Chapter

The Tourism Impacts of Lake Erie Hazardous Algal Blooms

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Abstract

Nutrient loading and warming waters can lead to hazardous algal blooms (HABs). Policymakers require cost-effective valuation tools to help understand impacts and prioritize adaptation measures. This chapter evaluates the tourism impacts of HABs in Western Lake Erie based on HABs that occurred in 2011 and 2014, both through a unique temporal and spatial specification of HAB severity as well as input/output analysis and decomposition of trips and profitability.

Keywords: hazardous algal blooms, HABs, nutrient loading, socioeconomic, benefits transfer, Lake Erie, input/output, tourism

1. Introduction

Attractive inland waters such as western Lake Erie can provide significant tourism services [1]. Hazardous algal blooms (HABs) that tend to result from warm water and nutrient loading result in murky and unpleasant water (**Figure 1**), potentially interrupting the $12.9 billion tourism industry in the region and putting

Figure 1.
Maumee Bay State Park, Ohio, 2013 HAB. Source: Ref. [2].

at risk up to 119,491 jobs in the sector [3]. Tourism losses can further disrupt local economic activity as tourists provide important demand for residential and hotel rentals, as well as other local expenditures such as restaurants and shops. As a result, profitability impacts to tourism can influence residential and commercial property values. Consequently, the economic implications of HABs in western Lake Erie are far-reaching and complex. In 2014 the authors of this chapter analyzed the socio-economic impacts of HABs in western Lake Erie. This chapter summarizes an evaluation of HAB effects to tourism that was part of a larger study of impacts to regional economic welfare including effects on property values, tourism, and recreation [1].

2. Ecological services and economic benefits

The study employs a forward-looking perspective in order to identify the economic benefits of reductions in future HABs. The economic methods employed are based on willingness to pay for ecological services. Reductions in these services impact economic values. That results in changes to behaviors and activities, ultimately affecting economic benefits. This process is depicted in **Figure 2**. This study examines the impact of reduction in quality of ecological services, which leads to changes in behaviors and activities, ultimately creating economic costs. This process is depicted in **Figure 2**.

As **Figure 2** depicts, there are many potentially interrelated ecological services. As a result, changes in these services affect behaviors and activities that are also interrelated. For example, lower boating quality could affect local boating trips, curbing tourism, which reduces commercial activity and profits as well as both commercial and residential property value.

Conceptually, this study relies on the assumption that individuals express their desires through their choices and trade-offs. Economic gains and losses are measured through consumer surplus—the difference between the amount someone is willing to pay for a good or service and the market value of that same item. For example, if someone is willing to pay $7 for an item with a market price of $4, then that item has a consumer surplus of $3.

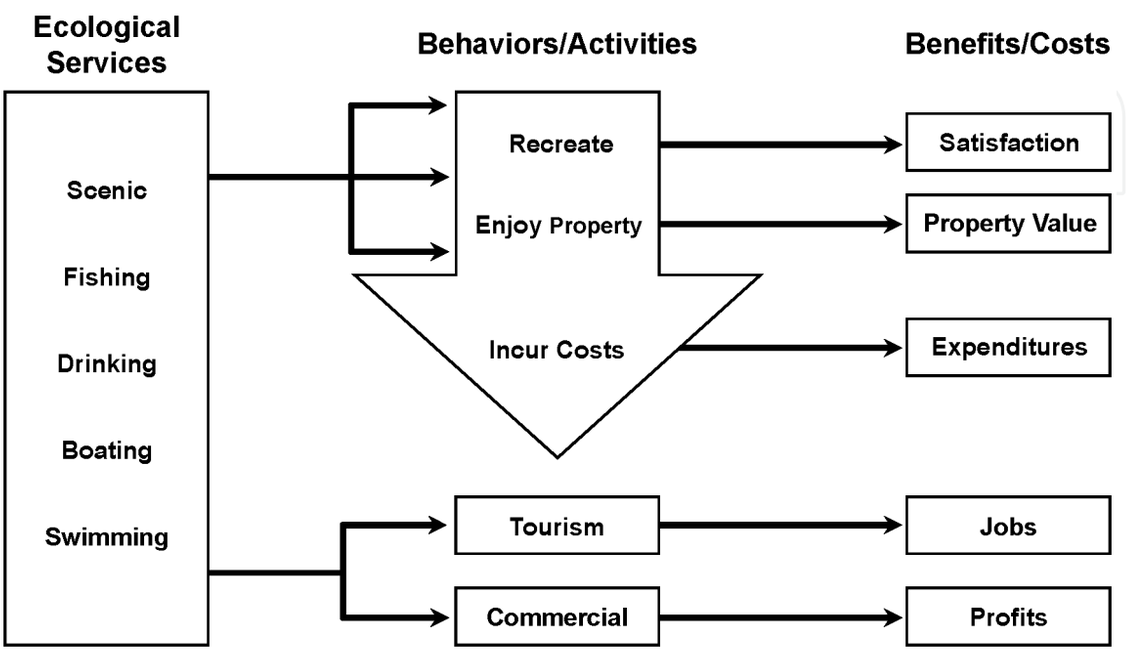

Figure 2.
Economic relationships.

3. HAB scenarios studied in this effort

HABs of varying levels of severity are likely to recur in Lake Erie. Their size and location are difficult to predict, but mitigation may allow for the avoidance of potentially large and far-reaching economic effects. Consequently, when considering the immediate (i.e., within-year) effects, this study uses past HABs to predict the economic effects that would accompany reductions in future HABs.

This study focuses on the most damaging recent HABs in 2011 and 2014, and the consequent service reductions for those years. While information about beach closures is available, there are no data specifically analyzing reductions in tourism, or quantitative analyses of the impacts of these two HABs While visual data showing reductions in ecological service (such as contaminated shorelines or clogged marines) are readily available, a lack of quantitative or written analysis hinders precise analysis of the date, location, and severity of past HABs.

Given this limitation, this study uses news reports and satellite images to create a scale of HAB severity [4]. Since most overhead images of Lake Erie's algal blooms are not precisely dated, the study relies on date-stamped satellite images from NOAA such as that depicted below (**Figure 3**).

For several years up to 2012, NOAA posted Medium-Spectral Resolution Imaging Spectrometer (MERIS) imagery of Lake Erie. Since then, NOAA has posted images of Lake Erie HABs from the Moderate Resolution Imaging Spectro-Radiometer (MODIS) on the AQUA satellite. Both MERIS and MODIS imagery are dated at least weekly [6]. An example satellite view is depicted above. This study uses a scale ranging from 0 to 1 to quantify HAB severity in a given area of Lake Erie.

This study uses the finest degree possible of both temporal specificity—weekly analysis—and spatial specificity—county-level for mainland shorelines in addition to three island groupings. Severity ratings by week and month were developed for 2011 and 2014 from July through October. **Table 1** below analyzes July of 2011.

This information was incorporated into the evaluation of effects to tourism.

Figure 3.
Satellite view of Lake Erie HAB. Source: Ref. [5].

Location	2011 July weeks			
	1st	2nd	3rd	4th
Essex mainland	0	0	0.25	0
Pelee Island	0	0	0	0
Wayne (southern tip)	0	0	0	0
Monroe	0	0	0.50	0.50
Lucas	0	0	0.50	0.25
Ottawa mainland	0	0	0	0
Bass Islands	0	0	0	0
Sandusky	0	0	0.50	0.25
Erie mainland	0	0	0	0
Kelleys Island, Erie County	0	0	0	0

Table 1.
Severity rating for HABs in the Western Basin of Lake Erie, July 2011. Sources: [6–9].

4. Tourism and commerce

Since tourism, business demand, and commercial property values are all closely related, by affecting tourism HABs can in turn negatively impact all three economic sectors in areas close to western Lake Erie. For example, a well-publicized HAB event would almost certainly reduce tourism, in turn lowering revenue for businesses such as local restaurants, hotels, and charter boat operators. As these businesses lose revenue, they would likely purchase fewer supplies, affecting other businesses upstream in the supply chain. Finally, since these businesses would be expected to purchase less labor due to lower demand, either by hiring less or through layoffs, the local economy suffers as a result of lost local wages.

Ultimately, these sorts of effects would be reflected in business balance sheets as reduced revenues and profitability. Additionally, since affected businesses' values are most likely tied to their assets and the real estate they occupy (for example, a marina is not easily converted to some other use), on-going balance sheet effects would ultimately lead to reductions in commercial real estate values.

There are many challenges to understanding the implications of changes in tourism from HABs. The clearest challenge obstructing a precise analysis of these impacts is a lack of data either on the amount of tourism at risk or the specific impact of HABs on tourism. For example, while county-level data exists for total expenditures on tourism, this includes tourism which would not be interrupted by HABs or other discouraging factors.

An additional challenge relates to the distinction between economic benefits (willingness to pay) and economic impacts (expenditures), and the measurement of the economic benefits that arise from economic impacts (profits). For example, consider a restaurant owner who loses $10,000 in revenue because of a HAB. The owner's willingness to pay to recover that revenue; is (roughly speaking) the lost profit on that revenue. This is more difficult to identify than lost revenue. Understanding the negative effects of HABs upstream in a supply chain requires knowing what expenditures were foregone, which depends on the operation's variable cost situation with respect to employees (salaried or not) already purchased foodstuffs (perishable or not) and utilities. To address this issue, the study identifies expenditure changes and then characterizes benefits associated with those changes.

An additional issue is that changes in tourism may represent changed rather than lost trips. A tourist who does not go to the western basin because of HABs might instead go to the central basin, or somewhere else. As a result, changes in demand in one area have an opposite effect in other areas. To address this, we limit the geographical scope of the study to a region affected by HABs.

Finally, because commercial property values tend to be linked to business profitability, evaluating both risks double-counting. This study focuses on business profitability.

The remainder of this chapter presents the detailed methods and results. Counties studied are United States counties depicted below (**Figure 4**).

Due to differences in available data, slightly different methods are applied for Ohio, and Michigan.

4.1 Ohio tourism

As different sorts of information are available by region, varying approaches are applied. This sub-section explores potential effects in Lucas, Ottawa, Sandusky, and Erie counties. The approach relies on estimates of expenditures per trip. Expenditure and trip data in Ohio are collected from [3, 10] which indicate $110 per Ohio day visitor in 2013. This is 57.4% of total visitor spending and 80% of total Ohio visitors. Some 33% are from Toledo and Cleveland.

Spending from overnighters in 2013 was estimated at $335 per day—42.6% of total Ohio visitor spending. These visitors were 20% of total visitors. Of these, 20% are with relatives and friends. Average of nights per trip was 3.2 nights per trip and that of members per party was 3.4. Eighteen percent of these visitors went to a beach at a lake. Consumers spend the most on transportation, as well as food and beverage, since both day and overnight visitors spend money in these categories. Lodging only accounts for 11% of spending, while retail and recreation expenditures are almost one-third of Ohio visitor spending.

These expenditure rates can be subdivided based on trip type and expenditures. For example, day visitors spend $110 per visitor with none of that being for air travel or lodging. Overnight visitors' costs vary depending on if visitors stay with friends/family or in commercial lodging. For the purposes of this study, we presume overnight visitors who stay with friends and family do not spend money on lodging and overnight visitors who stay with friends and family spend an average of $244. Those who stay in commercial lodging places spend about 10% more on food and beverages than overnight visitors who stay with friends and family. On average this is $358 per day for each overnight visitor who pays for lodging.

Figure 4.
Counties studied.

Per-day expenditures vary by type of visit. In order to capture the full effect of changes in tourism using available tourism information, the effect of consumer expenditures must be extrapolated in terms of their implications for expenditures in other parts of the supply chain. To do so, we apply a mathematical-economic technique called input/output analysis [11]. Input/output analysis can be used to assess the effects of direct changes in expenditures through indirect impacts which arise in supplying industries and induced impacts which result from changes in local employment impacts to local expenditures.

Impacts are estimated using IMPLAN [12] with equations and data from ZIP codes on the shoreline of Lake Erie in Lucas County, Ohio. IMPLAN contains detailed input-output information on more than 500 economic sectors at the national, state, county, and ZIP code level.

Expenditures are apportioned over these sectors at the rate that they appear in the IMPLAN data and then simulations are conducted using IMPLAN. The sum of per-trip indirect and induced effects is a fraction of direct effects.

The approach for estimating tourist trips and dollars at risk in Ohio begins with estimates of by county tourism economic impacts in 2013. These are available from [3].

These are converted into a composite trip. Modeling in IMPLAN indicates the economic impact of an average tourist day is $210. This approach provides estimates of tourist trips from outside Ohio's western basin shoreline counties, before narrowing the scope to trips that would potentially be affected by HABs, i.e. trips related to Lake Erie which occur when HABs are present in Lake Erie. Based on [10] which indicates that hotel stays are evenly distributed over the year and that 18% of tourist trip to Ohio are visits to lakeside beaches, the late summer and early fall account for 12% of annual days. Tourist days that are at risk from HABs are calculated as 2.16% of trips ($0.18 \times 0.12 = 0.0216$). The percentage of shoreline trips is not available, and 10% is specified. This process results in estimates of Ohio tourist dollars at risk that range from $66 million to $305 million.

Based on a percent of diverted trips of 5 and 10% Ohio tourist dollar losses on the low-end total approximately $3 million. On the high end, they exceed $30 million. Considering these estimates of lost revenue, it remains to consider the benefits associated with these. Changes in profit are the best-available representation of the benefit (willingness to pay) for changes in revenue. Profit is the difference between costs and revenues.

The authors of [13] report restaurants earn from 4 to 6% median income on revenue before taxes. According to calculations derived from [14] losing a marginal customer could impact restaurant profit anywhere from 5 to 68%, so long as labor and operating costs remain constant. This implies high-end lost profits of $20.79 million and low-end estimates of $165,000.

4.2 Michigan tourism

Wayne and Monroe counties are in Michigan and adjacent to Lake Erie. Because only a small portion of Wayne County is exposed and impacts there are minimal Wayne County was not evaluated. Using methods similar to those that were applied for Ohio the number and types of trips that would sum to 14 million visitors to Monroe County were evaluated [15, 16].

These 14 million visitors indicate a total of 74,288 trips at risk from the presence of HABs. This further breaks down to 24,728 day trips, 25,276 unpaid overnight trips, 16,355 at a hotel, and 7930 at a bed and breakfast that are at-risk. This is associated with $18.2 million. With indirect and induced effects included a total of $24.78 million in tourism economic impact is at risk in Monroe County.

Using methods as described for Ohio, there are high-end lost profits of $1.685 million and low-end estimates of $124,000.

5. Conclusions

Tourism is a dynamic activity that can be easily affected by negative events such as HABs. Ohio tourist dollars at risk from HABs range from $66 million to $305 million. Associated high-end lost profits are $21 million but could be under $1 million. In Michigan, about $25 million in tourism economic impact was judged to be at risk, which was associated with lost profits of $1.7 million on the high end. Deriving these results from available data requires numerous assumptions, and result in large ranges of uncertainty.

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Conflict of interest

There are no conflicts of interest.

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