144)	-0.392 (0.226)	0.316 (0.238)
D_YRS	0.001 (0.002)	0.0003 (0.004)	-0.001 (0.003)
D_GEND	0.005 (0.071)	-0.079 (0.107)	0.074 (0.100)
D_COLL	0.217 (0.098)*	-0.150 (0.138)	-0.067 (0.125)
D_AGE	-0.0004 (0.003)	-0.001 (0.004)	0.001 (0.004)
D_HISP	0.104 (0.172)	-0.357 (0.294)	0.253 (0.234)
D_INC	-0.161 (0.098)	0.115 (0.134)	0.047 (0.123)
A_PFSH	-0.001 (0.009)	-0.004 (0.011)	0.005 (0.010)
K_INFO	-0.034 (0.026)	0.016 (0.037)	0.018 (0.034)
K_DESC	0.008 (0.031)	-0.008 (0.048)	-0.001 (0.044)
K_REDT	0.011 (0.017)	0.006 (0.024)	-0.018 (0.022)
Restaurant patronage (n = 190):[b]			
Constant	N/A	N/E	0.421 (0.278)
D_FULL	N/A	N/E	-0.184 (0.094)*
D_YRS	N/A	N/E	0.005 (0.003)
D_GEND	N/A	N/E	0.226 (0.074)*
D_COLL	N/A	N/E	0.101 (0.094)
D_AGE	N/A	N/E	-0.008 (0.003)*
D_HISP	N/A	N/E	-0.201 (0.171)
D_INC	N/A	N/E	0.118 (0.086)
A_REST	N/A	N/E	0.0002 (0.0002)
K_INFO	N/A	N/E	0.057 (0.028)*
K_DESC	N/A	N/E	0.021 (0.037)
K_REDT	N/A	N/E	-0.016 (0.017)

[a] A single asterisk (*) indicates statistical significance at the 5% level.
[b] N/A indicates that the reaction was not applicable to this activity,; N/E indicates that the reaction was not explicitly estimated for this activity; delay was the base category.

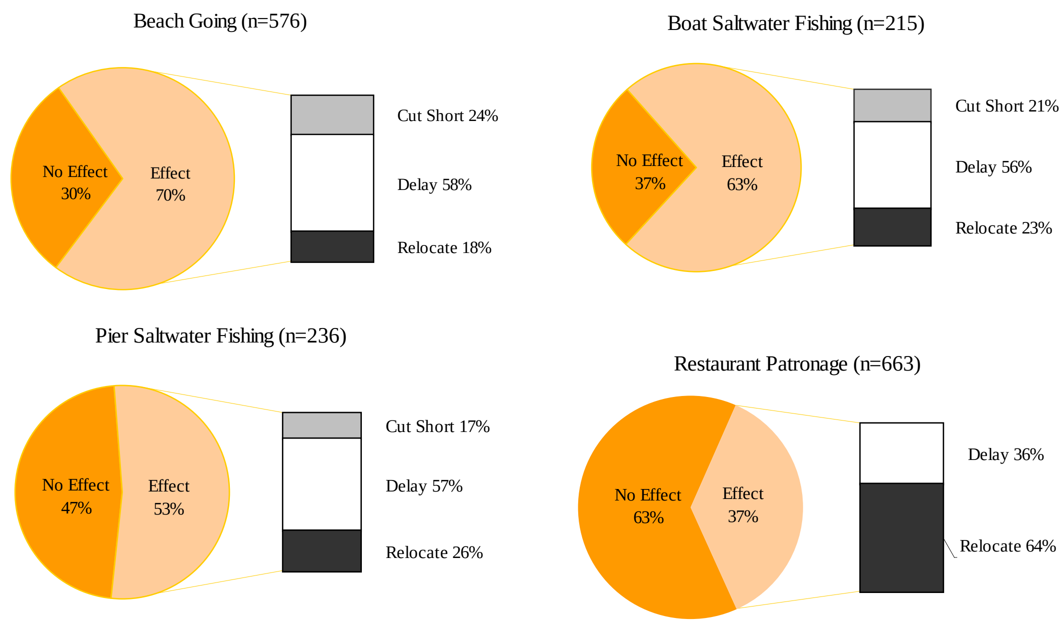


Figure 3-1. Reaction of residents (n = 755) to red tide events by marine-based activity (*j*)

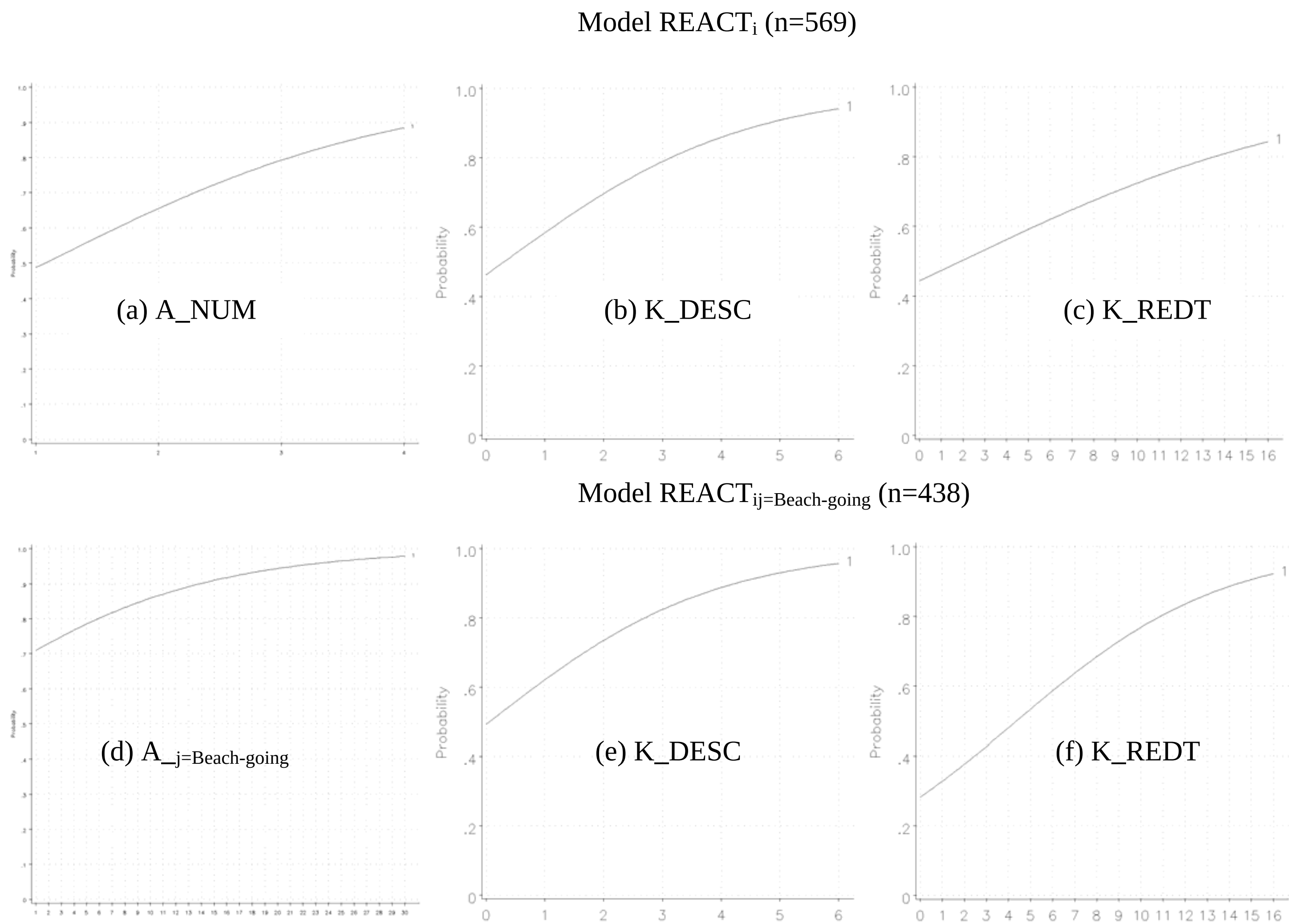
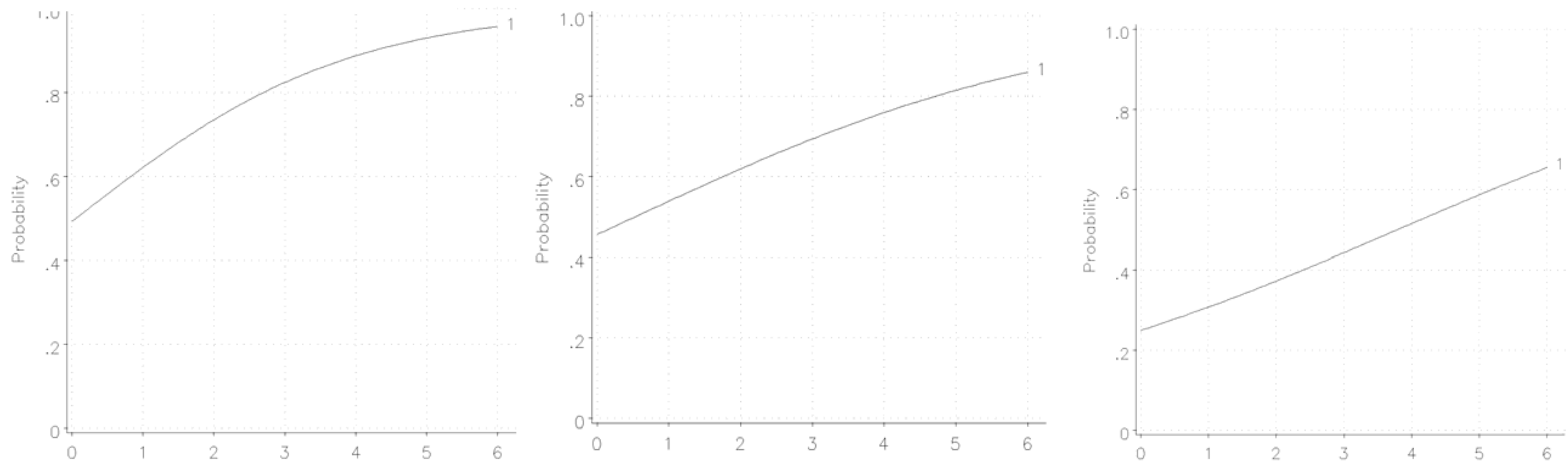


Figure 3-2. Predicted probabilities of participation in any activity (REACT$_i$) and beach-going (REACT$_{ij=\text{Beach-going}}$) due to a red tide event by the number of activities (A_NUM, fig. a) and the average participation days (A_$_{j\ \text{Beach-going}}$; fig. d), respectively, the red tide effects the respondent described (K_DESC; figs. b and e), and the number they know correctly (K_REDT; figs. c and f)

(a) $\text{REACT}_{ij=\text{Beachgoing}}$ Model
(n = 438)

(b) $\text{REACT}_{ij=\text{Boatfishing}}$ Model
(n = 173)

(c) $\text{REACT}_{ij=\text{Restaurant Patronage}}$ Model
(n = 495)



Number of red tide effects the resident described (K_DESC)

Figure 3-3. Predicted probability of participation in (a) beach-going, (b) boat fishing, and (c) restaurant patronage due to a red tide event by the number of red tide effects the resident described (K_DESC)

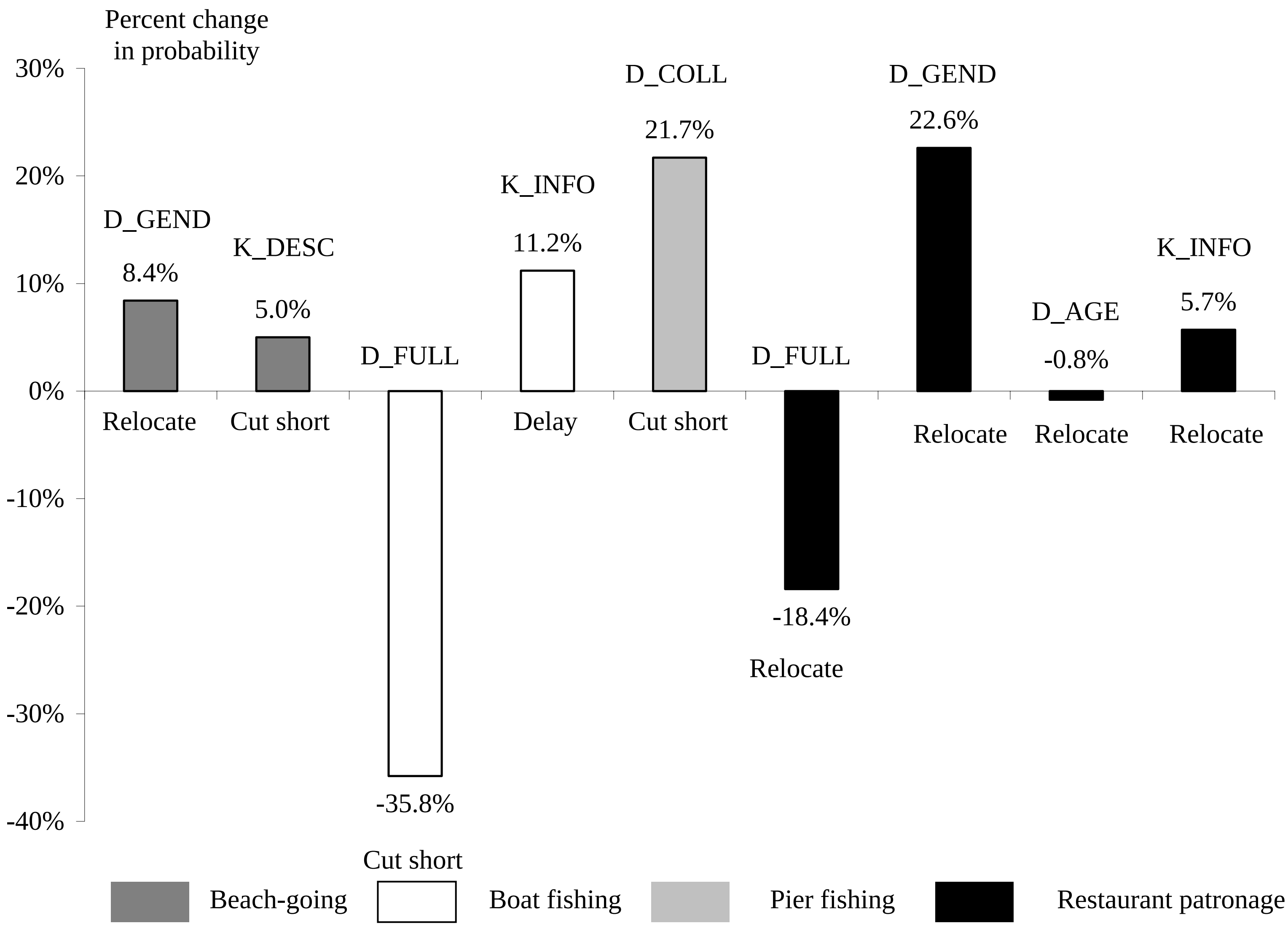


Figure 3-4. Change in predicted probability of response by marine-based activity for selected statistically significant variables

CHAPTER 4
PUBLIC COSTS OF FLORIDA RED TIDES: A SURVEY OF LOCAL MANAGERS

Introduction

Florida’s attractive climate has served as a motivating force behind its past, present and predicted population and tourism growth. Between 1990 and 2000, the state’s population grew by more than three million people, a 23.5% increase, and this trend is expected to continue with the influx of migration from other states (Perry and Mackun). Overall, 77% of Florida’s population resides in coastal counties and these areas accounted for an estimated $402 billion, or 77%, of the state’s overall economy in 2003 (Kildow).

As a popular tourist destination, Florida hosted 77.2 and 6.4 million domestic and international visitors (respectively) in 2005 (VISIT FLA). In 2000, Florida was the number one U.S. destination for at least one of 19 types of marine recreation including beach visitation, swimming, snorkeling, and scuba diving, and its beaches alone attracted more than 15 million U.S. tourists (Leeworthy and Wiley).

Changnon noted that the increasing movement of the population to coastal areas has increased coastal consumer and business exposure, which in turn, has increased the economic impacts of naturally-occurring environmental stressors. Harmful algal blooms (HABs) are one such stressor and the coastal waters of Florida host many indigenous species of marine algae, including *Karenia brevis*, which produces blooms known as “red tides”.

Florida has long been familiar with these naturally-occurring red tides, with the earliest recorded event noted over 150 years ago (Fish and Wildlife Research Institute [FWRI]). The causative agent, *Karenia brevis*, is known to produce a suite of as many as nine toxins, which are released in the water column and can kill marine life (Baden et al.). Red tide blooms contaminate shellfish beds and present public health concerns due to decomposing marine life on beaches, and the possibility of neurotoxin shellfish poisoning (NSP) if contaminated shellfish are ingested (Steidinger et al.; Flewelling et al.). Coastal wind conditions may exacerbate an algal bloom, and result in the release of airborne toxins that have been measured up to three miles inland on populated beach areas (Kirkpatrick, B., personal communication, Mote Marine Laboratory, 22 August 2006), where humans may experience eye, nose, and respiratory irritation (Backer et al.; Kirkpatrick et al., 2004).

A 2001 report submitted by the National Oceanic and Atmospheric Administration's National Sea Grant College Program to the Committees on Appropriations suggested national and local socio-economic impacts of red tide events that need to be quantified and addressed in order to develop efficient, timely management responses. The report stated that research efforts are needed to determine the nature and extent of private and public sector interactions in the case of a HAB event. Once these affected areas and corresponding issues are identified, accurate and efficient management decisions and aid estimates could be calculated and implemented at both the local and national levels.

Study Objective

To our knowledge, no studies have attempted to quantify costs incurred by resource managers to address the impacts caused by red tides, despite the need for resource allocation decisions. The overall objective of our study was to solicit specific information on costs associated with red tide blooms from municipal and county-level managers located on Florida's Gulf Coast.

This study was intended to quantify public expenditures and procedures resulting from red tide-related management and mitigation issues which have affected publicly managed beaches. Respondents were queried to determine which county or municipal departments are responsible for beach and red tide management, their budget sources and allocations, the existence and types of public relations efforts, and actual red tide-related beach cleaning protocols. This study sought to improve on previous analysis of direct HABs costs to the public by targeting a larger geographic region and using a standardized survey instrument. It is expected that the results of the survey effort will provide estimates of red tide-related expenditures incurred by local governments that can be used to guide financial planning for other public agencies.

Study Area

The total population for each county ranged from approximately 11,000 in Franklin to 905,000 in Pinellas, with an average of 307,000 persons (Table 4-1). Lee and Collier counties each experienced population growth rates exceeding 20% from 2002 to 2005. Manatee, Sarasota, and Charlotte also witnessed an influx of residents over this same time period, with populations increasing by 13.9%, 10.4% and 9.5%, respectively. Pinellas was the only county that experienced a negative growth rate, less than two percent, from 2002 to 2005.

Okaloosa County hosted nearly three million visitors in 2005 (Table 4-2), with slightly fewer visiting Pinellas and Lee counties, which received 2.4 and 2.3 million domestic visitors, respectively (VISIT FLA). Sarasota and Collier each attracted more than one and half million tourists in 2005, while Manatee saw 770,000 visitors to its area. Due to sample size constraints faced by the marketing agency, tourist estimates for Franklin, Gulf and Charlotte counties were not available.

With the exception of Franklin County, each of the remaining eight counties in the sample had some number of publicly managed beachfront, ranging from a maximum of 35 miles in Pinellas to a minimum of seven miles in Sarasota, for an average of nearly 17 miles (Table 4-3). While Sarasota had the fewest overall miles, it had nearly as many public access point, or parks, as Pinellas, with each having 30 and 31, respectively. Access to public beaches may be free or fee-based, and can include boardwalks, piers, jetties, parking lots, state parks, and in some cases are accessible by motorized vehicle. Each county's beaches exhibit a range of characteristics, from the sugar-white sands of the Panhandle beaches, the flat expanses in Pinellas, the barrier islands of Sarasota and Manatee, and the interwoven marshes of Collier.

To support the tourism industries in these regions, all of the counties collect tourist development taxes which are administered through the related Tourism Development Councils (Table 4-3). Tax rates ranged from two percent in Franklin to five percent in Pinellas, Charlotte, and Lee. The remaining five counties collected four percent in taxes on tourism-dependent business revenues. In total, FY 2005-06 tourist development collections ranged from $304,000 in Gulf, up to nearly $22 million in Pinellas, with an average of over $8 million across all nine counties. Lee and Collier ranked just behind Pinellas, with total tourist tax collections of $17 and $13 million, respectively. Okaloosa and Sarasota each collected just over $7 million and Manatee slightly less than $5 million annually.

Four of the counties indicated that at least 25% of annual tourism tax collections were earmarked for public beach management, maintenance, and improvements. In order to generate a scale of beach-related expenditures for each county, one-fourth of annual tourism tax collections were divided by miles of public beach managed by each county (Table 4-3). Tax collection records revealed that Sarasota and Lee Counties could spend $265,429 and $236,528, respectively, per mile of public beach. Pinellas and Collier Counties were each capable of allocating $164,023 and $148,364 per public beach mile.

Census population estimates ranged from the small community of North Redington Beach, with its 1,482 inhabitants, to the sprawling metropolis of St. Petersburg, with nearly a quarter-million individuals, both of which are located in Pinellas. Overall, 8 of the 18 cities, or

44%, were located in Pinellas County, while Manatee had three cities, Anna Maria, Bradenton Beach, and Holmes Beach, with an average of 2,754 residents. Sarasota, Lee, and Collier counties were each represented by two cities, with average populations of 35,240, 6,313, and 17,928, respectively. Longboat Key claimed county affiliations with both Manatee and Sarasota, and is home to an estimated 7,603 people.

Procedures

Nine Florida counties and 28 coastal cities located within these regions were selected due to their proximity to Gulf waters, historical patterns of exposure to red tide blooms, and popularity as tourist destinations. The counties selected (from northwest to southeast) were Okaloosa, Franklin, Gulf, Pinellas, Manatee, Sarasota, Charlotte, Lee and Collier. In an effort to estimate the fiscal costs of red tide events at a local level, 28 municipalities within each of the nine sample counties were targeted, based primarily on their location to Gulf waters. A total of eighteen successful interviews were completed during January through March of 2007. The 18 municipalities are located within the boundaries of five of the nine counties – Pinellas, Manatee, Sarasota, Lee and Collier (Table 4-4).

Top level administrators within these locations were identified as the target sample. A database of names and contact information was compiled using the 2006 Membership Directory published by the Florida Association of Counties and the Florida League of Cities, Inc. The interviews were conducted between January and March 2007, and final contacts completed by March 2007 by a single person.

The interviewer initially contacted the top-level county or city administrator to obtain permission and recommendations with respect to identifying appropriate individuals within their organizations that would most likely have access to the information associated with red tide events. Due to the sporadic nature of red tide blooms and the complexity of government titles and responsibilities across locales characterized by large ranges of population numbers, tourism dollars, and public beach areas, it was necessary to broaden the traditional scope of potential respondents. To that end, an effort was made to canvas all individuals that were actively involved with beach management issues or funding and employee management responsibilities within each public agency.

Respondents were first asked to discuss general beach management programs, and then queried about costs and activities specifically associated with red tide events. Respondents were encouraged to describe general types of beach management or maintenance programs, and to provide data concerning fiscal year expenditures on both labor and equipment used in support of these programs.

Questions pertaining to red tide events were designed to elicit detailed information for each responding county or city agency. The red tide-specific section included actual or estimated labor and equipment costs, evidence of communication protocols related to either clean-up activities or public relations, types of activities undertaken or sponsored by the agency, funds allocated to red tide mitigation or management, historical responses to red tide events, and identification of agency departments charged with red tide-related responsibilities.

Survey Results

Responses were grouped into three information categories. The first category includes a list of all departments (public or private, local or state) charged with physical responsibilities related to general beach maintenance and/or red tide bloom management or mitigation. The second category includes public funding sources for both beach and red tide management and actual or estimated fiscal and labor expenditures provided by these funding sources. The third category includes descriptions of any type of communication or activity protocols followed by each county or city in the event of an active red tide bloom. Information will be summarized across counties and cities for each category following a description of the response rate.

Response Rate

In sum, 37 telephone interviews were attempted by the Florida Survey Research Center (Table 4-5). Six municipalities were either unreachable, or unwilling to respond to the survey questionnaire. Of the total completed interviews, four responses were deemed ineligible, due to their distance from Gulf waters, or their lack of publicly managed Gulf-facing beaches. A total of 27 interviews were completed during the survey time period, which began in January and ended in March of 2007, for a response rate of 87.1%. These 27 respondents included all nine counties (Okaloosa, Gulf, Franklin, Pinellas, Manatee, Sarasota, Charlotte, Lee and Collier) and 18 cites located within these counties.

Agencies

Six counties involved at least two or more of their departments in the physical management of beach/red tide management responsibilities (Table 4-6). Parks and Recreation and Public Works/Utility departments were mentioned by the majority of county respondents (4 or more). Natural Resources or Environment/Pollution Control departments were mentioned by three of the counties. Sarasota and Gulf mentioned the involvement of their local branches of the Florida Department of Health, while Gulf also included the Florida Department of Environmental Protection. Franklin and Pinellas both mentioned the role of their Public Waste departments in fish kill clean-ups. Sarasota and Lee referred to the roles of outside private contractors in water monitoring and beach cleaning responsibilities, respectively. Okaloosa was the only county to refer to the role of their Tourism Development Council. Finally, Pinellas, Manatee and Sarasota stated the inclusion of the Management and Budget Office, the Division of

Marine Rescue, and Emergency Services, respectively, as holding responsibilities for beach-related physical management tasks.

The majority of cities interviewed, 12 out of 18, or 67%, assigned physical beach or red tide tasks to their Public Works department, while more than half of all cities (10) hired private contractors, contract labor, consulting firms, commercial fishers, marine inspectors, or equipment and boat rental suppliers to handle beach cleaning work (Table 4-7). Five cities mentioned the top administrator, i.e. Town Clerk, City Manager, City Council, or Mayor, as having primary responsibilities for managing beaches and red tide events. Three cities, Sarasota, Venice, and Marco Island, noted that their beaches were physically cared for by their counties. Parks and Recreation and Natural Resource departments were mentioned by three cities each, four of which are located in Pinellas. Anna Maria was the only one to mention the Garbage Collection department, although this could be considered equivalent to larger cities' Public Works departments. Madeira Beach involved their Finance Director in physical management tasks, primarily in the role of assigning funds to beach-related responsibilities.

Not surprisingly, three-quarters of the counties claimed their Tourism Tax Funds as the source of dollars used in both beach maintenance and red tide management chores (Table 4-8). Five of the counties also mentioned their own county government "regular", "emergency" or "contingency reserves" funds, with Pinellas and Charlotte relying solely on their own budgets for funding (no mention of tourism tax funding). While Franklin County used its own funds to clean its beaches, the respondent claimed that it "has no cities on the Gulf and is not greatly bothered by, nor concerned with, red tide or other HABs."

Funding Sources and Expenditures

Overall, six counties provided estimated and historical financial information with respect to overall beach maintenance efforts (Table 4-8). General annual beach management and maintenance costs ranged from nearly $1.5 million in Sarasota, down to $76,000 in Gulf. While some counties did not provide red tide-related costs, several respondents noted allocations of large portions of tourism tax dollars towards annual emergency beach cleaning accounts (which would be used in the event of a red tide), which ranged from $25,000 in Okaloosa up to $400,000 in Sarasota.

Four counties had kept precise records of red tide related beach cleaning expenditures, and included Pinellas, Sarasota, Lee and Collier. Sarasota respondents provided current red tide cleaning expenditures of $51,148 for six separate events in FY 2006-07, which included labor, equipment and vendor costs (Table 4-9). Pinellas offers a reimbursement program to its cities that had incurred costs related to red tide cleaning in 2005, and seven cities received $78,090 in total (Table 4-10). Pinellas' Office of Management and Budget has limited reimbursement parameters to include actual overtime, temporary labor, and equipment costs related directly to red tides that occurred during a specific time frame. Lee recorded costs of $250,000 for a single 2004 red tide event in Fort Myers, and Collier spent $250,000 in 2005 in red tide-related cleaning expenditures.

Seven cities are reimbursed by their host counties for at least some, but not all, of the labor or dollar expenditures on red tide cleaning efforts, six of these in Pinellas, and one in Lee (Table 4-11). Four cities (Holmes Beach, Sarasota, Venice, and Marco Island) indicated that they would notify their host counties in the event of a fish kill and, therefore, were not responsible for fiscal or labor expenditures. Three municipalities (Bradenton Beach, Fort Myers Beach, and Naples) indicated their own budgets were the only source of funds used to clean beaches after a red tide event. Two cities, Clearwater and St. Petersburg, used beach parking fee collections to maintain their beaches, and this would include cleaning up during a red tide event.

A total of 11 of the 18 cities, or 61%, provided red tide-related financial and/or labor costs (Table 4-11). These numbers ranged from $1,420 received by Belleair Beach from Pinellas County for its 2005 red tide clean-up efforts, up to Long Boat Key's annual red tide line item budget allocation of $100,000 for cleaning its 10.5 miles of public beaches. The seven cities receiving reimbursement funds from their counties collected between $1,420 up to $45,310 as a result of 2005 red tide events. Naples was the sole self-funded city to have a historical red tide annual cleaning allocation of $50,000 in its budget, although Long Boat Key established its $100,000 red tide budget in 2006. The majority of labor and equipment used to clean red tide-related fish kills is provided by regular city staff and machinery, and most counties waived the dumping fees associated with dead fish disposal. However, several respondents mentioned the need for overtime, contract labor, and prisoner trustees required to expedite the cleaning process, depending on volume and location of dead marine creatures.

Overall, five counties shifted existing personnel and equipment for red tide cleaning efforts, including Pinellas, Manatee, Sarasota, Charlotte and Collier (Table 4-12). These same five, plus Lee, hired additional temporary labor or private contractors and utilized prison trustees to achieve the timely removal of dead fish.

Communication or Activity Protocols

Five of the counties followed some program of public relations in the case of a red tide event. Sarasota and Manatee have equipped their lifeguards with Blackberries, which are used to send twice-daily reports of red tide conditions for their beaches that are staffed for 8-10 hours per day, year-round. These two are joined by Charlotte and Collier in placement of red tide warning signs on their public beaches. Gulf, Sarasota, Charlotte and Collier also issue press releases and emails to media, hotels, Tourism Development Council, Chamber of Commerce, health care agencies, and county websites. Manatee sends their Chief Lifeguard out into the community to educate beach users, schools and other organizations. Sarasota was the only county with a written, red tide-specific protocol designed to provide stringent guidelines as to policies and procedures for beach cleaning and public safety notifications. Two counties do not manage their beaches (Okaloosa) or do not have municipalities exposed to the Gulf of Mexico (Franklin). Lastly, Pinellas and Lee Counties did not engage in any type of public notification efforts.

A total of 13 of the 14 cities that were directly responsible for red tide beach cleaning followed similar action plans described as follows in the event of a red tide (Table 4-13). Typically when a complaint (odor or dead fish) was received by the city it was then investigated by natural or marine resource personnel. Following their recommendations and any environmental or health guidelines established by state or federal agencies (e.g., Florida Department of Health, Environmental Protection Agency), the Public Works and/or Parks and Recreation departments combined existing personnel and/or temporary labor and equipment to begin the cleaning process. St. Petersburg, with its small beach length of approximately 650 feet, had their usual private contractor remove any dead fish resulting from red tide blooms, and provided no further elaborations. The remaining four cities notified their host counties as previously mentioned, although Holmes Beach was willing to assist the county on a "where needed and as manpower is available" basis. Holmes Beach is unique in that it possesses several "blind canals" where fish kills build up, and it has hired commercial fishers to collect these with nets and haul them back out into the Gulf. Only one city, Indian Rocks, provided the public with red tide information, including red tide fact sheets that were provided by Pinellas County.

Summary and Conclusions

The overall objective of this survey effort was to provide an analysis of the direct costs associated with harmful algal bloom events incurred by city and county agencies located on or near coastal waters with historical exposure to red tide blooms. Information was gathered via in-depth telephone interviews of individuals charged with red tide-related responsibilities ranging from physical public beach cleaning, to funding allocation decisions, to public relations efforts. Respondents were successfully interviewed for a total of nine Florida Gulf Coast counties and 18 cities within these counties, each of which had experienced red tide events in 2005.

The majority of funds for red tide-related cleanups were generated by tourism tax dollars, with only two counties relying strictly on their regular county dollars, perhaps due to the lack of public beaches in these areas (e.g., none were reported in Franklin and only one in Charlotte). In all, four counties and two cities were able to provide actual dollar amounts specific to red tide events that occurred on their public beaches. These six locations provided red tide-specific costs totaling $653,890 over the 2004-07 time period, with total expenditures per event (including labor, equipment, supplies and vendor fees) ranging from $11,114 to $250,000. Only two cities, Longboat Key and Naples, have placed red tide cleaning costs as a line-item in the annual budget, in the amounts of $100,000 and $50,000, respectively.

Although Sarasota County provided the only official written protocol outlining specific policies and procedures in the case of a red tide event, each of the other counties and cities appeared to follow a similar pattern of activity. Initially, a complaint of odor from a red tide-related fish kill was received by the agency, either from a member of the public or from beach or park personnel. An agency member, or private consultant, with some level of resource management experience, was sent to the area to investigate the claim and establish a cleaning protocol that would meet any human welfare, environmental and access restrictions (e.g., human health hazard, turtle nesting site, protected dunes, etc.). At this point, cleaning personnel were assigned from existing staff, outside labor agencies, or prison trustees, while machinery was also either diverted from usual uses or rented from local suppliers. Once the debris was collected in either trucks or garbage bags, it was hauled to local waste disposal sites following prescribed regulatory procedures (e.g., dead fish might be bagged, buried, or incinerated in designated locations).

In addition to data concerning red tide fiscal costs, respondents provided insight into the difficulties associated with cleaning public beaches in the event of a fish kill. For example, many of the Gulf County beaches harbor protected nesting areas for turtles and seabirds, as well as native flora that have low tolerance levels for invasive mechanized equipment. Several beaches have strict environment protocols in place to limit or prevent removal of washed up marine materials for a set period of time in an effort to preserve the natural state of coastal ecosystems. Such policies include criteria such as “no-rake” areas, cleaning only when there are “significant numbers” of dead fish, or they require “one large fish per foot of shoreline” or “substantial portion of the beach be covered by fish for 24-48 hours, or to a depth of six inches” before cleaning can occur. Adherence to environmental policies must be enforced by public officials on private businesses, and in some cases exceptions have been granted for resorts that are “grandfathered” and allowed to follow their own cleaning policies. On at least one occasion, the state health department stepped in and required a county to clean private homeowners’ beaches as the fish kill was deemed a human health hazard.

Five of the counties, and only one city, mentioned public notification of an ongoing red tide event, typically by placing warning signs on the beach and sending alerts to tourism-related businesses. However, a few counties and cities mentioned financial support of the grassroots organization START, or Solutions To Avoid Red Tide, which has active membership in most of the responding regions and works to educate the public and businesses about red tide. Manatee and Sarasota counties have equipped their lifeguards with Blackberries, which are used to send twice-daily messages concerning red tide and other beach conditions.

Our study has provided some insight into actual public management strategies and funding sources linked to a red tide event. An important finding is the estimated costs of a red tide event per linear foot of beach, which can be extracted from the data provided by Sarasota and Pinellas counties. Sarasota spent an average of $4.87 per linear foot of beach to provide the labor and equipment necessary to remove the dead fish resulting from a single red tide event that occurred in October 2006 through February 2007. In Pinellas, seven cities were reimbursed an average of $14.27 per linear foot of beach for red tide-related cleaning required throughout 2005; however, incidence and duration of the events were not mentioned, and city expenditures may have exceeded county reimbursements due to in-kind labor and equipment reallocations. This information may provide a useful baseline for estimation of red tide-related budget needs for other cities and counties that are responsible for public beach management. However, it should be noted that public government protocols associated with red tide events are strongly dependent on all of the following factors: the timing, duration and severity of an event; size of budget and labor force; overall importance of tourism (evidenced by tourism tax collections); quantity and accessibility of public beaches; and the environmental regulations that are specific to each locality.

Table 4-1. Population estimates of nine Florida Gulf Coast counties

County	County population[a]	Population change, 2002-05
	(number)	(%)
Okaloosa	177,284	+ 4.0
Franklin	11,057[b]	N/A
Gulf	13,332[b]	N/A
Pinellas	905,158	- 1.8
Manatee	300,828	+ 13.9
Sarasota	359,783	+ 10.4
Charlotte	154,716	+ 9.5
Lee	539,097	+ 22.3
Collier	302,514	+ 20.3

[a] U.S. Census Bureau, 2005.
[b] U.S. Census Bureau, 2002 (2005 not available).

Table 4-2. Tourist tax collections, dollars and percent of total county taxes, and estimated annual tourist numbers for nine Florida Gulf Coast counties

County	Estimated annual domestic tourists, 2005[a]	Tourist development tax rate, FY 2005-06[b]	Tourist development tax collections, FY 2005-06[b]
	(1,000)	(%)	($1,000)
Okaloosa	2,934	4.0	7,364
Franklin	N/A	2.0	669
Gulf	N/A	4.0	304
Pinellas	2,393	5.0	21,651
Manatee	772	4.0	4,760
Sarasota	1,621	4.0	7,432
Charlotte	N/A	5.0	1,625
Lee	2,316	5.0	17,030
Collier	1,544	4.0	13,056

[a] Estimated tourist numbers from VIIST FLA -Domestic Visitors to Florida, Florida Visitor’s Study, 2005 (N/A refers to unavailable data).
[b] Validated tax receipts data for July 2005, through June 2006, Florida Department of Revenue, Office of Tax Research.

Table 4-3. Approximate tourism tax dollars collected per public beach miles for nine Florida Gulf Coast counties

County	Public beachfront length[a]	Tourist tax dollars per mile of public beach[b]
	(miles)	($/beach mile)
Okaloosa	24	76,708
Franklin	0[c]	N/A
Gulf	17	4,471
Pinellas	35	164,023
Manatee	14	85,000
Sarasota	7	265,429
Charlotte	12	33,854
Lee	18	236,528
Collier	22	148,364

[a] Public beachfront access miles retrieved from various online county government sources – Sarasota: http://apoxsee.co.sarasota.fl.us/ ; Charlotte: http://www.charlotte-florida.com/ ; Okaloosa: http://www.co.okaloosa.fl.us/ ; Lee: http://www.lee-county.com/ ; Pinellas: http://www.pinellascounty.org/ ; Gulf: http://www.visitgulf.com/ ; Collier: http://www.colliergov.net ; Manatee - http://www.flagulfislands.com/ .
[b] Calculated as 25% of annual FY2005-06 Tourist Development Tax collections (see Table 4-2).
[c] Franklin County reported no Gulf-front public beaches.

Table 4-4. Population estimates of Florida Gulf Coast cities

City	2002 population[a]	County
	(number)	
Belleair Beach	1,751	Pinellas
Clearwater	108,787	Pinellas
Indian Rocks Beach	5,072	Pinellas
Indian Shores	1,705	Pinellas
Madeira Beach	4,511	Pinellas
North Redington Beach	1,474	Pinellas
Saint Petersburg	248,232	Pinellas
Treasure Island	7,450	Pinellas
Anna Maria	1,814	Manatee
Bradenton Beach	1,482	Manatee
Holmes Beach	4,966	Manatee
Longboat Key	7,603	Manatee/Sarasota
Sarasota	52,715	Sarasota
Venice	17,764	Sarasota
Fort Myers Beach	6,561	Lee
Sanibel	6,064	Lee
Marco Island	14,879	Collier
Naples	20,976	Collier

[a] U.S. Census Bureau, 2002.

Table 4-5. Disposition of telephone interviews and response rates

Description	Number	Percent
	(number)	(%)
Total Interviews Attempted	37	100.0
Unsuccessful Attempts	6	16.2
Successful Interviews	31	83.8
Total Interviews	31	100.0
Ineligible Respondents [a]	4	12.9
Total Completed Interviews	27	87.1

[a] Ineligible respondents included the cities of Apalachicola, Carrabelle, Northport, and Punta Gorda, due to their proximity from Gulf waters and/or lack of public Gulf-front beaches.

Table 4-6. Summary of public departments charged with physical beach/red tide management responsibilities by county

County	Departments
Okaloosa	Okaloosa Tourism Development Council – Beach Manager
Franklin	Waste Disposal Department
Gulf	Public Work Department; Florida State Health Department; Department of Environmental Health and Protection
Pinellas	County Solid Waste; Technical Management; Office of Management and Budget; Department of Environmental Management
Manatee	Parks and Recreation Department; Utility Operations; Division of Marine Rescue, Department of Public Safety
Sarasota	Sarasota County Health Department (branch of Florida State Department of Health); Mote Marine Laboratory (water testing); Parks and Recreation Department; Emergency Services; Public Works
Charlotte	Parks and Recreation Department
Lee	Parks and Recreation Department; Natural Resources; Division of Public Works; Private Contractors
Collier	Parks and Recreation Department; Pollution Control

Table 4-7. Summary of public departments charged with physical beach/red tide management responsibilities by city

City	Departments	County
Clearwater	Landscape Manager (Parks and Recreation); Clearwater Marine Aquarium Inspector	Pinellas
Treasure Island	Public Works, Assistant Director; Beach Stewardship Committee; Consulting Firm	Pinellas
St. Petersburg	Parks and Recreation, Manager of Athletic Operations; Public Contractors	Pinellas
Indian Rocks	Public Service	Pinellas
Belleair Beach	Communication Services, IT Director - Public Works; Private Contractors	Pinellas
Indian Shores	Public Services; Workforce Contract Labor	Pinellas
Madeira Beach	Parks and Recreation; Finance Director; Utilities	Pinellas
North Redington Beach	Town Clerk; Public Works; Private Contractor	Pinellas
Bradenton Beach	Public Works	Manatee
Holmes Beach	Public Works; Mayor; Commercial fishers	Manatee
Anna Maria	Public Works; Garbage Collection	Manatee
Long Boat Key	Public Works; Private Contractor	Manatee/Sarasota
Sarasota	Sarasota County	Sarasota
Venice	Sarasota County	Sarasota
Fort Myers Beach	City Council; City Personnel	Lee
Sanibel	City Manager; Private Contractor; Public Works; Natural Resources Manager;	Lee
Naples	Natural Resource; Public Works; Contract Labor; Hauling Contractors; Equipment Rental Suppliers; Boat Suppliers	Collier
Marco Island	Collier County	Collier

Table 4-8. Summary of sources of funds for financial beach/red tide management responsibilities and estimated funds and expenditures, by county

County	Source of funds	Estimated funds and/or expenditures
Okaloosa	Okaloosa Tourism Development Council Emergency Funds	$25,000 annually for emergency beach clean-up
Franklin	Franklin County Government Budget	Not applicable
Gulf	Gulf County Government Budget Gulf Tourism Development Council Funds - Tourism Tax Funds	25% of annual tourism tax funds (~$76,000 based on Table 4-2)]
Pinellas	Pinellas County Government Contingency Reserves	$78,000 total paid to reimburse eight cities for 2005 red tide beach cleaning costs (see Table 4-10)
Manatee	Manatee County Tourism Development Council – Tourism Tax Funds	$1.25 - $1.275 million annually for beach maintenance
Sarasota	Sarasota County Tourism Development Council – Tourism Tax Funds	$1.4 - $1.5 million annually for beach maintenance $400,000 annually for emergency beach cleaning $51,148 paid out for six red tides in FY 2006-07 (see Table 4-9)
Charlotte	Charlotte County Government	Beaches cleaned by hand (May-October ~ $10,000; Nov-April ~ $40,500)
Lee	Lee County Tourism Development Council – Tourism Tax Funds; Lee County Government	$300,000 - $340,000 annually for emergency beach cleaning $250,000 paid out for single 2004 red tide in Fort Myers
Collier	Collier County Tourism Development Council – Tourism Tax Funds	$550,000 annually for beach maintenance $250,000 paid out for 2005 red tide beach cleaning

Table 4-9. Sarasota County expenditures for six red tide events by public beach

Public beach/ Event number[a]	Red tide days	Cost per event Labor	Equipment	Vendor	Total	Cost per beach area
	(days)	($)	($)	($)	($/event)	($/ft)
Siesta Beach#1	37	10,201.50	5,166.60	1,165.00	16,533.10	6.89
Siesta Beach#2	2	327.12	327.12	0.00	654.24	0.27
Siesta Beach#3	25	2,813.00	1,237.73	1,865.00	5,915.73	2.46
Siesta Beach#4	20	10,147.00	5,776.43	720.00	16,643.43	6.93
North Jetty#1	7	5,522.00	3,712.86	1,890.00	11,154.86	12.39
North Jetty#2	1	137.00	109.23	0.00	246.23	0.27
AVERAGE	15	4,862.94	2,721.66	1,410.00	8,524.60	4.87

a Siesta Beach #1: October 2 – November, 8, 2006; Siesta Beach #2: November 9-10, 2006; Siesta Beach #3: December 4-29, 2006; Siesta Beach #4: January 8-28, 2007; North Jetty #1: February 1-7, 2007; North Jetty #2: February 22, 2007.

Table 4-10. Pinellas County reimbursements for 2005 red tide events by city public beach

City	Labor	Equipment/ supplies	Total	Costs per beach area
	($)	($)	($)	($/ft)
Belleair Beach	985.14	126.80	1,111.94	10.14
Indian Rocks Beach	9,214.96	5,095.75	14,310.71	5.04
Indian Shores (1)	9,972.49	304.02	10,249.51	22.32
Indian Shores(2)	8,160.00	20,878.00	29,038.00	38.09
Madeira Beach	10,868.00	35,998.00	46,866.00	7.01
North Redington Beach	1,198.86	842.80	2,041.66	14.64
Treasure Island	7,851.03	12,633.80	20,484.83	2.61
AVERAGE	4,862.94	5,064.29	8,524.60	14.27

Table 4-11. Summary of public departments charged with financial beach/red tide management responsibilities and estimated expenditures and labor by city

City	Source of funds	Estimated labor and/or expenditures
Clearwater	Beach parking fees	$200,000 standard beach maintenance for 1.4 miles public beach; staff of 12 clean daily from 5am to 1:30 pm routinely
Treasure Island	Reimbursed by Pinellas County for some red tide cleaning costs	After 2005 red tides, city requested $20,485, received $9,660 from county for 3 miles public beach; regular beach cleaning biweekly with tractor and rake; 18 employees "wanted to work overtime" during 2005 red tide
St. Petersburg	Beach parking fees	Pay private contractor $200/month for standard beach cleaning for 600-700 ft public beach
Indian Rocks	Reimbursed by Pinellas County for some red tide cleaning costs	During 2005 red tides, 10 full-time personnel cleaned beaches, and county reimbursed $11,000 to city; standard beach raking during first week of month; county waived landfill dumping fees
Belleair Beach	Reimbursed by Pinellas County for some red tide cleaning costs if "Work cannot be done by regular [city] personnel…reluctant reimbursement program"	After 2005 red tides, county reimbursed $1,420 to city; pay dead fish dumping fees of $37/ton
Indian Shores	Reimbursed by Pinellas County for some red tide cleaning costs	After 2005 red tides (June 13 through August 19), received $45,310 from county after submitting two requests (labor and equipment); dump fees waived

Table 4-11. Continued.

City	Source of funds	Estimated labor and/or expenditures
Madeira Beach	Reimbursed by Pinellas County for some red tide cleaning costs	During 2005 red tides (June through mid-September), city personnel logged 770 hours cleanup, 8-22 man hours per day; front-end loader, pickup truck, dump fees not waived (fish mixed with garbage), paid overtime of $10,800; city requested $46,866, received $8,310 from county
North Redington Beach	Reimbursed by Pinellas County for some red tide cleaning costs	After 2005 red tides, requested and received reimbursement of $2,050 from county
Bradenton Beach	General city budget for overtime and part-time; no red tide line item	None given
Holmes Beach	Manatee County Budget	Follow Manatee County red tide protocols
Anna Maria	Place annual requests for red tide clean-up funds, not granted; however, clean-up funds appear in the overtime and part-time budget "possibly to avoid negative images"	Average 3 red tides per year, from early July through mid-September; if major event, county assists beach cleaning with rakes, 4-12 laborers, 4-6 prison trustees, who handpick dead fish
Long Boat Key	Prior to 2005, red tide funds from City General Revenues; from 2006 to present, City Red Tide Budget	$100,000 annual red tide cleaning funds for 10.5 miles public beaches
Sarasota	Sarasota County budget	Follows Sarasota County red tide protocols
Venice	Sarasota County budget	Follows Sarasota County red tide protocols
Fort Myers Beach	City budget	During 2006 event, dead fish hand-picked for ~ 2 months, approx. costs of $15,000 (beach raking prohibited)

Table 4-11. Continued.

City	Source of funds	Estimated labor and/or expenditures
Sanibel	City presents county Tourism Development Council with estimated red tide cleaning costs which are paid by county Parks and Recreation funds	February 2004 city received $11,114 from county; January 2007 city received $9,742 for Nov. ’06 red tide for 11 miles public beach; average 4-5 fish kills per year; 8-10 man hours per week beach inspection during red tide event
Naples	City Red Tide Budget	$50,000 annual red tide cleaning funds; no severe outbreaks in last 4-5 years
Marco Island	Lee County budget	Follow Lee County red tide protocols

Table 4-12. Summary of communication and activity protocols followed in the case of an active red tide event by county

County	Communication and activities
Okaloosa	• None - cities manage their own beaches
Franklin	• None (respondent indicated that no municipalities are exposed to red tide)
Gulf	• Gulf County Tourism Development Council issues Public Service Announcements to county and tourism-related businesses as needed
Pinellas	• No public notification efforts • Reimburses municipalities following 2005 FEMA standards regarding extreme environmental events by providing contingency reserves funds to those municipalities that incur beach clean-up expenditures and submit requested reimbursement amount • Shifts existing beach cleaning personnel and equipment, approve overtime, hire temporary workers
Manatee	• Participates in twice-daily lifeguard red tide monitoring program via Blackberries, who also place beach signage on all public beaches for 8-10 hours per day, year-round • "Participate in PR efforts to overcome surveys done by universities" • Chief Lifeguard presents red tide information to beach-goers, schools and other organizations • Shifts existing beach cleaning personnel and equipment, and add prisoner workers, extra staff if necessary
Sarasota	• Participates in lifeguard red tide monitoring program via Blackberries for six county beaches • Follows Florida Department of Health protocol with respect to water hazard threats to human health • Follows an extensive beach cleaning policy developed by county in 1995 and updated in 2006 • County cleans up municipality beaches

Table 4-12. Continued.

County	Communication and activities
Charlotte	• Charlotte County Parks and Recreation Department issues press releases to media and hotels and posts red tide warning signs at the beaches • Shifts existing county beach cleaning personnel and tractor and golf cart, no overtime
Lee	• Reimburses Fort Myers and Sanibel for HAB clean-up costs • Cleans unincorporated and regional beaches within cities and Bonita Springs • Uses temporary labor and hire private contractors
Collier	• Posts red tide warning signs on beaches • Monitors fish kill reports, NOAA and HAB bulletins • Sends emails to Tourism Development Council, Chamber of Commerce, health care agencies, media, and county website • Shifts existing beach maintenance crews (2 beach cleaners and 1 supervisor) and rake and drag equipment • In the case of limited access beaches and canals, uses community service individuals to hand pick dead fish if heavy deposits

Table 4-13. Summary of communication and activity protocols followed in the case of an active red tide event by city

City	Communication and activities
Clearwater	• Clearwater Marine Aquarium inspector checks turtle nesting spots • Shifts existing beach cleaning personnel to clean up fish kills at public beaches • In 2005, FL Department of Health declared dead fish a health risk, so city hired extra help to clean private beaches as well
Treasure Island	• Beach Stewardship Committee determines “no-rake” areas • Shift existing labor, approve overtime • File reimbursement request with Pinellas County
St. Petersburg	• Private contractor paid to do standard beach cleaning removes dead fish
Indian Rocks	• Public Service Department monitors beaches and provides information and fliers, as well as red tide fact sheets provided by Pinellas County • Clean up dead fish when “significant numbers” • Department of Environmental Protection permit required to dispose of dead fish • File reimbursement request with Pinellas County
Belleair Beach	• Parks management work done by private contractors • Dead fish are bagged, put into dumpsters, taken to county incinerator • File reimbursement request with Pinellas County
Indian Shores	• Shifts existing Public Works personnel, pays overtime • Hire contract labor - Workforce • File reimbursement request with Pinellas County
Madeira Beach	• Shift existing Parks and Recreation and Utility Department labor and pays overtime • Hire temporary workers • File reimbursement request with Pinellas County

Table 4-13. Continued.

City	Communication and activities
North Redington Beach	• Rent skid loader, hire day laborers to hand pick debris, place in piles and city dumpster • File reimbursement request with Pinellas County
Bradenton Beach	• City receives odor complaints from fish kills washed into bay (Gulf beach owned by Manatee County) • Public Works director determines clean-up need • Shift existing personnel • County provides free county stockade trustees, if needed. • City garbage truck hauls fish away
Holmes Beach	• Manatee County cleans up without cost to city • City assists county on "where needed and as manpower is available" basis by providing shovels, forks to load fish into front-end loaders • City has several "blind canals" where fish kills build up, cleared by 2-3 commercial fishers using nets to haul fish back out into Gulf
Anna Maria	• City notified of foul odor • Public Works Director investigates, employees alerted to possible fish kill (smell without dead fish often occurs with onshore winds) • Shift existing Public Works and Garbage Collection employees to collect and haul away dead fish
Long Boat Key	• City receives complaint • Mote Marine Laboratory scientists walk beach and tell Public Works when safe to clean up dead fish (avoid nesting turtles) • Private contractor uses weed harvesters to clean
Sarasota	• Follows Sarasota County protocols
Venice	• Follows Sarasota County protocols

Table 4-13. Continued.

City	Communication and activities
Fort Myers Beach	• City has development code which forbids beach raking (certain areas are grandfathered and allowed to rake because they are resorts, etc.) • Must get a permit from FL Department of Environmental Protection to rake or clean the beach • Shift existing personnel to hand-pick dead fish, pay overtime • Use jail inmates, at no cost, to hand-pick dead fish
Sanibel	• Public Works Director actively manages clean-up, determines where and when based on environmental regulations, i.e. one large fish per foot of shoreline, avoid wildlife nesting sites • Natural Resources biologists inspect and contribute to clean-up decisions • Estimates cleaning costs and presents to Lee County Tourism Development Council with requested reimbursement • Shift existing Public Works staff to hand-pick dead fish • Private contractors already under beach cleaning contracts also participate in beach cleaning
Naples	• Daily city beach cleaners call in a fish kill • Public Works Director and Natural Resources Manager inspect beaches • Clean-up criteria: “Substantial portion of the beach be covered by fish for 24-48 hours or to a depth of six inches” • Most of clean-up done with contracted labor • With existing red tide line item in city budget, purchase orders with hauling contractors, equipment and boat suppliers are already set up to “facilitate rapid response”
Marco Island	• Collier County is notified and county provides equipment, labor and funding

CHAPTER 5
SUMMARY AND CONCLUSIONS

Red tide blooms have occurred on Florida's coastlines for decades prior to the state's rapidly growing population. Historically, as coastal areas faced increasing pressure from development, targeted environmental management efforts (e.g., Florida Beach Erosion Control Program (1964), Statewide Coastal Monitoring Program (2000), Marine Turtle Protection Act (1979), Florida Healthy Beaches (1998), The BEACH Act (2000)) were developed to protect native biota and simultaneously ensure continued public access to safe, clean, and healthy marine environments. The origin, movement, and expected duration and intensity of naturally-occurring *Karenia brevis* blooms (i.e., red tides) have proven difficult to predict, further increasing the difficulty of quantifying economic impacts.

While anecdotal evidence of the negative effects resulting from red tide events on water and shoreline conditions have appeared in local popular press for more than 50 years, the prolonged series of events in 2005 served to highlight the need for more precise information. This research provides estimates of the localized economic impacts of red tide events, which can help to justify continued or proposed prevention, mitigation, and control efforts. In particular, this study focused on impacts to specific to restaurants, local residents, and coastal governments, all of which are located within nine counties along Florida's Gulf Coast.

The analysis of daily restaurant sales over a seven year period revealed many unique insights and contributions regarding how to measure and model the short-run fiscal impacts on individual firms. First, it is the only case study (to our knowledge) that quantifies a reduction in sales due to red tide events by using proprietary data that has been consistently collected over time. Average inflation-adjusted daily sales were found to decline by 13.7% and 15.3% for the two highest-grossing restaurants, *ceteris paribus*; however, these declines would be relatively larger if noticeable red tide conditions were present on low volume sales days that tend to occur on Mondays and Tuesdays, or in the month of September.

Second, the empirical findings were based on subjective notations of environmental conditions (i.e., red tides, rainfall, and tropical storms or hurricanes) at the location of sales, not by secondary data collected at distant monitoring stations. A comparison of the red tide observations noted by the restaurant managers corresponded with FWRI recorded cell counts measured within seven days (recall that cell count monitoring is infrequent). More importantly, the subset of observations that matched (i.e., subjective observations were made on the same days that cell counts were recorded), cell counts averaged 585,183 cells per liter. Thus, FWRI cell count measurements may need to be much higher than average levels (or levels used to regulate shellfish harvests) to impact beachfront restaurant patrons. If these thresholds are supported in other studies, they could be used to estimate red tide effect thresholds for any beachfront business and, thereby, allow for the use of nearby cell count data in subsequent empirical analysis.

Third, these models were specific to the unique waterfront location and physical characteristics of each restaurant and, thus, the results cannot be used to predict or project aggregate sales losses to the restaurant sector. However, this approach highlights how proprietary data can be used with nearby cell count data to estimate sales reductions due to red tide events in order to pursue opportunities for economic disaster relief. For example, the U.S. Small Business Administration (SBA) has provided loans ranging from $4,832 to $81,912 per event to individual Florida restaurants from 1996-2002. By comparison, this study found daily sales reductions of $3,734 and $868 when a red tide was present, ranging from $868 to $22,404 per red tide event.

However, given the relatively small total losses of $252,242 for two of the restaurants over a seven-year time period, development of private business disruption insurance such as that available for hurricane or flood disasters with relatively low-cost annual premiums may be more appropriate solutions as compared to public assistance programs. The relevance of insurance instruments provided by the market is further supported when sales for the two high-grossing restaurants in 2005 are closely examined, as this year was noted for its intense, long-lasting red tide bloom activity. Using estimated percentages of daily sales losses generated by the model, inflation-adjusted average 2005 sales, average daily 2005 sales, and the number of 2005 red tide days noted by the manager, restaurants B and C experienced sales losses of 2.4% and 2.2%, respectively, as a direct result of the presence of a red tide in 2005.

Lastly, the firm-level investigation of sales reductions during red tide events revealed that aggregate losses to each firm (in absolute values) in this study were relatively small compared to reported gross sales. Thus, it seems appropriate that the SBA continue to provide loans, which could perhaps be used to fund immediate clean-up activities or replacement staff (i.e., to solve a cash flow problem) as opposed to offering grants. Moreover, the characteristics of red tides (i.e., as an exogenous environmental event with localized impacts) could support the development of private business disruption insurance such as that available for hurricanes or floods. While such an industry would need fairly accurate prediction models, the state of the science is progressing and could support relatively low-cost annual premiums given that red tide conditions can vary across short geographic distances. Such a mitigation approach may be the most appropriate in addressing the impacts of red tides as opposed to other forms of public assistance.

The second analysis, which provided empirical models of the probability of a resident's decision to alter their participation in marine-related activities during a red tide, offers additional insights and contributions regarding economic impacts. Overall, the survey revealed that 70% of residents in Sarasota and Manatee counties had their participation in at least one marine-related activity disrupted due to red tides in 2000. A change in participation (i.e., disruption) was defined as whether the individual cut short, delayed, or relocated during a red tide.

The model to explain this overall effect found that none of the demographic characteristics (such as age, education, income, or residency status) mattered; only the factors that could be affected by Extension activities had a measurable impact on the probability that an individuals' participation in at least one marine-related activity would change. These Extension-related variables included red tide knowledge levels and the number of information sources that they had used to obtain information on red tide events; higher levels of each were associated with higher probabilities of disrupted participation, which implies economic losses associated with reduced recreational expenditures in the immediate region.

When a change in the probability of a disruption was examined for each of four distinct marine-related activities, the models revealed differences that would support unique education and outreach campaigns to mitigate economic losses during red tides. For example, beach-going residents that have lived in Florida longer, visit the beach more often, or have more red tide knowledge or more accurate recollections of red tide effects, they have a higher probability of being affected. In particular, beach users that know more about the environmental characteristics and effects of a red tide had a higher probability of cutting short a beach visit. Restaurant patrons that resided year-round in Florida, dined out more often, accessed more sources of red tide information, and recalled more red tide effects also had a higher probability of reacting during a red tide event; in general by dining out less. Specifically, the restaurant patrons who reacted (i.e., had a higher probability of having their patronage affected) were less likely to relocate away from beachfront dining locations if they were older and lived full time in Florida, and more likely to select another restaurant if they were male and used additional sources of information about red tide.

Although this survey effort was conducted prior to the widespread red tide events in 2005, it serves to preview the potential for amplification of negative economic impacts in cases where accurate public education efforts are not forthcoming. Results should spur private and public sector beach-related concerns to develop appropriate educational materials and make them available in both time and location-sensitive manner in an effort to minimize both short and long run probable losses. Given the general finding that each additional piece of red tide information and source resulted in increased likelihood that a resident would alter his or her participation in a marine-related activity (and, thus, incur lost revenues), extension materials could focus on a few direct educational messages provided at a single venue to targeted recreationists, rather than an abundance of literature and messages scattered across many sources and aimed at all residents.

Lastly, extrapolation of study results to all residents within the study counties generates absolute numbers of affected residents based on participation in each activity. For example, survey results revealed that 76% of residents engaged in beach-going, which suggests that 503,989 people visit Manatee and Sarasota beaches at least once per year. Of these, 70%, or 352,793 people have indicated that red tide affected their beach participation. Fifty-eight percent, or 204,620 residents, delayed their day at the beach, while 84,670 cut short a beach day and 63,503 relocated away from red-tide affected beaches. These changes in participation levels revealed in this study can be combined with estimated values of a day at the beach, or on a boat fishing trip, or beach and pier fishing, or restaurant's average daily sales to estimate potential losses to local businesses and communities reliant on marine-related activities. Future resident surveys could focus on their willingness-to-pay for red tide prevention, mitigation, and control measures to avoid disruption in recreational activities that are affected by red tide events, particularly in the case of beach users.

The final study provides perspective on the public management protocols, and labor and equipment expenditures resulting from red tide events on public beaches that were incurred from 2004 through 2007 in Florida. Encompassing Franklin, Gulf, Okaloosa, Pinellas, Manatee, Sarasota, Charlotte, Lee and Collier counties and eighteen coastal municipalities located within these nine counties, it presents a seminal collection of recorded red tide expenditures.. Six localities recorded red tide expenditures totaling $653,890 during the three-year time period. Two cities that privately manage their beaches had annual line-item budget allocations of $50,000 and $100,000 for red tide-related clean up and research.

It is important to emphasize that the hidden costs of in-kind expenditures incurred by public agencies due to lost or redirected labor or equipment hours used to assist in red tide cleaning efforts are not captured in these numbers. Additional labor is also provided by prison trustees that represent an implicit cost to taxpayers that was not directly included in red tide expenditure calculations recorded by managers. These costs are not explicitly recorded and, thus, are excluded from the calculations in this study, yet they represent explicit costs to taxpayers.

Using the precise dollars expended by Pinellas and Sarasota counties on red tide cleaning efforts and approximate linear feet of public county beaches, it is possible to generate conservative cost estimates for all beaches. Sarasota County spent an average $0.47 per linear beach foot per day of a red tide event in 2006-07, and with its seven miles of beaches, this agency could spend an average $17,371 per red tide day were its entire beachfront exposed to a red tide bloom. Pinellas County spent an annual average $14.27 per linear beach foot in 2005, and its 35 miles of public beaches could cost taxpayers $2,637,096 in annual red tide cleaning costs. These estimates could be used to determine a maximum amount that beach users may be willing to pay via tax dollars to ensure timely red tide beach cleaning, although the numbers are conservative due to in-kind matches. These survey results suggest that it is vital to recognize the benefits of quantifying both direct and indirect red tide-related costs, and required personnel and financial efforts necessary for timely red tide event management, for planning and budgeting purposes.

In sum, the results indicate that the restaurants, residents, and public agencies are aware of, and have experienced negative economic impacts due to, red tide events, in spite of limited (or no) public education efforts and erratic and localized red tide events. This study showed that beachfront restaurants have incurred statistically significant reductions in daily sales when red tide events leave behind dead fish, or aerosolized toxins prevent diners from enjoying water-side dining. As revealed in this study, economic losses are likely given residents' decisions to cut short, delay or relocate their marine-related activities due to red tide events. While such impacts may be short run, such behaviors may translate into future decreases in demand for both tourism and property values should tourists choose an alternate red tide-free destination, current residents abandon beach properties, or potential residents select away from locations susceptible to red tide events.

The results revealed by these efforts suggest many fruitful directions for future research efforts. Analysis of other firms that are dependent on beach-related activities following a time-series regression approach may reveal statistically and economically significant negative losses during a red tide event. Improvement of current red tide cell count measurements through implementation of a statistically valid sampling process would provide much-needed data for firm or local analyses. Finally, there is a strong need for empirical analysis of various educational messages related to red tide, which could serve to guide the timing, placement, and exposure levels necessary to ensure public awareness of the nature of red tide events.

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BIOGRAPHICAL SKETCH

Kimberly Ludwig Morgan graduated from Mendham High School in Mendham, New Jersey, in 1988. She received her Bachelor of Science in Animal Science in December 1993, and her Master of Science in Food and Resource Economics was awarded in December 1997, both from the University of Florida in Gainesville. Since 2000, she has worked as an economic analyst for the Florida Agricultural Market Research Center, participating in many agriculture-oriented survey research efforts for a variety of producer, extension, and government organizations. For the past five years she has served as an adjunct faculty member for Southern New Hampshire University, facilitating distance education courses such as Principles of Macroeconomics and Microeconomics, Managerial Economics, and Economics for Business. Kimberly lives in High Springs, Florida, with her husband Michael and three beautiful children, on a mini-ranch where they cater to eight equine friends, three cats, a standard poodle, and an African grey parrot.