Economic Impacts of Red Tide Events on Restaurant Sales

Kimberly L. Morgan and Sherry L. Larkin

Selected Paper prepared for presentation at the
Southern Agricultural Economics Association Annual Meetings
Orlando, Florida, February 5-8, 2006

The economic impact of red tide events were examined for three Southwest Florida waterfront restaurants. Daily gross sales from January 1996 through September were analyzed using a multiple regression time series model to examine whether the presence of a red tide, as measured within three and six miles of the beach, reduced sales revenues. Preliminary results indicate that red tide blooms closer to shore had a significantly large negative influence on sales revenues across restaurant locations.

Key Words: Florida environment, harmful algal blooms, red tide

JEL Classification: Q51

Kim Morgan and Sherry Larkin are graduate student and assistant professor, respectively, Department of Food and Resource Economics, PO Box 110240, University of Florida, Gainesville, FL 32611-0240. Author email addresses: kimorgan@ufl.edu; slarkin@ufl.edu.

This research was supported by a grant from the Environmental Protection Agency and by the Florida Agricultural Experiment Station.

Economic Impacts of Red Tide Events on Restaurant Sales

Introduction

The coastal waters of Florida host many indigenous species of marine algae. The population levels of the algae depend primarily on water quality (e.g., salinity levels, dissolved oxygen content, nutrient levels, mineral content, etc.). Changing water quality can trigger algal population growth. These algal "blooms" occur naturally along the southwest coast of Florida, as well as other regions in the Gulf of Mexico. During a high-density bloom, some species of algae produce a harmful toxin that is transmitted within the water column and can become windborne. One particular species of marine algae, the dinoflagellate *Karenia brevis*, produces a suite of as many as nine toxins (Backer et al. 2003). These toxins can kill marine life and contaminate shellfish beds. Aside from the environmental damage, these effects can pose public health concerns from decomposing marine life on beaches and the possibility of neurotoxic shellfish poisoning if contaminated shellfish are ingested. In addition, during periods of high-density blooms near beaches, humans can experience eye, nose, and respiratory irritation, especially if there are onshore winds with breaking surf. The blooms of *K. brevis* are sometimes so dense that they impart a reddish color to the water, thereby giving rise to the term "red tide". In Florida, red tides have been blamed for significant business losses in coastal communities where it occurs.

Red tides have a long history in Florida, with the earliest recorded event dating to the 1800s. The duration and geographical location of red tides vary, but they generally last for less than three months, occur nearly every year, and occur predominantly along the southwest coast of the Gulf of Mexico. Aside from the biological risks, local tourism activities such as boating, recreational fishing and beach related activities are negatively affected by the presence of the

noxious airborne toxins and the foul odor emanating from large quantities of decomposing marine life collecting on the water surface and beaches. Thus, red tides can create a multitude of negative economic impacts on local communities (Anderson, Kaoru, and White 2000; Adams et al. 2000).

Recreation and tourism are perhaps the most notable sectors of the economy that are susceptible to impacts from a red tide event as expenditures may decline (at least in the short run) due to the inhospitable beach environment and potential sickness. Absenteeism of restaurant personnel due to sickness from red tide toxins can lead to further economic losses to the local restaurants. Medical costs may also be incurred by individuals (local residents and tourists) that experience more pronounced physical reactions to the airborne toxins. Tourists and convention attendees may cancel their hotel/motel reservations.

In a recent study of economic impacts from red tides in Florida, the change in business activity that occurred during red tide events from 1995 through 2000 in the Ft. Walton Beach and Destin areas of Okaloosa County were investigated (Larkin et al. 2003). The study found that monthly losses to restaurants and hotels/motels in the combined region were estimated to be $2.8 million and $3.7 million, respectively, or nearly $6.5 million total. By comparison, $6.5 million is 25% of the average total monthly sales revenue in the region from June through October, which are the months most frequently affected by red tide. By comparison, adverse weather was found to reduce monthly restaurant revenues by just $0.7 million. Adverse weather was not found to affect the lodging sector.

The purpose of this study is to generate information that would provide for a better understanding of the economic consequences of red tide events to restaurants located on the Gulf of Mexico in Southwest Florida, which is an area that has experienced more frequent and severe

red tide events. Southwest Florida also has more beaches and tourism revenues and, as such, is likely to be more heavily impacted by red tide events. The specific objective of this paper is to estimate the change in gross revenues of three beachside restaurants due to the presence and intensity of red tide events. This study offers an initial examination of the economic consequences of red tide events at the firm level. The use of proprietary data sales by each restaurant on a daily basis are expected to accurately capture these economic effects.

Data and Model Development

Daily gross sales data from three restaurants located on beachfront properties in Manatee County, Florida were analyzed to examine whether or not the presence of red tide events, when measured up to three miles offshore, significantly reduced real gross sales. Proprietary data on daily sales for the restaurants were obtained directly from the company's chief financial officer for the period January 1996 through September 2005. The data on hurricanes, tropical storm conditions, and precipitation were obtained from the National Climatic Data Center (NCDC), U.S. Department of Commerce, National Oceanic and Atmosphere Administration (NOAA). The NCDC has reporting stations located within the geographic areas of the restaurants. The data on red tide cell counts was obtained from the Florida Marine Research Institute, Florida Fish and Wildlife Conservation Commission, and Mote Marine Laboratory, and compiled by researchers at NOAA's National Ocean Science Center. Additionally, these data record observations of the concentration of *K. brevis*, presence of fish kills, and reports of respiratory irritations at various sampling sites.

The theoretical model will involve a cross section (panel) data set using daily revenues across the three restaurants over the same time period. Given that cell counts are not recorded

every day, but only when anecdotal evidence suggests an event may be beginning, these data will represent an unbalanced panel. In addition, the resulting impacts may reflect conservative estimates since a bloom may be occurring on these days, even though it is not detected at the sampling site.

A general description of the variables expected to affect sales are summarized in Table 1. These variables are grouped into four categories: environmental characteristics, restaurant characteristics, time, and location of the restaurant (i.e., characteristics of the local population and infrastructure, include number of competitive firms).

A basic multiple regression time series model was specified for the initial empirical estimation. The following model is used extensively in time series data analysis since it simplistically handles time trends and seasonality. The model was specified in a linear form as follows:

$$\begin{aligned} Y = {} & RT3BIN + LOCAT1 + LOCAT2 + MTH1 + MTH2 + MTH3 + MTH4 \\ & + MTH5 + MTH6 + MTH7 + MTH8 + MTH9 + MTH10 + MTH11 + YR1 \\ & + YR2 + YR3 + YR4 + YR5 + YR6 + YR7 + YR8 + YR9 \end{aligned} \tag{1}$$

where the dependent variable Y (daily real gross revenue) is expressed as a function of the presence of red tide measured up to three miles west of the beachfront areas (RT3BIN); two of the three restaurants are identified using dummy variables (LOCAT1 and LOCAT2); indexed months range from MTH1, MTH2, … MTH12 representing January through December, respectively; and indexed years range from YR1, YR2, …, YR10 representing 1996 through 2005, respectively. The dependent variable (Y) is the real gross taxable sales revenue in dollars, which was adjusted annually by the consumer price index to bring all sales into 2005 dollars. Red tide intensity, as determined by cell counts of *K. brevis* from water samples drawn from specific locations within three miles, was captured in two binary variables, where 1 = present and

0 = not present. Red tide was considered present if the daily cell counts averaged above zero.

Given that red tide events are associated with fish kills, eye irritations, and nasal and other respiratory distresses, the occurrences of red tides were hypothesized to reduce beach and water-related activity, resulting in a negative impact on beachfront dining business revenues. The decision to capture red tide in the form of a binary variable was the result, in part, of the wide range in measured values of algal cell counts; for example, the minimum reading is measured as zero cells per liter seawater, while the maximum ranged up to a value of 28.8 million algae cells per liter. The simplification of environmental effects into a single variable in the presented regression (i.e., RT3BIN) was also necessary at this stage due to the complications associated with linking the environmental data to each firm location. The complexity of the task is highlighted by the observance that red tide events are likely to only have an effect on human behavior if they are of high enough intensity, they are measured at a location that is nearby, they occur in isolation of a tropical storm, and the wind is blowing toward the establishment during hours when the restaurant is open.

The gross sales were adjusted for inflation in order to account for long-term changes in business activities such as marketing or promotional expenditures, population and inflation changes that may impact growth in nominal sales. The location dummies were used to allow for variation in daily sales between locations due to dissimilar seating types (indoor versus outdoor), hours of operation, and menu offerings and prices. Monthly dummies were included to represent the expected differences between months based upon typical Florida tourism patterns, as described by the business manager during the initial interview process.

Figure 1 depicts the sampling locations and results from 2000 through October 2005 when red tide was found to be present. The figure also identifies a five mile radius around the

study area, which includes the three restaurants that are represented in this paper. A total of 366 motels, hotels, and restaurants were located within this area in 2005.

Empirical Results

The parameter estimates and signs associated with each of the independent variables are presented in the Table 2, along with associated t-values and significance levels. The data set included 339 observations; these are dates within the study period when red tide cell count data were collected.

The model shows that, with respect to red tide, it's presence on any given day, would reduce sales by $615.70. For comparison, average daily sales across the three restaurants were $4,422, $10,591, and $12,062. Thus, this effect (which was only statistically significant at 11.6%) ranged from 5% to 14% of daily sales. These results could be used to extrapolate and obtain an estimate of the impacts on other restaurants, including the entire study area and on a county-wide basis.

Statistically significant (at the more traditional 5% level) monthly impacts ranged from -$2,363 to $8,387. The seasonality of restaurant sales was much larger than annual effects, which ranged from -$3,387 in 1998 to $2,639 in 2003.

Summary

While this basic simplistic model was able to capture, in a crude manner, the effects of a red tide, the estimated model failed to capture most of the variables hypothesized to affect sales (i.e., Table 1). For this reason, the model is likely to be mis-specified. In addition, the model is specified as a panel data set but it could also be estimated as an SUR system to capture

commonalities among the error terms since all three restaurants are owned by the same individual. Current improvement of this paper is concentrating on inclusion of the 6-mile cell count data, inclusion of cell count data with multiple ranges (i.e., low, medium, and high counts as in Figure 1) and/or nonlinear specifications, wind speed and direction by octant most relevant to each restaurant, and precipitation.

References

Adams, C.M., D. Mulkey, S. Holland, A. Hodges, and J.W. Milon. "Development of An Economic Impact Assessment Methodology for Occurrence of Red Tide." Staff Paper SP 00-12. Food and Resource Economics Department, University of Florida, Gainesville, FL (58 pp.), 2000.

Anderson, D.M., Y. Kaoru, and A.W. White. *Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States*. Technical Report WHOI-2000-11, Woods Hole Oceanographic Institution, Woods Hole, MA (96 pp.), 2000.

Backer, L.C., L.E. Fleming, A. Rowan, Y-S. Cheng, J. Benson, R.H. Pierce, J. Zaias, J. Bean, G.D. Bossart, D. Johnson, R. Quimbo, D.G. Baden. "Recreational Exposure to Aerosolized Brevetoxins During Florida Red Tide Events." *Harmful Algae* 2(2003):19-28.

Larkin, S., C.M Adams, Ballyram, D. Mulkey, A. Hodges. "Red Tides and Coastal Business: Measuring Economic Consequences in Florida." Working paper, Food and Resource Economics Department, University of Florida, Gainesville, FL (21 pp.), 2003.

Table 1. Explanatory Variables Hypothesized to Affect Daily Restaurant Sales

Variables	Expected Sign
Environmental Characteristics:	
Ride tide cell counts	Negative
Wind speed in onshore direction	Negative
Presence of insects (e.g., mosquitoes, love bugs)	Negative
Ambient Temperature	Positive or Negative
Precipitation (cm of rainfall)	Negative
Restaurant Characteristics:	
Number of seats	Positive
Percentage of seating that is outdoors	Positive or negative
Food quality (average price of entrée)	Positive
Number of employees	Positive
Whether any marketing programs were ongoing	Positive
Time:	
Day of week	Positive or negative
Season	Positive or negative
Holiday	Positive or negative
Location of Restaurant:	
Number of hotels nearby	Positive
Number of hotels nearby	Negative
Education, income, population of nearby population	Positive

Table 2. Estimation Results

Variable	Parameter Estimate	t value	Pr > |t|
Intercept	9091.08	7.54	<0.0001
RT3BIN	-615.731	-1.58	0.1156
LOCAT1	-6246.705	-18.35	<0.0001
LOCAT2	1410.358	4.16	<0.0001
MTH1	1009.454	0.86	0.3923
MTH2	6645.314	5.68	<0.0001
MTH3	8387.060	7.04	<0.0001
MTH4	5954.094	5.00	<0.0001
MTH5	4063.100	3.37	0.0008
MTH6	2117.274	1.77	0.0785
MTH7	2460.036	2.05	0.0411
MTH8	615.352	0.52	0.6060
MTH9	-2362.870	-2.12	0.0348
MTH10	468.785	0.40	0.6868
MTH11	1837.268	1.48	0.1409
YR1	-1964.420	-2.78	0.0057
YR2	-2430.636	-2.90	0.0039
YR3	-3386.929	-2.10	0.0365
YR4	-2439.962	-4.41	<0.0001
YR5	-1553.242	-2.52	0.0121
YR6	1280.121	2.19	0.0295
YR7	-1537.503	-2.47	0.0140
YR8	2638.817	2.23	0.0264
YR9	71.869	0.12	0.9026

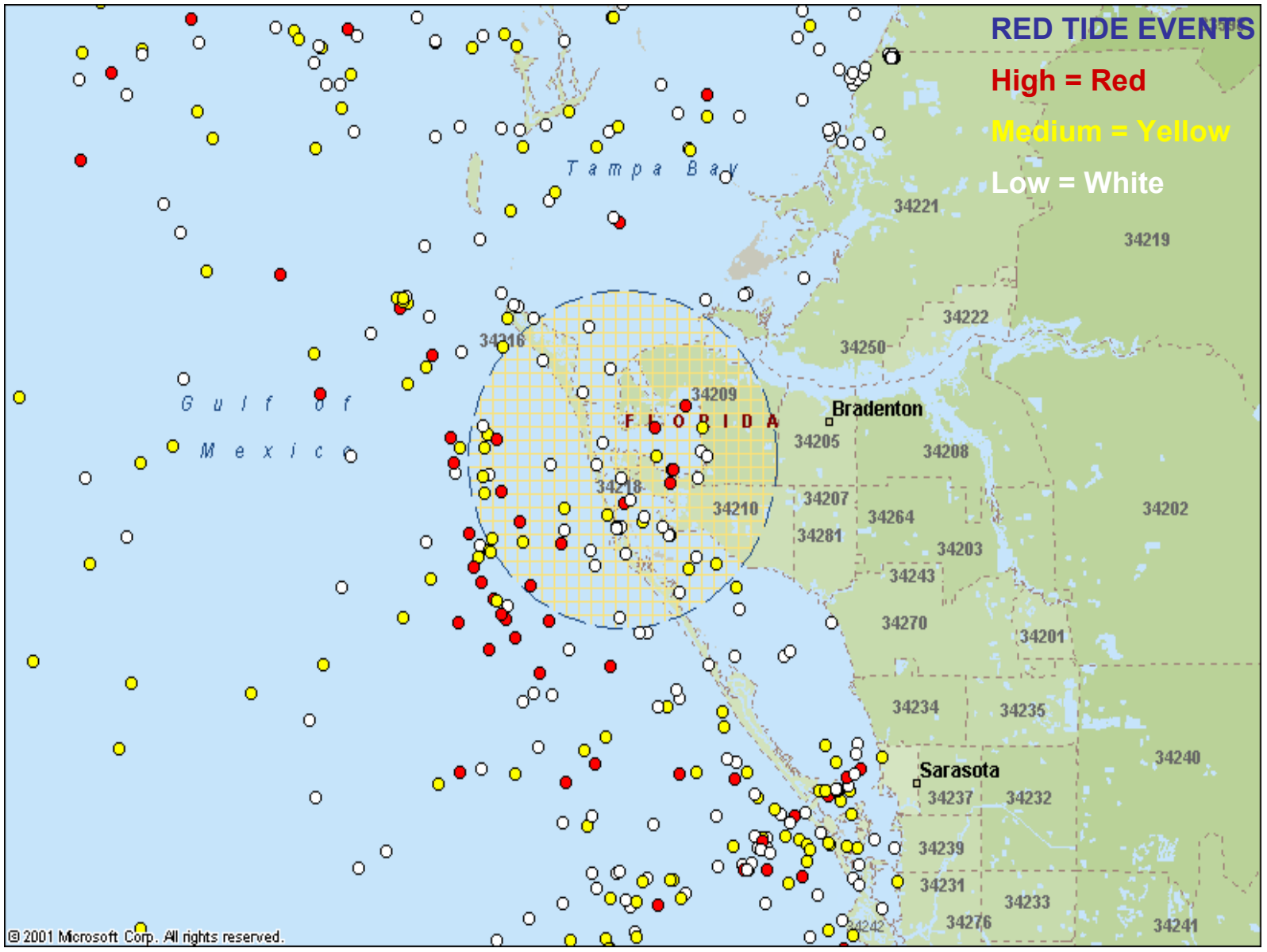

Figure 1. Map Identifying Red Tide Events as Low, Medium, or High and the Five Mile Radius around the Study Area, 2000-05