

Effects of Information on Knowledge about *Pfiesteria* and Seafood Consumption

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Coverage of fish kills attributed to toxic algal outbreaks by both the media and members of the scientific community have caused seafood eaters to reconsider or abandon their seafood consumption habits. One government agency (EPA) has tried to ameliorate public fears caused by misinformation by providing brochures of the best available data on safety issues involved in these outbreaks. This study addresses the effectiveness of information disseminated to the public concerning a rather complex natural phenomenon. Telephone interviews were used to access the effects of brochure information on respondents' characterization of the organism *Pfiesteria*, and their probable response in terms of seafood consumption. The random effects probit model is used as well to quantify probable effects of toxic algal outbreaks on seafood consumption in view of the respondents understanding of the phenomenon (cultural model) and socioeconomic traits.

Introduction

Pfiesteria piscicida (*Pfiesteria*), identified by Burkholder et al. in (1992), is an alga that has been associated with fish kills in Delaware, Maryland, North Carolina, and Virginia.¹ While generally not a problem to fish populations, *Pfiesteria* can, under certain conditions, exhibit toxic life phases², which when in contact with fish result in their skin lesions, paralysis, or death. *Pfiesteria* is not a form of pollution, a disease, nor a parasite, yet direct contact with the water of the kill and with the air directly above these waters is purported to cause disorientation, memory loss, and skin rashes in humans (Burkholder and Glasgow 1999; Buck et al. 1997).

The novelty and complexity of the organism, and the ensuing lack of scientific consensus, allowed for the dissemination of misleading information. News stories concerning *Pfiesteria* dramatized its "predatory" nature, giving little attention to ongoing scientific debate. Its characterization is disputed even among those who specialize in the biological sciences. Burkholder (1995) refers to the organism specifically as a "...toxic ambush-predator dinoflagellate" (p.177), while other scientists consider the organism only one

of many stressors that contribute to fish kills in degraded estuarine environments (Pearl et al. 1998).

In the late 1990s, association between fish-kills and *Pfiesteria* led to a media driven scare about seafood safety. In some cases the stories went so far as to wrongly portray *Pfiesteria* as a disease-causing pathogen. Another dramatization was to attribute all sores and lesions on fish to *Pfiesteria* (even though algae are one of the least likely causes of such maladies). Coupled with fictional stories³ and official quarantine policies (of fish kill areas), public alarm ensued. As documented by Lipton (1999), the resulting losses in the tourism and seafood industry sales in Delaware, Maryland, North Carolina, and Virginia approached 43 million and losses to recreational fishing about four million.

Problems regarding the accuracy of public understanding became especially apparent as the public ignored new information, and as public concerns about coastal pollution and food safety generated confusion and contradictory consumer behavior (Johnson and Griffith 1996). Concerns grew even as reports were published that should have reduced anxiety. In terms of human exposure to fish kill waters,

Griffith (1999) found that there was no higher incidence of disease in commercial crabbers exposed to *Pfiesteria* inhabited waters than those working in *Pfiesteria*-free waters, and Buck et al. (1997) showed that no illnesses resulted from eating fish harvested from *Pfiesteria* outbreak areas and that the air from areas adjacent to fish kill sites was not dangerous. In addition, state and federal agencies designed informational campaigns to reassure the public that seafood and coastal waters are safe. In spite of these reports, Kempton and Falk (2002) found that many people persisted in their characterization of *Pfiesteria* as a pollutant, toxin, disease, or parasite. They argued that due to socio-economic, cultural, or political reasons, many people rejected scientific evidence in favor of simplified models that coincided with individual experience and understanding. They concluded that people tended to retain these models even when faced with contrary scientifically based information.

In this paper we further consider the effects of information on knowledge about *Pfiesteria*. We specifically examine the effects of scientific information on individual intentions to reduce seafood consumption. The data is from a three-phase study. In the first phase, a telephone survey of mid-Atlantic residents was conducted to determine the degree to which concerns about *Pfiesteria* impacted their seafood consumption habits. In the second phase, respondents were mailed scientific information about associations between *Pfiesteria* and seafood safety designed to reduce public alarm. In the final phase, respondents were again surveyed to determine whether or not the information caused any significant changes in respondents' intentions to consume seafood.

We hypothesize that informational brochures produced and disseminated by government agencies of the best available scientific data concerning natural phenomena that have induced public alarm are helpful in mitigating that alarm. We also propose that the ability to assimilate and use that information in terms of risk-assessment is contingent on individual education level, as well as individual capacity to understand relatively complex cultural models that may be outside their realm of experience. In view of this, we expect socio-economic differentiation displayed within respondent data. The following sections de-

scribe the conceptual model as it informed our research hypothesis, the details of our survey methods, and the results. The final section discusses the broader implications and conclusions of information dissemination and cultural models.

Model

We consider a model of how information affects seafood consumption in two ways: directly using a linear model and indirectly through the cultural model (i.e., knowledge) of *Pfiesteria*. As defined by Kempton and Falk (2002), "a cultural model is a simplified way of understanding a complex system, shared by members of a culture." Kempton and Falk find that those who think of *Pfiesteria* in incorrect ways, as a pollutant, a toxin, or as a disease or parasite in fish, behaved in similar ways. Information in the *Pfiesteria* brochure and counter information insert asserts that marketed seafood is safe even after *Pfiesteria* outbreaks. It is proposed that this information will make it less likely that consumers will reduce their seafood consumption. Information in the *Pfiesteria* brochure describes *Pfiesteria* as a potentially toxic organism. If respondents accept this information, a more appropriate cultural model of *Pfiesteria* will be developed by the time the second survey takes place. Those respondents who consider *Pfiesteria* to be a toxic organism relative to a form of pollution or a disease in fish will be less likely to reduce their seafood consumption after *Pfiesteria* outbreaks.

We estimate the factors that affect the dependent variables using the random effects probit model ((Greene, 1998) see (1) below). The probit model is a statistical approach for analyzing the determinants of an event, or to gauge the probability of a response that can be quantified as a discrete variable. In this case, the response to a *Pfiesteria* episode may be a decrease in consumption of seafood, so the quantification of the discrete dependent variable equals one if seafood consumption is reduced and zero if it stays the same.

$$(1) \quad \begin{aligned} y_{i1t} &= \alpha_1' X_i + \beta_1' I + e_{i1t} \\ y_{i2t} &= \alpha_2' X_i + \beta_2' I + \delta y_{i1t} + e_{i2t} \end{aligned}$$

where y_{ijt} are dummy dependent variables, $i = 1, \dots, n$, $j = 1, 2$, $t = 1, 2$, α_i , β_i are parameter vectors, δ is a scalar parameter, X_i is a vector of independent control variables, I is a vector of information variables, and e_{ijt} are error terms.

The dummy dependent variables measure the underlying latent continuous dependent variables

$$2) \quad y_{ijt} = \begin{cases} 0 & \text{if } y_{ijt}^* \leq 0 \\ 1 & \text{if } y_{ijt}^* > 0 \end{cases}$$

The dummy dependent variables measure knowledge about *Pfiesteria* (TOXIC, $j = 1$) and the intention to reduce seafood consumption after a *Pfiesteria* outbreak (REDUCE, $j = 2$).

The probit model estimates the probability, π , of the outcome variable using the normal distribution

$$(3) \quad \begin{aligned} \pi(y_{it} = 1) &= \Phi(\alpha_i' X_i + \beta_i' I) \\ \pi(y_{it} = 1) &= \Phi(\alpha_i' X_i + \beta_i' I + \delta y_{it}) \end{aligned}$$

where Φ is the standard normal distribution function.

As analysis of discrete dependent variables is a challenge if linear models are used because of heteroskedasticity and the prediction of probabilities, the problem model imposes a functional form restriction on the data, which involves a normally distributed error term and constrains predicted probabilities to between zero and one. Since we have two observations on each dependent variable (i.e., first and second surveys) we treat the data as a panel. The random effects probit model is a panel data extension of the simple probit model where the error term accounts for the correlation across respondents. The error terms are distributed normally and are composed of two parts

$$(4) \quad e_{ijt} = v_{ji} + u_{ijt}$$

where v_{ji} is the normally distributed random error with mean zero and variance, σ_v^2 , u_{ijt} is the error common to each individual with mean zero and variance, σ_u^2 , and $\sigma_e^2 = \sigma_v^2 + \sigma_u^2$. The correlation in error terms, $\rho = \sigma_v^2 / \sigma_e^2$ is the ratio in individual

variance to total variance and is a measure of the appropriateness of the random effects specification.

Since the *Pfiesteria* brochure and counter information insert appear after the first survey ($t = 1$) the variables in the information vector take on a value of 0 in the first time period

$$5) \quad I = \begin{cases} 0 & t = 1 \\ I & t = 2 \end{cases}$$

The information variables are dummy variables for whether the respondent received the *Pfiesteria* brochure (BROCHURE = 1) and counter information insert (COUNTER = 1). If the respondent did not receive the information the values of the dummy variables are zero. Control variables are the demographics and state dummy variables found in Table 2.

Survey

A telephone-mail-telephone survey of Delaware, Maryland (including District of Columbia), North Carolina and Virginia seafood eaters was conducted from August 2000 through November 2000. The first telephone survey was designed to collect information on past and current seafood consumption patterns, prices paid for seafood, health risk perceptions, attitudes about associations between seafood and *Pfiesteria* and contingent seafood consumption, and socioeconomic information (See Haab et al. (2002) for details).

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 hypothetical fish kill scenario, and a description of a seafood inspection program. The *Pfiesteria* brochure is based on the U.S. Environmental Protection Agency (2001) 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*.

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.

The *Pfiesteria* brochure contained the following text about human health problems and *Pfiesteria*:

"Any human health problems associated with *Pfiesteria* are from its release of toxins into coastal waters. Preliminary evidence suggests that exposure to waters where toxic forms of *Pfiesteria* are active may cause memory loss, confusion, and a variety of other symptoms including respiratory, skin and gastrointestinal problems. ... There is no evidence that *Pfiesteria*-associated illnesses are associated with eating finfish or shellfish."

The counter information insert states: "In general, it is safe to eat seafood. There has never been a case of illness from eating finfish or shellfish exposed to *Pfiesteria*. There is no evidence of *Pfiesteria*-contaminated finfish or shellfish on the market. There is no evidence that illnesses related to *Pfiesteria* are associated with eating finfish or shellfish." The insert then recommends to obey public health advisories and to avoid contact with water and fish during a fish kill.

The second telephone survey was designed to collect information on seafood consumption patterns, health risk perceptions, seafood consumption, and attitudes about seafood and *Pfiesteria*, as well as socioeconomic information. Most of the questions were identical or similar to questions asked in the first survey. The purpose of these questions is to determine if attitudes and behavior change after receiving the scientific information.

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 through November. The first telephone survey was conducted from August to October. About one week after respondents agreed to participate in the second telephone survey the information booklet was mailed. About three weeks after the information was mailed interviewers attempted to contact the respondents. The second survey was conducted from October through 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 described in Table 1.

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. More than 77% of Delaware and Maryland respondents and a little less than 70% of North Carolina and Virginia respondents had heard about *Pfiesteria* before the first survey.

Data

Summary statistics and variable descriptions are presented in Table 2 for all those who had heard about *Pfiesteria* in the first survey and responded to both surveys (n=454). The average number of years lived in the state of residence is 29. The typical household has two parents and one child. The typical respondent is 45 years old with years of schooling is 15. Forty-one percent of the sample is male and 78% is white. Thirty-one percent live in an urban county. The average annual household income is \$57,200. Forty-two percent of the sample lives in Delaware, Maryland (including DC), and Virginia.

When asked about the safety of seafood in general, 92.5% responded that they considered seafood to be very or somewhat safe. When asked about the chances of getting sick from eating seafood, 84.4% stated it was somewhat not likely or not likely at all. When asked about how concerned they are about *Pfiesteria*, 77.6% stated they were very or somewhat concerned. Fifty five percent revealed that an outbreak of *Pfiesteria* would decrease the number of seafood meals that they consume.

Over 93% of respondents found the scientific information about *Pfiesteria* very helpful or somewhat helpful. In addition to the survey-related information, 39%, 20%, 31%, and 19% of respondents in

Delaware, Maryland, North Carolina, and Virginia had heard or read something about *Pfiesteria* between the first and second surveys. In Delaware, 76% of this information was read in the newspaper while only 18% was seen on television. In Maryland, 57% and 38% was obtained from newspapers and television. In North Carolina, 47% of respondents obtained their information from television while 43% obtained it from newspapers. In Virginia, 56% received their information from newspapers and 44% received it from television or something else.

Following Kempton and Falk (2000), respondents were then asked the closed-ended question, "to the best of your knowledge, would you say that *Pfiesteria* is a toxic organism, a form of pollution, a

TABLE 1. Area Response Rates for First and Second Seafood Surveys.

Area Covered	First Survey	Second Survey
Delaware	53%	70%
Maryland	49%	82%
District of Columbia	46%	44%
North Carolina	69%	74%
Virginia	54%	77%

TABLE 2. Data Description.

Variable	Description	Mean	Std.Dev.	MIN	MAX
STATE	Tenure in state	29.06	18.96	0	81
HOUSE	Household size	2.73	1.29	0	7
CHILDREN	Number of children	0.72	1.03	0	5
EDUC	Years of schooling	14.88	2.44	7	20
AGE	Age in years	45.04	13.90	18	100
MALE	Gender: Male=1, 0 otherwise	0.41	0.49	0	1
WHITE	Race: White=1, 0 otherwise	0.78	0.41	0	1
URBAN	Urban county = 1, 0 otherwise	0.31	0.46	0	1
INCOME2	Household income (in thousands)	57.72	26.55	5	100
DE	Delaware resident = 1, 0 otherwise	0.13	0.34	0	1
MD	Maryland/DC resident = 1, 0 otherwise	0.17	0.37	0	1
VA	Virginia resident = 1, 0 otherwise	0.12	0.32	0	1
Sample Size		454			

disease in fish, a predator that attacks fish, or a parasite in fish?" We changed one answer category from those offered by Kempton and Falk (2000). "A toxin or poison" was changed to be consistent with the EPA (2001) definition of *Pfiesteria* as "a toxic organism." In the first survey the next question began with "*Pfiesteria* is a potentially toxic organism." The *Pfiesteria* brochure contained the same definitional sentence in its description of *Pfiesteria*. The second survey asked the same knowledge question again.

While most respondents had heard about *Pfiesteria*, they had difficulty when answering the knowledge question. The item non-response rates were greater than 20% in Delaware, North Carolina, and Virginia and greater than 12% in Maryland. Thirty-five percent of respondents to the first survey answered "a toxic organism" correctly. Sixty percent of the respondents in the second survey answered correctly. About one-quarter of first survey respondents considered *Pfiesteria* to be a form of pollution or a parasite in fish. This fraction fell to about 15% for both responses. The difference in responses across surveys is significant at the $\alpha = .01$ level. Twenty-one percent answered "a toxic organism" in both surveys while 31% answered incorrectly in the first survey and correctly in the second survey suggesting that the information allowed some learning about *Pfiesteria*. Seven percent of respondents answered correctly in the first survey and incorrectly in the second (Table 3).

Respondents were then asked if they would reduce their seafood consumption in the month following a *Pfiesteria* outbreak in their home state (Table 4). REDUCE is equal to 1 if respondents would reduce their seafood consumption and zero otherwise. In the first survey 56% of respondents would reduce their seafood consumption. This number falls to 50% in the second survey suggesting that information is a somewhat effective mitigation tool.

The cultural model variable is recoded to a dummy variable (TOXIC) equal to 1 if the respondent believes *Pfiesteria* to be a toxic organism and zero otherwise. The respondents who believe that *Pfiesteria* is a toxic organism are less likely to reduce their seafood consumption. In the first survey 47% of those who believe that *Pfiesteria* is a toxic organism would

reduce seafood consumption compared to 53% of respondents who believe that *Pfiesteria* is something else. In the second survey, slightly less of those respondents who believe that *Pfiesteria* is a toxic organism (43%) would reduce their seafood consumption following a *Pfiesteria* outbreak. These differences are significant at the $\alpha = .01$ level (Table 5).

Results

We first consider how the brochure and counter information changes the correct response to the cultural model of *Pfiesteria* (TOXIC) after its recoding to a dummy dependent variable (Table 6). The results from the random effects probit model indicate that 40% of the error variance is due to the variation across respondents indicating that the random effects specification is appropriate. Those respondents who received the *Pfiesteria* brochure are significantly more likely to consider *Pfiesteria* to be "a toxic organism" relative to the other choices. This response is also more likely for white households with higher education levels. Delaware residents are more likely to consider *Pfiesteria* a toxic organism. The counter information has no effect on answering with the correct cultural model.

In the seafood consumption model, 58% of the error variance is due to the variation across respondents indicating that the random effects specification is appropriate. Those who receive the counter information are significantly less likely to reduce seafood consumption following a *Pfiesteria* outbreak. Males and white respondents are less likely to reduce seafood consumption. Those with more education and those in Virginia are less likely to reduce seafood consumption. Finally, those who believe that *Pfiesteria* is a toxic organism are significantly less likely to reduce their seafood consumption in the month following a *Pfiesteria* outbreak.

Implications and Conclusions

In this paper we present empirical results focused on the effects of scientific information on attitudes about *Pfiesteria*. Respondents receive varying amounts of information depending on whether they received the *Pfiesteria* brochure, the counter information insert, or both. The purpose of the information is to

TABLE 3. Cultural Models of Pfiesteria

	First	Second
A form of pollution	114 25.11%	66 14.54%
A disease in fish	55 12.11%	37 8.15%
A toxic organism	158 34.80%	273 60.13%
A predator that attacks fish	10 2.20%	8 1.76%
A parasite in fish	117 25.77%	70 15.42%
Total	454	

TABLE 4. Would Reduce Seafood Consumption Following Pfiesteria Event.

REDUCE	First	Second
NO	201 44.27%	229 50.44%
Yes	253 55.73%	225 49.56%

TABLE 5. Frequencies of Cultural Model and Seafood Consumption.

		First Survey		Second Survey	
		TOXIC		TOXIC	
REDUCE		No	Yes	No	Yes
No		117 39.53%	84 3.16%	74 40.88%	155 56.78%
Yes	179	74 60.47%	107 46.84%	118 59.12%	
χ^2 (df)		7.77(1)		10.97(1)	

mitigate the negative reactions to media dramatization of *Pfiesteria*-related fish kills, which may adversely affect seafood consumption unnecessarily.

In contrast to Kempton and Falk (2000) we find that respondents are receptive to scientific information about *Pfiesteria*, especially if the educational background has been obtained to appropriately interpret the data. Respondents are more likely to recognize that *Pfiesteria* is "a toxic organism", as described in the brochure, relative to the other cultural models in the second survey. This correct identification of the nature of *Pfiesteria* was found to correspond with a more appropriate risk response to seafood consumption, in other words, reassurance that seafood is safe to eat. These results do also reveal that the term "potentially toxic organism" lends itself to misinterpretation among groups unable to comprehend this fairly complex cultural model. Even though this characterization is technically correct, the lower education levels of some groups may predispose them to reject the term in its entirety and focus on the word "toxic", which is the easiest to interpret and incorporate into preexisting notions, as well as associate with previously encountered media reports. The media can be blamed only so far as they do not as actively pursue follow-up stories that may disagree with and possibly deflate previous dramatizations.

In terms of the race and gender differentiation between respondents, white males tended to respond more as hypothesized with the scientific information. The explanation for this is not in evidence, other than the possibility that women tend to be more risk averse due to their roles as caregivers, and white males may more often find themselves in positions where they must make risk-based decisions based on complex issues.

The counter information, which described which dangers may or may not be associated with the air and water in the proximity of an outbreak, is shown as effective in making respondents less likely to reduce their seafood consumption after *Pfiesteria* outbreaks.

These results reveal that when lack of knowledge, misinformation by media, and the application of inappropriate cultural models cause an overblown or incorrect assessment of risk, provision of accurate information and the proposal of government action

will mitigate the risk response. The level of mitigation is contingent, however, upon the ability of the recipients to understand and assimilate the information. As revealed in Whitehead et al. (2003), if educational background and the ability to discern information is not sufficient, then the brochure information may actually lead to an unintended result. In this case, it resulted in an increased assessment of risk and the association of the term "toxic organism" with the incorrect cultural model of toxin or poison in fish, which lead to a stated response of decreasing seafood consumption.

Pfiesteria-related fish kills in the 1990s led to a media driven scare about seafood safety and water-based recreation in the mid-Atlantic region leading to significant losses in the tourism and seafood industries. Following these losses, state and Federal government agencies responded with information campaigns to reassure the public that seafood and coastal waters were safe. We suggest that receiving scientific information is an effective mitigation strategy for some

TABLE 6. Random Effects Probit Models

Variable	TOXIC		REDUCE	
	Coeff.	t-ratio	Coeff.	t-ratio
Constant	-3.285	-5.909	2.960	4.124
PFIEBROC	1.141	7.277	0.160	0.851
COUNTER	-0.112	-0.588	-0.489	-2.271
STATE	-0.002	-0.393	0.005	0.899
HOUSE	-0.047	-0.535	0.061	0.563
CHILDREN	0.026	0.261	-0.120	-0.939
EDUC	0.163	5.321	-0.084	-2.212
AGE	0.001	0.174	-0.006	-0.861
MALE	0.240	1.802	-0.588	-3.466
WHITE	0.315	1.938	-1.188	-5.000
URBAN	0.158	0.929	-0.320	-1.489
INCOME	0.002	0.635	0.000	-0.019
DE	0.470	2.091	-0.055	-0.227
MD	-0.345	-1.582	-0.162	-0.607
VA	-0.002	-0.008	-0.443	-1.678
TOXIC			-0.341	-2.285
s	0.405	5.598	0.581	9.712
Log-L(B)	-536.82		-534.39	
Log-L(0)	-628.21		-628.11	
Sample Size	484		484	

respondents, but further research on risk communication is needed in order to develop better strategies for dealing with acute safety concerns that arise from emergent scientific phenomena.

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Endnotes

¹ The dominant species of fish found in the fish kills are menhaden (see Fig.1), a non-food species used to produce fishmeal. Less affected species that are used for human consumption and are also present in the kills include croaker, spot and flounder (Buck et al., 1997).

² This group of "dinoflagellates", which have both plant and animal characteristics, are proposed to have a complicated life cycle of more than twenty forms (Burkholder et al., 1992).

³ See ... *And the Waters Turned to Blood*, by Rodney Barker. New York: Simon & Schuster, 1997.