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Economic effects of *Pfiesteria*

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ABSTRACT

Pfiesteria is a single-celled microorganism that is a toxic predator of a number of fish species. We measure the effects of information about Pfiesteria on three related decision processes of the consumer: risk perceptions, seafood demand, and willingness to pay for a mandatory seafood inspection program. Using responses to a survey on seafood consumption and hypothetical Pfiesteria-related fish kills, we find that announcement of a fish kill increases the perceived risks of seafood and decreases the demand for seafood. Information policies that assure the safety of seafood have little effect in restoring consumer confidence in seafood. Perceived negative information tends to decrease welfare by more than the counter effects of perceived positive information. Welfare losses are recovered through a mandatory seafood inspection program rather than safety announcements.

1. INTRODUCTION

In 1992 researchers identified *Pfiesteria piscicida* (Pfiesteria) as one possible cause of fish kills in eastern North Carolina's estuaries [1]. Pfiesteria is a single-celled microorganism that lies dormant in the sediment of estuaries, but in combination with high nutrient concentrations potentially becomes a toxic predator of a number of fish species. Pfiesteria has also been linked to fish kills in Virginia, Maryland and Delaware. Public perception of Pfiesteria and other harmful algal blooms has the potential to impose significant economic losses on coastal regions. Lost use of recreational resources, lost tourism revenues, decreased consumption of seafood, lost fishing time due to area closures, possible medical costs for treatment and increased regulation on industries all represent decreases in economic welfare.

Media coverage of Pfiesteria has led to temporary, but substantial, decreases in seafood purchases despite a lack of scientific evidence linking these outbreaks to human illness [2]. Significant amounts of research have been conducted to assess the ecological aspects of Pfiesteria (e.g., [3]). Some research has been conducted to assess the social aspects of Pfiesteria (e.g., [2] and [4]). Yet, very little work has been conducted considering the economic costs of Pfiesteria. Kahn and Rockel [5] consider the economic costs of harmful algal blooms.

In this paper we assess the economic effects of Pfiesteria. We consider the effect of general and persuasive information about Pfiesteria on risk perceptions concerning seafood safety, contingent behavior concerning seafood demand, and willingness to pay for a mandatory seafood inspection program.

2. LITERATURE

The food safety literature suggests that information affects perceptions and behavior. Studies investigating revealed behavior reactions to media coverage in food markets find that information about increased risk tends to decrease consumption, while counter information does not necessarily have the opposite effect. Smith et al. [6] find that negative media coverage of a ban and recall of milk in Hawaii significantly decreased milk consumption but counter information about safe milk did not significantly increase consumption. Brown and Schrader [7] find that an index of cholesterol information using medical journal article pages has a consistently negative effect on egg consumption. They find that as egg prices fell and incomes rose, consumption increased less than if there had been no information.

In related survey research, Viscusi et al. [8] present risk information in the form of alternative labeling formats and the size of the warning area for nonfood products (bleach and drain openers). They find that the amount of risk information and the level of risk have predictable effects on the amount of precautions consumers take to protect their health. Smith and Johnson [9] find that a radon information program presented with an information pamphlet had a measurable effect on perceived radon risk. However, the information contained in the pamphlet did not cause perceived and objective measures of risk to converge. Lin and Milon [10] find that safety perceptions were not important in shellfish consumption decisions. Responses to new health information, in the form of a television program that aired during the survey period, were most important in affecting the amount of shellfish consumed, but not whether the respondent would participate in the market.

Eom [11] links risk information, perception, and valuation in a paired comparison, discrete choice willingness to pay framework and finds that consumers are willing to pay higher prices for safe produce, even if the risk reduction is small. Also, technical risk information has only small effects on willingness to pay except when the information is interacted with perceptions about risk. Hayes et al. [12] find that respondents underestimate the low probabilities of food-borne illness. Willingness to pay does not vary over a large range of risk reductions suggesting that respondents do not respond to risk information, instead relying on prior risk perceptions. Ready et al. [13] find willingness to pay for pesticide free grapefruit fell with age and income. These results are explained by recognizing that older respondents are less risk averse to food safety. Also, higher income respondents may be less concerned about food safety because they have access to better information.

Wessells et al. [14], in a study of Rhode Island seafood consumers, consider the determinants of seafood safety and consumption. They find that seafood risk perceptions decrease with increases in past seafood consumption and if respondents take additional risks when eating seafood (e.g., eating raw seafood). They find that seafood consumption increases with positive information about seafood (learning about preparation of seafood and a mandatory seafood inspection program) and decreases with negative information (information about an oil spill and closure of the Naragansett Bay to fishing). These consumption changes depend primarily on existing seafood risk perceptions. Those who consider seafood to be somewhat unsafe are more likely to change seafood consumption. A limitation of their analysis is the qualitative nature of the measure of risk perceptions and seafood consumption changes.

One conclusion that can be drawn from this research, and is directly applicable to an understanding of how consumers react to Pfiesteria and harmful algal blooms, is that information about risk will alter behavior and consumers tend to self-protect against risk. However, the degree of self-protection will depend on several factors. For instance, negative information might lead to consumers dropping out of markets completely while counter information about food risk of products may not have similar positive effects. We measure the effects of information on quantitative risk perceptions, quantitative changes in seafood consumption and the willingness to pay for a mandatory seafood inspection program.

3. SURVEY

A telephone–mail–telephone survey of Delaware, Maryland (including District of Columbia), North Carolina and Virginia seafood eaters was conducted during August–November 2001 (see [15] for details. The first telephone survey was designed to collect information on seafood consumption patterns, prices paid for seafood, health risk perceptions, revealed and contingent seafood consumption, attitudes about seafood and Pfiesteria, and socioeconomic information.

Respondents who agreed to participate in the follow-up telephone survey were sent an information mail-out consisting of four parts: a Pfiesteria brochure, a counter information insert, a fish kill scenario, and a description of a seafood inspection program.[1] The Pfiesteria brochure is based on the US Environmental Protection Agency's brochure titled “What you should know about *Pfiesteria piscicida*.” The Environmental Protection Agency's brochure was shortened, simplified and revised based on comments received from focus groups and from reviews by scientists familiar with the Pfiesteria literature. The purpose of the brochure was to provide descriptive information and educate respondents about Pfiesteria. The brochure describes Pfiesteria as “a toxic organism. ” This is similar to the Pfiesteria as a “toxin or poison” cultural model described by Kempton and Falk [4].

Some respondents received a counter information insert in the brochure. The purpose of the counter information was to provide additional information about Pfiesteria and seafood, swimming and boating safety and inform respondents about the governmental response to Pfiesteria. This information focused on the safety of these activities and emphasized that government was taking action to protect public health. About 80% of the sample received the Pfiesteria brochure. About 40% received the counter information. About 20% received neither sources of information.

All respondents were asked to consider a hypothetical fish kill that is described in a press release. There are four versions of the hypothetical fish kill: Maryland major, Maryland minor, North Carolina major, and North Carolina minor. The hypothetical Maryland fish kill occurs on the lower Pokomoke River between the towns of Shelltown and Fair Island. The North Carolina fish kill occurs on the lower Neuse River between the city of New Bern and Slocum Creek. A map on the back of the sheet illustrates the location. The major fish kill was described as occurring over a “large” area of the river affecting 300,000 menhaden, 10,000 croaker, and 5000 flounder. Pfiesteria-related lesions were observed on over 75% of the fish. The minor fish kill was described as occurring over a “small” area of the river affecting 10,000 menhaden. Lesions were observed on over 50% of the fish. The rest of the press release is identical for all four versions. Respondents in Delaware, Maryland, and Virginia received one of the Maryland fish kill versions. Respondents in North Carolina received one of the North Carolina fish kill versions.

All respondents received information about a hypothetical mandatory seafood inspection program. The US Department of Commerce's voluntary seafood inspection program, in which participating producers and processors receive the US Grade A seal of approval, is described. The mandatory program would require that all seafood producers participate in the inspection program and would result in all seafood receiving the US Grade A seal of approval.

The second telephone survey was designed to collect information on seafood consumption patterns, health risk perceptions, revealed and contingent seafood consumption, attitudes about seafood and Pfiesteria, and socioeconomic information. Most of the questions were identical or similar to questions asked in the first survey. The main purpose of these questions is to determine if perceived health risk and seafood demand would change after receiving the information. A contingent valuation scenario was also presented. The purpose was to elicit respondent willingness to pay for the mandatory seafood inspection program.

4. DATA

The sample frame includes seafood eaters in all of Delaware and the eastern parts of Maryland, North Carolina and Virginia. It was stratified based on an urban/rural split and on a North Carolina/Maryland fish kill split. The goal was to conduct the survey during fish kill season: June–November. The first telephone survey was conducted from August to October. About 1 week after respondents agreed to participate in the second telephone survey the information booklet was mailed. About 3 weeks after the information was mailed interviewers attempted to contact the respondents. The second survey was conducted from October to November.

One thousand eight hundred and seven completed interviews were conducted. Dividing the completed interviews by contacts (contacts include refusals and completed interviews) yields the response rate of 61%. This response rate varies significantly by state. The response rate in North Carolina is highest at 69%. The response rates in Delaware, District of Columbia, Maryland and Virginia are 53%, 46%, 49%, and 54%. Seventy percent of respondents to the first survey and 47% of those contacted for the first survey agreed to participate in the second survey. The response rate to the second survey is 73% of those who were contacted for the second survey and 28% of those contacted for the first survey. The response rate to the second survey of those who agreed to participate and were contacted is 70%, 44%, 82%, 74%, and 77% for Delaware, District of Columbia, Maryland, North Carolina, and Virginia. All statistics reported are weighted to account for the sample stratification.

The average age is 47. The sample is 65% white and 63% female. The average household size is 2.69 and the average number of children is 0.70. The average years of education are 14.58. The average annual household income is over $53,000. The average tenure in the state and county is 30 and 22 years, respectively. A comparison of those who responded to the first survey only and those who responded to the second survey reveals several differences. Respondents to the second survey are more likely to be white with more education and higher incomes. Respondents who had heard about Pfiesteria are more likely to respond to the second survey.

5. RISK PERCEPTIONS

The perceived risk questions were presented as a dichotomous choice with a follow-up. Respondents were first asked:

To get a better idea of how safe you think you are from eating seafood consider the seafood meals you expect to eat next month. What do you think are your chances of getting sick from eating those meals?

After a qualitative risk question, respondents were asked:

Do you think your chances are greater or less than 1%?

The interviewers accepted the potential answer categories “more,” “less,” or “about 1%. ” Respondents who perceive that the chance of getting sick is less than one percent were asked a follow-up question with a lower risk amount:

This means that you think your chance of getting sick is less than one in 100. We’d like to know how low you think your chances are. Do you think your chances of getting sick are greater or less than 1 in *X*?

The variable *X* took on one of four randomly assigned values: 1000, 10,000, 100,000, or 1,000,000 implying risks of 0.001, 0.0001, 0.00001, and 0.000001. The interviewers accepted the potential answer categories “more,” “less,” or “about 1 in *X*%.”

In the second survey respondents were asked to assess their perceived risk of eating seafood under two different scenarios. First, they were asked for their risk perception after the hypothetical fish kill. Then they were asked for their risk perception after the fish kill scenario and with the mandatory seafood inspection program. The risk questions are the same as those in the first interview.

Focusing only on the first response to the risk questions (i.e., greater or less than 1%?) the perceived risks (greater than or equal to 1%) of getting sick from seafood meals increases from 38% to 55% after the fish kill. The seafood inspection program decreases the proportion of respondents with perceived risk greater than or equal to 1% from 55% to 31%.

The three versions of the risk perception questions are combined into a single random effects probit model. Each respondent has between one and six responses to the risk perception questions yielding unbalanced panels. For example, a respondent that considered risk to be greater than 1% and who did not participate in the second survey will have only one response. A respondent that answered that the risk is less than 1% for all three questions will have six responses (3 first responses and 3 follow-ups). It is assumed that each individual has an error term that carries across all six potential responses, and a random effect that is specific to each of the six responses. This random effect is assumed to be distributed the same across all responses.

Table 1 presents the results from the random effects probit model for the risk perception model. The dependent variable is equal to one if the respondent felt that the risk was greater than or equal to 1 in *X* and 0 otherwise. The model includes as independent variables dummies for the state of residence and to indicate the various information treatments: hypothetical major and minor fish kills, Pfiesteria brochure, counter information, and seafood inspection program. The variable *X* is also included and its coefficient is equal to the inverse of the standard deviation of the regression. As expected, the probability that the respondent believes the probability is greater than or equal to the randomly assigned number increases as the percentage decreases.

Table 1
Random effects probit model of risk perception

Variable	Coeff.	z-stat
Constant	−0.436	−5.98
Pfiesteria brochure	0.199	2.48
Minor fish kill	0.016	0.21
Major fish kill	0.185	2.36
Counter information	−0.078	−0.99
Seafood inspection program	−0.647	−9.58
Maryland	−0.145	−1.92
Delaware	0.011	0.08
Virginia	−0.101	−1.31
District of Columbia	0.185	1.17
Random effect	−0.436	−5.98
$1/\sigma$	−0.145	−1.92
Log-likelihood	−3197.84	
Model χ^2	364.94	
Cases	1746	
Observations	5269	

The other results are somewhat surprising. The first striking result is the significant increase in perceived risk due to the Pfiesteria brochure. The definitions and explanations of Pfiesteria provided to respondents appears to have scared respondents into thinking seafood is more risky than they originally thought. The second striking result is the inefficacy of the counter information. The counter information states explicitly that seafood is safe to eat, and it is safe to swim and boat in coastal waters. Respondent risk perceptions do not change in the expected way when they receive the counter information. The size of the fish kill has a significant effect on risk perceptions with the major fish kill leading to a larger increase in perceived risk than the minor fish kill. The effect of the minor fish kill on risk perceptions is indistinguishable from zero.

The seafood inspection program has a large negative effect on perceived risk of illness from seafood. The seafood inspection program counteracts the increases in perceived risk from the brochure and the fish kill, and reduces risk beyond the baseline risk case (before the fish kill and information treatments).

6. SEAFOOD DEMAND

Respondents were presented a baseline contingent behavior question for the number of seafood meals eaten next month in both the first and second surveys. Following this, two contingent behavior questions in both surveys pose changes in the price of seafood. Each respondent was asked how their number of seafood meals consumed (monthly) would change if the price of seafood were to rise:

Seafood prices change over time. For example, if a lot of fish are caught, prices go down. When fewer fish are caught, prices go up. Suppose that the price of your portion of your average seafood meal goes up by $A but the price of all other foods stays the same. Compared to the Y meals you ate last month, do you think you would eat more, less, or the same number of meals next month with the higher price?

The variable *$A* was randomly assigned and took on one of four values: $1, $3, $5, or $7. The variable *Y* is the number of seafood meals the respondent consumed the previous month. Then respondents are asked:

About how many more/less seafood meals do you think you will eat next month?

Similar questions were then presented with a hypothetical price decrease. The decreases in the price were randomly assigned and took on one of four values: $1, $2, $3, or $4. These questions are designed to infer the slope of the demand curve.

The next three questions pose hypothetical fish kills. In the first, respondents were asked to consider either the North Carolina or Maryland fish kill. Following the risk perceptions question presented above, respondents were asked how the fish kill would alter the number of seafood meals they consume. The second fish kill question poses exactly the same circumstance as the previous question except that the respondents were asked to assume that there is a mandatory seafood inspection program in place at the time of the kill. The final question is a slight variation on the previous question. The inspection program is still assumed to be in place but the respondent is told that the program will increase the price of seafood. These questions follow the basic format above and are designed to infer shifts in demand.

The baseline average number of meals consumed in a month in the sample is about 5. More than half the respondents make no change in their monthly consumption in response to the price changes; 55% report no change for an increase and 57% report no change for a decrease. For a price increase, about 30% say they would decrease the number of meals consumed by 1 or 2 meals per month. For a price decrease, 30% say they would increase consumption by 1, 2, or 3 meals.

The percent of respondents reporting no change in consumption is over 50% for all three fish kill questions. For the case of a fish kill without an inspection program, 65% report they would make no change in consumption, 22% would reduce consumption by 1 or 2 meals, 8% by 3–5 meals, and 3% by more than 5 meals. About 2% report that they would increase consumption with a fish kill. Of those who reduce consumption, about 40% stop eating fish for that month.

With the seafood inspection program about 80% of the sample report that they would make no change in consumption relative to the baseline, 7% would still reduce consumption by 1 or 2 meals, and 4% by 3 or more. Approximately 9% say they would actually increase consumption with a fish kill after implementation of an inspection program. However, when individuals are told that the price of fish will go up to pay for the program, the profile looks more like the case of a fish kill without an inspection program. Now, only 58% reduce consumption to zero compared to the baseline, 26% cut back by 1 or 2 meals, 9% by 3–5 meals, and 4% by more than 5 meals. Still, 3% report that they would increase consumption following the kill.

The dependent variable in the seafood demand model is the difference in seafood meals between scenarios. The difference model is estimated as a Tobit regression with censoring at the negative of the quantity consumed. This is because individuals cannot reduce their consumption of fish by more than the current quantity consumed. Since individuals consume different quantities, the censoring point varies across observations. The data are stacked allowing us to constrain parameters across equations to be constant and to estimate the model with random effects. Random effects allows the error terms in the model to be correlated across equations for each observation. Since all observations in the sample do not make it to the second survey, an unbalanced version of a random effects model is estimated. The dependent variables in the model are the price increase and decrease variables and dummy variables for the information treatments.

The regression results from the seafood demand difference model appear in Table 2. There are several noteworthy findings. First, the effects of a price increase and a price decrease are asymmetric. Quantity demanded seems to be more responsive to price decreases than price increases. This may be due to individuals' inability to reduce consumption beyond their current level thereby capping the response to price increases. Fish kills shift the seafood demand function to the left. The effect of a major kill and a minor kill are about the same.

Table 2
Random effects tobit model of seafood demand difference

Variable	Coefficient	t-stat
Price increase	−0.285	21.6
Price decrease	−0.424	20.1
Major fish kill	−1.17	9.0
Minor fish kill	−1.27	9.8
Pfiesteria brochure	−0.081	0.6
Counter information	0.082	0.7
Seafood Inspection Program	1.07	9.2
Seafood Inspection Program with price increase	−0.264	10.9
σ	2.39	100.3
Cases	1700	
Observations	5799	

Information provision in the form of a brochure or a brochure along with counter information appears to have limited sway on consumers. The presence of an inspection program, unlike information provision, shifts the demand function significantly rightward—returning close to its pre-fish kill position. The impact of a rise in seafood prices due to an inspection program is about the same as a general price rise. Of course, this has the potential of offsetting some of the recaptured losses by the inspection program.

We estimate the change in consumer surplus per meal using the reported level of monthly consumption and the estimated value of the coefficient on the price change variable. The asymmetry in the price effects complicates the calculation of consumer surplus because the coefficient on price change appears in the denominator of all measures of surplus. For this reason we present our consumer surplus measures in pairs—one using the coefficient for a price increase and the other for a price decrease. For example, the total consumer surplus per meal is between $11 (price increase) and $7 (price decrease).

The change in consumer surplus for each seafood meal associated with the fish kill is reported in Table 3. The change in consumer surplus per meal with a minor or major fish kill is on the order of $2–$3 per meal. The change in consumer surplus per meal associated with the fish kills assuming individuals have a brochure or have a brochure and counter information is about the same as with no information. The change in consumer surplus per meal with the inspection program in place drops dramatically. The change in consumer surplus per meal is now close to zero. We present the welfare loss of a fish kill assuming an inspection program is in place that raises the price of fish by $1 per meal. The gains due to the inspection program are largely lost.

Table 3
Change in consumer surplus per seafood meal

	Major fish kill		Minor fish kill	
	Price increase	Price decrease	Price increase	Price decrease
No information	−$3.14	−$2.11	−$3.31	−$2.23
Pfiesteria brochure	−$3.29	−$2.21	−$3.45	−$2.32
Pfiesteria Brochure with counter information	−$3.14	−$2.11	−$3.31	−$2.23
Seafood Inspection Program	−$0.33	−$0.22	−$0.65	−$0.44
Seafood Inspection Program with price increase	−$3.59	−$2.41	−$3.72	−$2.51

7. WILLINGNESS TO PAY

We use the contingent valuation method to elicit respondent willingness to pay for the mandatory seafood inspection program:

Suppose that the proposed mandatory seafood inspection program is put to a vote in the November national election. If more than one-half of all people voted for it the Department of Commerce would put it into practice. If you knew the price of your portion of your average seafood meal would go up by $A but the price of all other food stays the same, would you vote for or against it?

Respondents could answer “for,” “against,” or “don’t know. ” The price change variable, $*A*, is the same price change the respondents considered in the seafood consumption questions. Eighty-five percent of the respondents who were presented with the $1 price change voted for the seafood inspection program. Eighty percent, 74%, and 65% of the respondents voted for the seafood inspection program when the price change rose to $3, $5, and $7.

The contingent valuation responses are analyzed with the bivariate probit model. The first dependent variable is whether the respondent participated in the second survey. The independent variables include demographics and seafood safety perceptions. The dependent variable in the second stage model is equal to one if the respondent voted “for” the inspection program and zero if the respondent voted “no” or did not know how they would vote. The independent variables include the price increase, dummy variables for information treatments and state of residence.

The correlation coefficient between the disturbance terms in both models is not statistically significant. This indicates that there is no sample selection bias when the willingness to pay model is estimated independently. Therefore, only the second stage model regression results appear in Table 4. The effect of the price change on the probability of a vote for the seafood inspection program is negative and statistically significant. The Pfiesteria brochure and counter information have no effect on the probability of a “for” vote. There are no differences in the vote probability across state.

Table 4
Bivariate probit model of willingness to pay for a seafood inspection program[a]

Variable	Coefficient	*t*-ratio
Constant	0.732	2.12
Price increase	−0.110	−4.37
Pfiesteria brochure	0.159	1.22
Counter information	−0.184	−1.40
Delaware	0.117	0.49
Maryland	−0.33	−0.25
Virginia	0.225	1.62
Log likelihood	−1517.12	
Cases	745	

[a] Selection model not shown.

Willingness to pay is estimated as in Cameron and James [16]. Setting state residence variables at their means and evaluating willingness to pay with full information, the average willingness to pay per meal for the seafood inspection program is $7. The contingent valuation estimate is more than twice as great as the conceptually similar consumer surplus estimate from the contingent behavior model. The seafood inspection program in the contingent behavior model leads to a positive change in consumer surplus of about $3 per meal.

8. CONCLUSIONS

Understanding the role of public perception of the risks and the potential changes in behavior due to Pfiesteria-related fish kills is fundamental to the design of education campaigns, policies, and regulations to address the problems associated with Pfiesteria and other harmful algal blooms. This paper presents results from a survey of the economic effects of Pfiesteria-related fish kills in the Mid-Atlantic region. In particular, the paper focuses on reactions to reports of a Pfiesteria-related fish kill, and the effects of information on risk perceptions, seafood demand and willingness to pay. The primary result is that Pfiesteria-related fish kills result in adverse reactions on the part of seafood consumers.

The magnitude of the Pfiesteria-related fish kill (as distinguished by a major and minor fish kill) is a significant determinant of risk perceptions. However, the magnitude of the Pfiesteria-related fish kill is an insignificant determinant in seafood demand. A number of explanations exist. The effect of the magnitude of the fish kill on seafood demand could be indirect through risk perceptions and not well measured in the empirical demand model. Also, the result may be a survey design issue. The objective magnitude of fish kills offered to individuals may not have led to a divergence in the perceived magnitude. There is some evidence for this conclusion. In a follow up question, most individuals interpreted both fish kill scenarios as “major” events.

Information in the form of educational brochures sent to seafood consumers have mixed effects in reducing the negative economic effects of Pfiesteria-related fish kills. The Pfiesteria brochure actually increased the perceived risk of eating seafood. The Pfiesteria brochure has no effect on the stated changes in the demand for seafood or the willingness to pay for a mandatory seafood inspection program. The increase in risk perceptions indicates that consumers had a significant adverse reaction to the educational brochure. This conclusion is supported by a small sample of in-person interviews that found that 43% of respondents found seafood to be less safe after viewing the brochure. Counter information treatments designed to alleviate misperceptions associated with Pfiesteria-related fish kills have no effects on the adverse economic effects of a fish kill.

Given these mixed results, we conclude that simply informing consumers of the current objective knowledge about Pfiesteria is an ineffective mechanism for reducing the negative economic effects of Pfiesteria-related fish kills. The Pfiesteria brochure described Pfiesteria as a toxic organism. Kempton and Falk [4] find that almost two-thirds of those who believe that Pfiesteria is a “toxin or poison” believe that Pfiesteria can harm people if they eat seafood. Considering this result, the Pfiesteria brochure information treatment may have led respondents to adopt a cultural model that leads to a perceived increase in risk. Kempton and Falk [4] suggest that mitigation of economic losses from Pfiesteria will require that more appropriate cultural models of Pfiesteria be communicated to the public.

A mandatory seafood inspection program is an effective mechanism for alleviating the economic losses associated with a Pfiesteria-related fish kill. A mandatory seafood inspection program proves to be robust in eliminating the changes in the perceived risk of eating seafood and the demand for seafood after a fish kill.

We find that the economic effects of a Pfiesteria-related fish kill are substantial. The lost consumer surplus due to a Pfiesteria-related fish kill is estimated to be between $2 and $3 per meal depending on whether no information, counter information or a seafood inspection program is provided to the consumer. Aggregating this number to the population of seafood consumers in the mid-Atlantic region (about 13 million residents, of which 42% are seafood consumers who eat between 4 and 5 meals per month on average), the lost consumer surplus due to a Pfiesteria-related fish kill is between $37 million and $72 million in the month following the fish kill.

Further evidence of the significance of the lost welfare due to uncertainty regarding the safety of seafood is the respondents' willingness to pay of $7 per meal for a mandatory seafood inspection program, or almost $1.91 billion annually. The aggregate willingness to pay seems to be unrealistically large, suggesting that respondents overstated their willingness to pay. One cause of the overstatement may be a lack of belief in the payment vehicle, an increase in seafood prices. However, in a follow-up question respondents were asked if they believed that prices would increase. A large majority stated that they believed the price increase would occur, indicating that they were not voting for the seafood inspection program with the belief that costs would not increase.

Taken as a whole, these results are surprising since the survey was conducted almost 9 years after the discovery of Pfiesteria and 4 years after the initial public scare associated with Pfieseteria. Since that time much research has been conducted and much has been learned about Pfiesteria-related fish kills. During 1997, uncertainty and massive media attention created a near panic among seafood consumers. Our results indicate that little has changed. Most scientists believe that marketed seafood is safe as long as standard precautions are observed, even after Pfiesteria-related fish kills. This information was emphasized to survey respondents, but ignored by many. This is the same approach toward Pfiesteria currently in use by the US Environmental Protection Agency and state agencies. Further research focusing on risk communication is needed in order to communicate risk information in an acceptable way.

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