Economic Consequences of Harmful Algal Blooms: Literature Summary[1]

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Introduction

The Gulf of Mexico Alliance (GOMA) sought information on how best to (1) co-educate the management and scientific communities on the economic impacts of harmful algal blooms (HABs) and new methods to better capture HAB economic and social impacts, and (2) move the communities toward a standardized way of measuring the economic ramifications of HABs (Figure 1). This information is critical to assessing the economic risk that HABs pose to coastal communities and thereby help to direct the appropriate level of resources toward investigating potential prevention, mitigation, and control strategies. In the United States, federal programs include the interagency Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program; the NOAA Monitoring and Event Response for Harmful Algal Blooms Program (MERHAB); and the NOAA Prevention, Control, and Mitigation of Harmful Algal Blooms Program (PCM HAB).

To address these needs, this factsheet first summarizes the existing literature that attempts to measure some of the economic consequences associated with harmful algal blooms (HABs). This is accomplished by using the recent report by Adams and Larkin (2013) that contains an annotated bibliography of both peer-reviewed and "grey" (i.e., unreviewed) research papers (available online at http://www.fred.ifas.ufl.edu/pdf/Adams-Larkin-LitRev-April2013.pdf). In addition, this factsheet describes the methodologies that have been used to measure economic losses; reviews the types and sources of data used; discusses the complexities of addressing the scope of HAB events; analyzes the focus of previous studies in terms of types of HABS examined; and identifies research gaps.

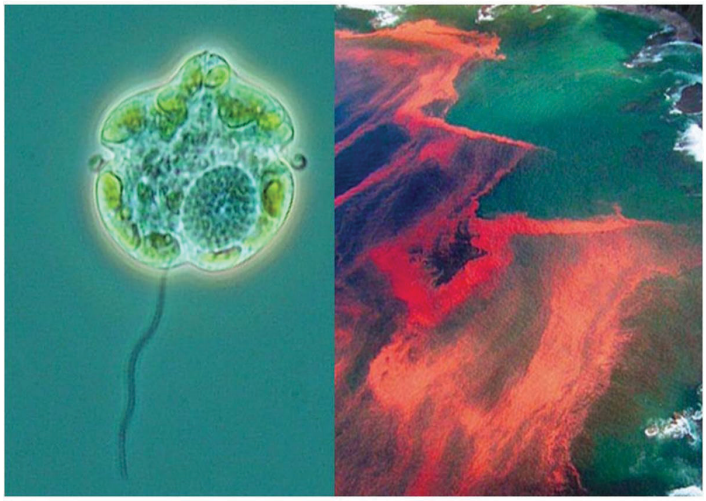

Figure 1. HAB: *Karenia brevis* (Red Tide).
Credits: M. Godfrey, CoML

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Summary of Existing Research Articles

Overview

Twenty-nine "research" papers that attempted to estimate the economic losses of a HAB event or several HAB events over time were identified (Adams and Larkin 2013, p. 27–29). The review included any paper that reported distinct economic effects, from those conducting primary data collection and found in peer-reviewed outlets to those considered to be in the grey literature that, for example, reported calculations of impacts from secondary data. The overall contribution of these 29 papers is considered by discussing the following four aspects of the research: (1) the methodologies used to generate the economic effects, (2) the sources and types of data used, (3) the spatial and temporal scope of the analyses (e.g., the geographic boundaries, such as zip codes or counties, and whether measured by day, week, month, etc.), and (4) the nature of the problem (e.g., the species or specific effects measured). Each is discussed in turn, but the content is not mutually exclusive because some overlap exists (e.g., the methodology and data are often linked). In addition, for quick reference, the papers are summarized by column in Table 1.

Research Methodologies

The most basic distinction to make regarding approaches used to estimate economic consequences as a result of HABs is whether the consequences are "market" or "non-market" in nature. Market-related losses can be measured with data from markets (e.g., prices and or quantities of goods that are bought and sold)—either directly or through surrogate markets—to identify the effects of HABs. Direct market methods are those that use data that reflect a change in market value, revenue, or expenditure (e.g., seafood market sales, sales by water-adjacent businesses, and costs of HAB monitoring and/or cleanup). Surrogate market methods use data from related or substitute markets to capture a change in value (e.g., real estate values, travel costs to substitute recreational sites).

Measuring market losses with either direct or surrogate market data is referred to as using "revealed preference approaches" in the economics discipline. Revealed preference approaches are so named because user preferences (i.e., economic values) are obtained (i.e., revealed) from market data (e.g., expenditures) that have been incurred by users (e.g., restaurant patrons and recreational boaters). This market information can be obtained directly from businesses or from surveys that ask users how their behavior changed following a red tide. The advantage of using revealed preference data is that this data may be especially reliable because it reflects past choices that users made in response to a red tide. Unfortunately, for some types of economic losses, revealed preference data is unavailable (e.g., to value proposed programs designed to mitigate and control for the effects of HABs), so stated preference approaches must be used.

In contrast to revealed preference approaches, "stated preference approaches" measure non-market losses by determining user preferences by asking individuals how they value a certain good (e.g., a proposed program to control algal blooms before they become HABs). Non-market goods are those for which no formal market exists (i.e., equilibrium price and quantity derived from supply and demand conditions). Examples of non-market goods as they relate to HABs include the value that residents have for proposed public programs to prevent, control, and mitigate HABs; clean coastal waters for marine-related recreation; and clean coastal waters for the ecosystem services or existence values of marine mammals that coastal waters support. Stated preference approaches necessarily involve surveys that ask users how they value certain non-market goods, often by asking them how they would vote on various referendums to establish programs that would prevent HAB-related losses. The advantage of stated preference approaches in general is that such studies are tailored to measure exactly what is, as opposed to being constrained by the available market data. Stated preference approaches to measure non-market economic values are generally referred to as using the "contingent valuation method" (CVM) because the results are contingent upon the hypothetical scenario that respondents are being asked to value. Although stated preference surveys are most useful precisely because they can be tailored to measure exactly what is needed, this flexibility is also the most common criticism for the stated preference approach; that is, respondents are being asked to value hypothetical programs or changes with which they have little experience (e.g., programs that would have an uncertain effect on the duration or intensity of bloom events). However, there is a large and growing body of literature to guide the successful use of stated preference approaches in generating valid economic values after such approaches were accepted for use in courts of law to determine compensation following the Exxon–Valdez oil spill.

Using the broad distinction between market (revealed preference) and non-market (stated preference) methods, the majority of studies have employed the revealed preference approach to estimating losses. In particular, of the

29 key papers reviewed, 22 papers (76 percent) have used secondary data as reported by government agencies or historic data provided by businesses or individuals. The revealed preference papers also include four papers that use input-output models to determine the economic impact of a HAB to a local community, typically using industry multipliers at the county or state level. Input-output models calculate the change in overall economic activity of a county, region, or state caused by a disruption in total revenues experienced by a given economic sector (e.g., reduction in seafood sales). These models track the effects of lost economic activity by sector and up through the value chain by measuring impacts such as change in total output (in dollars) and the associated change in tax revenues and jobs. An additional four papers (14 percent) used stated preferences only, most by surveying residents or coastal managers. In addition, three papers (10 percent) used both the revealed preference and stated preference approaches by asking for past behavioral choices (e.g., recreational visits before, during, and/or after a red tide event) in a survey before asking for their preferences concerning a hypothetical change in coastal water quality (i.e., preferences for a program that could affect HABs and, therefore, coastal water quality at residential and recreational sites).

Sources and Types of Data

The data used to derive empirical results include both primary and secondary data. Primary data include those collected directly from businesses (e.g., lost sales), coastal managers (e.g., costs incurred for cleanup or monitoring), and individuals (e.g., how previous HABs changed eating and recreational choices and how individuals value proposed programs to reduce HAB losses). Secondary data (which are primarily collected by government agencies) include quantitative information that has been previously collected such as a time series of commercial fishery landings, recreational fishing trips, beach attendance, reported tourism revenues (restaurant and lodging industries), seafood sales, number of illnesses, data on environmental conditions, HAB-related press releases, etc. The primary source of secondary data is government agencies.

Of the 29 studies reviewed, 11 studies (38 percent) used primary data, while 10 studies (34 percent) used secondary data. Six studies (21 percent) required the use of both primary and secondary data to achieve the research objectives. In the final two studies (7 percent), one did not report the type of data used and the other used metadata, or results (economic losses) reported in several previous studies.

Overall, the data used in these studies were obtained from a variety of sources. The secondary data were obtained mostly from municipal, state, and federal agencies, while the primary data were obtained from surveys administered by the research team. The surveys were administered to a wide range of user groups, depending on the nature of the study objectives.

Spatial and Temporal Scope

"Spatial scope" refers to the location of HAB events and the general geographic area of impacts. The spatial scope of studies focusing on economic effects has ranged from impacts on single lakes, bays, or counties up to national impacts (e.g., United States, Finland, and Canada). In between are impacts that encompass multiple counties (e.g., southwest Florida, northwest Florida, Cape Cod) or multiple states (e.g., Mid-Atlantic region, New England). The definition of the geographic scope depends on either the distribution of the HAB event or the market area expected to be impacted (e.g., local beach areas or entire states where impacted seafood consumers reside). In some cases, attempts were made to assess the HAB impacts on a very fine scale of spatial resolution. However, such attempts are often constrained by the required data on economic activity (e.g., issues of confidentiality limit the availability of secondary data, or the spatial data simply do not exist on a high level of resolution as might be needed to assess very localized impacts).

"Temporal scope" refers to when HAB events have occurred, their duration, and the time step of measurement (i.e., days, weeks, months, etc.). The temporal scope of studies focusing on the economic effects ranges widely. Some studies attempt to quantify the impacts of a single bloom event (which could range from days to several months), and others span multiple years. Studies commonly use a time series of data (such as historic seafood landings, or reported tourism revenues for tax purposes, on a weekly or monthly basis) to identify changes in business activity or value during HAB events. Again, assessing the impact of the HAB event at the appropriate level of temporal resolution may be difficult due to the availability of data. For example, secondary data are often collected periodically by state governments for tax purposes; these data may not match the time period needed to assess relatively short HABs (data collected monthly may not capture a two-week HAB that spans over two reporting months, for instance), or HABs that do not match the geographic resolution of data collection (tax data, for example, are often collected by zip codes, which can cover unaffected inland areas). Data for shorter time periods or more localized coastal areas need

to be collected outside of existing agency data collection programs. Such primary data collection efforts are time consuming and costly for affected residents, businesses, government agencies, and researchers.

Of the studies reviewed, the range of temporal and spatial scopes of analysis was considerable. The wide range was a function of the problem being studied, which indicates that the economic effects of major HABs have been investigated to date, and that data are available to address the questions. On a temporal basis, studies primarily used annual and monthly data. On a spatial basis, of the 29 studies reviewed, six studies (21 percent) addressed HABs on a national scope, eleven (38 percent) addressed HABs on the state level, nine (31 percent) addressed HABs on a multi- or single-county level, and three (10 percent) addressed a HAB event on a very localized basis.

Nature of the Problem

The primary focus of this literature review effort was to summarize past research on the "economics of red tides," including related studies to the extent possible. While red tides are HABs that are typically associated with algal blooms of a particular algae species due to visible changes in coastal waters (e.g., *Karenia brevis*), the economic impacts of algal blooms are often described based on impacts to affected natural resources (namely freshwater and marine fish and shellfish) and humans.

There are five types of HAB toxins found in North America that affect fish and shellfish. These toxins and their associated affects include:

1. brevetoxins (neurological shellfish poisoning, NSP)
2. saxitoxins and their derivatives (paralytic shellfish poisoning, PSP)
3. domoic acid (amnesic shellfish poisoning, ASP)
4. okadaic acid (diarrhetic shellfish poisoning, DSP)
5. ciguatoxin (ciguatera poisoning)

Red tides in the Southeast United States—the region of primary interest for the Gulf of Mexico Alliance (GOMA)—have been dominated by algal species that produce brevetoxins during a bloom (namely *Karenia brevis*). The economic effects of these red tides result from fish, shellfish, and marine mammal kills that affect recreation activities and human seafood consumption (they may also affect those who value a healthy ecosystem and the services it provides). The red tide brevetoxins can also become airborne and affect the respiratory system of humans and, thereby, negatively affect coastal recreation. Of the 22 papers that identified an algae species, 36 percent reported economic effects associated with *Karenia brevis* blooms.

With respect to shellfish consumption, the toxic algae are undetectable by sensory analysis such that potential poisoning and illness due to ingestion is likely. The toxins are also heat resistant, which means they cannot be destroyed by cooking. The remaining four toxins (PSP, ASP, DSP, and ciguatera) are the subject of the remaining papers (13 papers, or 64 percent) and are mostly associated with cold-water species, with the primary human health impacts linked through impacts on recreational or commercial harvest for consumption.

Conclusions and Current Research Gaps

While much research on the economic consequences of HABs has been conducted, there remain some gaps that provide the potential for additional and critically needed work.

- Time series analyses routinely use historic data (weekly, monthly, or annually) from businesses or the government (fishery landings, reported earnings, recreational trips) that encompass red tide events. No studies have used both time-series and cross-section data. The use of the Marine Recreational Information Program, a national data collection program based on coastal intercept surveys, holds promise for such studies.
- Linking HAB impacts with community demographic "layers" of data would allow for an assessment of the distribution of HAB impacts across segments of the population. Such work has not been done with HAB events in the United States. IMPLAN analysis is particularly well-suited to modifying the extent to which changes in economic activity affect each layer.
- Data useful for assessing the impact of HABs on nearby water-related businesses are typically secondary in nature. Such data often provide strict limits on describing the temporal and spatial characteristics of the HAB impacts. Developing data collection programs on a "real time" basis would better allow for a more complete assessment of HAB events on local businesses and communities. Such real time data may require an on-going data collection process at a very fine level of resolution, both temporally and spatially. Designing and implementing such primary

data collection efforts would require "buy-in" by local businesses that are vulnerable to the effects of HABs.

- HAB events may have a lagged impact on local business communities. This potential dynamic element of HAB event impacts has not been fully explored.
- HAB events are characterized by a wide range of intensity and duration levels. Few studies have investigated the role of intensity and none appear to address the potential for a non-linear relationship between economic losses and duration. Better linking economic impacts of HABs with intensity and duration would provide coastal planners with additional information that would be useful in making decisions regarding prevention, mitigation, and control options for HABs.
- HABs may have an impact on coastal property values and comprehensive location planning efforts. How have local property markets and planning efforts been compromised and impacted by HAB events across communities and over time? While some research has been conducted in isolated areas, there is room for additional work given property market data are readily available.
- HABs may generate significant indirect impacts, such as when local finfish and shellfish populations are impacted either by short-term or long-term events. How do these impacts manifest themselves in long-term resource management decisions on a state and federal level? For example, fisheries management is a complex process throughout the United States. The recent impacts of red tides on the reef fish resource in the eastern Gulf of Mexico (i.e., when official grouper population estimates were altered to acknowledge the adverse impact of a red tide event) is an example of how long-term resource viability can be impacted and highlights the fact that HAB events can play a role in broader resource management issues.
- "Research" articles contain a diversity of papers in terms of scientific rigor. While some estimate correlations using a time series or cross section of data (e.g., commercial fishery landings or general public surveys, respectively), a fair amount perform basic calculations using less reliable secondary data. Research proposals should be explicit about what the research will measure and how measurements will be taken, in order to provide for assessment of the credibility of final results.
- The nature of results is inconsistently reported. Empirical results should be reported as percentage changes to facilitate comparisons. Absolute losses are important but difficult to assess in terms of magnitude without baseline figures or relative changes.
- Time horizons and geographic areas affected are often vaguely defined. Studies should explicitly state both the region and time horizons and the extent to which the data are able to capture and do in fact capture the sole effects of the HAB event.
- Potential researchers should explore alternative ways to combine revealed and stated preference approaches following the recent advances in the non-market valuation literature.
- Potential researchers should strengthen stated preference studies by surveying only representative populations and by reducing identifiable biases typically associated with surveys.
- Few studies have used existing models to take full advantage of past and related modeling efforts. Ecosystem-type models in particular (e.g., EcoSim and Atlantis) would be helpful to assess the relative importance of HAB events compared to other environmental and anthropogenic stressors to help guide managers.

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Reference

Adams, C.M., and S.L. Larkin. 2013. *Economics of Harmful Algal Blooms: Literature Review*. Final report for Gulf of Mexico Alliance Project #00100304, Tallahassee, FL. http://www.fred.ifas.ufl.edu/pdf/Adams-Larkin-LitRev-April2013.pdf.

Table 1. Summary of existing research articles from Adams and Larkin (2013) that measured the economic consequences of HABs or related events (in alphabetical order)

Authors	Title	Publisher	Year published	Temporal scope	Spatial scope	Method	Source/ Type of data	Algae/Toxin
Athearn	Economic Losses from Closure of Shellfish Harvesting Areas in Maine	University of Maine (working paper)	2008	2001–2005	Maine	Revealed: Estimated decline in landings, input-output modeling (IMPLAN)	Maine Department of Marine Resources (secondary)	Unspecified
Cummins	Potential Economic Loss to the Calhoun County Oystermen	Dolphin Talk (online newsletter)	2012	2011–2012	Calhoun County, Texas	Revealed: Calculated decline in dockside value	Texas Parks and Wildlife Department (secondary)	Karenia brevis
Diaby	Economic Impact of Neuse River Closure on Commercial Fishing	North Carolina Division of Marine Fisheries (report)	1996	1995	Neuse River, North Carolina	Revealed: Calculation of reduction in landings from previous year	Surveys of seafood dealers; North Carolina Division of Marine Fisheries (primary & secondary)	Pfiesteria
Dodds et al.	Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages	Environmental Science & Technology (journal)	2008	Unspecified	United States freshwaters	Revealed: Calculated reductions multiplied by value	Unspecified (secondary)	Unspecified
Dyson & Huppert	Regional Economic Impacts of Razor Clam Beach Closures due to (HABs) on the Pacific Coast of Washington	Harmful Algae (journal)	2010	2008	Washington state (Pacific and Grays Harbor Counties)	Revealed: Input-output analysis (IMPLAN)	Survey of recreational clammers (primary)	Pseudo-nitzschia, Alexandrium
Evans & Jones	Economic Impact of the 2000 Red Tide on Galveston County, Texas: A Case Study	Texas A&M University (report)	2001	2000 red tide event	Galveston County, Texas	Revealed: Input-output analysis (IMPLAN)	Survey of agencies; Texas Parks and Wildlife; Texas Department of Health (primary & secondary)	Karenia brevis
Habas & Gilbert	The Economic Effects of the 1971 Florida Red Tide and the Damage it Presages for Future Occurrences	Environmental Letters (journal)	1974	1971	Southwest Florida	Revealed: Calculation of losses to tourism industry and commercial fishermen	Survey of industry; Florida Department of Revenue; accountant records (primary & secondary)	Karenia brevis

Authors	Title	Publisher	Year published	Temporal scope	Spatial scope	Method	Source/ Type of data	Algae/Toxin
Hoagland et al.	The Economics Estimates of HABs in the US: Estimates, Assessment Issues and Information Needs	Estuaries (journal)	2002	1987–1992	United States	Revealed: Calculation of losses per event, averaged annually	Survey of experts; literature review (primary & secondary)	Unspecified
Hoagland et al.	The Costs of Respiratory Illnesses Arising from Florida Gulf Coast Karenia brevis Blooms (journal)	Environmental Health Perspectives	2009	Time span	Sarasota County, Florida	Revealed: Cost estimation: Estimated number of cases multiplied by calculated cost of illness	Sarasota Memorial Hospital; Mote Marine Lab; CDC; Florida Agency for Health Care Administration (secondary)	Karenia brevis
Jin & Hoagland	The Value of HAB Predictions to the Nearshore Commercial Shellfish Fishery in the Gulf of Maine (journal)	Harmful Algae	2008	Event specific	New England (Maine and Massachusetts)	Revealed: Calculated value of using HAB prediction model	NMFS; Massachusetts Division of Marine Fisheries (secondary)	Unspecified
Jin et al.	Economic Impact of the 2005 Red Tide Event on Commercial Shellfish Industries in New England	Ocean and Coastal Management (journal)	2008	1990–2005	New England (Maine and Massachusetts)	Revealed: Estimated reduction in landings, imports and prices with values extrapolated	NMFS; U.S. Census Bureau; New York Fulton Fish Market (secondary)	Alexandrium fundyense
Kahn & Rockel	Measuring the Economic Effects of Brown Tides	Journal of Shellfish Research (journal)	1988	Unspecified	New York state	Revealed: Regression analysis of bay scallop industry (implied)	Unspecified (unspecified)	Brown tide
Lankia & Huhtala	Valuation of Trips to Second Homes in the Country: Do Environmental Attributes Matter?	EAAE 2011 Congress (working paper)	2011	Jan-09	Finland	Revealed and Stated: Estimated decline in trips, reduction in CS/ trip	Survey of owners of second homes (primary)	Unspecified
Larkin & Adams	HABs and Coastal Business: Economic Consequences in Florida	Society and Natural Resources (journal)	2007	1995–1999	Northwest Florida	Revealed: Estimated reduction in reported monthly earnings for tourism businesses	Florida Department of Revenue; National Climatic Data Center; Florida Marine Research Institute (secondary)	Karenia brevis

Authors	Title	Publisher	Year published	Temporal scope	Spatial scope	Method	Source/ Type of data	Algae/Toxin
Lucas	Willingness-to-Pay for Red Tide Prevention, Control and Mitigation Strategies: A Case Study of Coastal Residents	University of Florida (report)	2010	2009	Florida	Stated: Estimated preference for proposed strategy, WTP	Survey of coastal residents (primary)	Karenia brevis
Lipton	Pfiesteria's Economic Impact on Seafood Industry Sales and Recreational Fishing	University of Maryland (working paper)	1998	January–December 1997	Maryland	Revealed: Calculation of lost sales and recreational trips (multiplied by $/ trip from Strand)	Survey of seafood industry members; NMFS/MRFSS (primary & secondary)	Unspecified
Morgan et al.	Red Tides and Participation in Marine-based Activities: Estimating the Response of Southwest Florida Residents	Harmful Algae (journal)	2010	January–December 2008	Sarasota and Manatee Counties, Florida	Revealed: Estimated probability of behavioral change by activity	Survey of county residents (primary)	Karenia brevis
Morgan et al.	Firm-level Economic Effects of HABS: A Tool for Business Loss Assessment	Harmful Algae (journal)	2009	Time span	Southwest Florida	Revealed: Estimated reduction in daily restaurant revenues multiplied by affected days	Proprietary business data; National Climatic Data Center (primary & secondary)	Karenia brevis
Morgan et al.	Public Costs of Florida Red Tides: A Survey of Coastal Managers	University of Florida (university extension)	2008	2004–2007	Florida Gulf coast	Revealed: Calculated costs to cities and counties associated with HABs	Survey of coastal managers (primary)	Karenia brevis
Nierenberg et al.	Changes in Work Habits of Lifeguards in Relation to Florida Red Tide	Harmful Algae (journal)	2010	Time span	Sarasota County, Florida	Revealed: Test of reduced attendance multiplied by salary	Survey of lifeguards (primary)	Karenia brevis
Nunes & van den Bergh	Can People Value Protection Against Invasive Marine Species? Evidence from a Joint TC-CV Survey in the Netherlands	Environmental and Resource Economics (journal)	2004	2001	Holland	Revealed and Stated: Estimation of recreation demand and travel cost, comparison of WTP	Survey of beach visitors (primary)	Unspecified

Authors	Title	Publisher	Year published	Temporal scope	Spatial scope	Method	Source/ Type of data	Algae/Toxin
Oh & Ditton	A Time Series Approach to Estimating the Economic Impacts of Exogenous Events on Recreational Fishing	Human Dimensions of Wildlife (journal)	2008	2001–2003	Possum Kingdom Lake, Texas	Revealed: Estimated reduction in visitors and IMPLAN	Texas Comptroller of Public Accounts; Possum Kingdom Lake State Park (secondary)	Prymnesium parvum
Parsons et al.	The Welfare Effects of Pfiesteria-Related Fish Kills in Seafood Markets: A Contingent Behavior Analysis	Agricultural and Resource Economic Review (journal)	2006	2001	Mid-Atlantic Region, United States	Stated: Estimated demand functions and CS	Survey of seafood consumers (primary)	Pfiesteria
Ralston et al.	An Estimate of the Cost of Acute Health Effects from Food- and Water-Borne Marine Pathogens and Toxins in the U.S.	Journal of Water and Health (journal)	2011	Annual	United States	Revealed: Estimated annual cost from lit review (pseudo meta analysis)	Other papers (secondary)	Unspecified
Taylor & Longo	Valuation of Marine Ecosystem Threshold Effects: Application of Choice Experiments to Value Algal Bloom in the Black Sea Coast of Bulgaria	University of Bath (working paper)	2009	Unspecified	Varna Bay, Bulgaria	Stated: Conjoint choice experiment (probability of support and WTP by scenario)	Survey of residents (primary)	Sceletonema costatum, Cerataulina pelagica, Prorocentrum minimum and Gymnodinium sp
Todd	Estimated Costs of Paralytic Shellfish, Diarrhetic Shellfish and Ciguatera Poisoning in Canada	Book chapter (book)	1995	Unspecified	Canada	Revealed: Estimates of number of illness multiplied by cost of illness (society and individual, except pain and suffering)	Unspecified (secondary)	Shellfish poisoning (paralytic, diarrhetic and ciguatera)
van Beukering & Cesar	Ecological Economic Modeling of Coral Reefs: Evaluating Tourist Overuse at Hanauma Bay and Algae Blooms at the Kihei Coast, Hawaii	Pacific Science (journal)	2004	2001	Hawaii	Revealed: Calculated reductions in business using available dynamic econ-ecol simulation model and available economic values	Previous studies, including survey-based non-market valuation (secondary)	Not specified

Authors	Title	Publisher	Year published	Temporal scope	Spatial scope	Method	Source/ Type of data	Algae/Toxin
Wessells et al.	Toxic Algae Contamination and Demand for Shellfish: A Case Study of Demand for Mussels in Montreal	Marine Resource Economics (journal)	1995	May 1987–March 1991	Montreal, Canada	Revealed: Estimation of shellfish demand and sales losses due to information	Proprietary data; Montreal Gazette; Agriculture Canada; Statistics Canada; IMF (primary & secondary)	Domoic acid
Whitehead et al.	The Economic Effects of Pfiesteria	Ocean and Coastal Management (journal)	2003	2001	Delaware, Maryland, North Carolina, Virginia	Stated: Estimation of risk perceptions, seafood demand, and WTP for a safety program from CVM study	Survey of seafood consumers (primary)	Pfiesteria