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Florida Red Tide Knowledge and Risk Perception: Is there a need for tailored messaging?

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Abstract

Harmful algal blooms of the toxic dinoflagellate, *Karenia brevis*, occur throughout the Gulf of Mexico. Recent research efforts sponsored by the National Institute of Environmental Health Sciences (NIEHS) and others found that Florida red tide causes both acute and possibly chronic health effects from the toxic aerosols. Florida red tide also demonstrated significant social and economic impacts to both coastal residents and visitors. In conjunction with the research, persistent outreach efforts were conducted over the 11 year period. The goal of this project was to assess potential needs for tailored messaging needed among different red tide information user groups. Survey participants included 303 local residents, both with asthma and without, and 'snowbirds (seasonal residents that reside in the Sarasota area for more than 3 months but less than 6 months/year), also both with asthma and without. The questionnaire assessed Florida red tide knowledge and risk perception regarding Florida red tide using items drawn from two previously published surveys to allow comparison. Our results reveal that overall knowledge of Florida red tide has not changed. We found that knowledge was consistent across our selected groups and also did not vary by age, gender and education level. However, knowledge regarding consumption of seafood during Florida red tide has declined. Risk perception increased significantly for people who have asthma. Individuals responsible for public health communication regarding Florida red tide and human health concerns need to continue to pursue more effective outreach messages and delivery methods.

Keywords

Florida red tide; *Karenia brevis*; *K. brevis*; outreach; messaging; harmful algal blooms

Introduction

Karenia brevis is a dinoflagellate that can form a HAB known as "Florida red tide," an event that occurs throughout the Gulf of Mexico with blooms observed as far north as North Carolina. The blooms can last for a few weeks to over a year, and may be growing in size, with the 2007 bloom affecting the Florida panhandle, the east coast of Florida, and the

Florida Keys. *K. brevis* blooms produce a group of powerful natural neurotoxins known as brevetoxins (Baden et al., 1995; Kirkpatrick et al., 2004). In recent research, supported by the National Institute of Environmental Health Sciences (NIEHS) and others, Florida red tide was demonstrated to cause both acute and possibly chronic health effects from the toxic aerosols, as well as significant social and economic impacts to both coastal residents and visitors (Fleming et al., 2009; Backer et al., 2005a; Kirkpatrick et al., 2004; Kirkpatrick et al., 2006; Hoagland et al., 2009; Watkins et al., 2008; Backer et al., 2003; Backer et al., 2005b; Fleming et al., 2005; Fleming et al., 2007; Milian et al., 2007; Kirkpatrick et al., 2006).

Several studies in the past have detailed currently held knowledge of residents and tourists regarding Florida red tide. Nierenberg et al. (2010) found inconsistent and inaccurate Florida red tide knowledge among both residents and tourists. When queried regarding where people wanted to get their information, the Internet was cited as the preferred resource. In another study that examined the perceptions of individuals regarding Florida red tide, Kuhar et al. (2009) found that women and older individuals reported higher perceived health and other risks associated with red tide, consistent with other findings showing that women generally have higher health concerns than men (Flynn et al., 1994).

Since these studies were conducted there have been significant scientific advances in the understanding of the human health effects from the toxic aerosols, including *K. brevis*. In parallel, the corresponding information available on the Internet, (e.g., Mote Marine Laboratory website, the National Oceanic and Atmospheric Administration HAB Bulletin, and Florida Fish and Wildlife Conservation Commission/ Fish and Wildlife Research Institute Red Tide website, Florida Department of Health website, and citizen group efforts such as Solutions To Avoid Red Tide (START)), has been greatly improved (Nierenberg et al., 2011). Despite the extensive outreach, it is unknown whether individuals who are in areas that are at risk for Florida red tide have used these resources to increase their knowledge of red tide. Therefore, we initiated this study to determine whether Florida red tide knowledge and perceptions have changed since our last survey, and specifically whether outreach messages need to be tailored for specific groups. We compare the current findings with previous studies to determine whether outreach has been successful in improving knowledge and perceptions about Florida red tide.

Methods

The University of Miami Institutional Review Board classified the study as exempt.

The study population included residents of Sarasota FL, and individuals who spend a significant part of the year in that area (> 3 months but < 6 months) but are not residents (“snowbirds”). For each of these groups, we sought to include equal numbers of individuals with and without asthma, as individuals with asthma are at higher risk for respiratory illness during and after a visit to the beach during a red tide event (Fleming et al., 2005; Fleming et al., 2007). Thus, a 2×2 design was employed with an overall sample size of 300. The goal was to recruit 75 adults age ≥18 yrs for each of the 4 groups. Asthma was defined by self-report of an asthma diagnosis by a physician or other health care provider. The sample reflected the population in Sarasota County which has a high proportion of retirees. Therefore, the residents sampled were age-matched with the snowbirds. Potential participants were informed that this was a one time survey exploring aspects of Florida red tide. All participants received a $50 gift card after completing the survey.

Participant recruitment

A variety of strategies were used to recruit participants in the study. E-newsletters from Mote Marine Laboratory and Aquarium and START carried short news articles as well as postings on their websites. Mote's large (>1600 people) volunteer group was informed at their monthly meetings and also via e- newsletter. Advertisements were purchased in 4 local free beach weekly newspapers. To specifically recruit asthmatics, flyers were distributed in the waiting rooms of 2 large pulmonary physician groups in both Sarasota and Manatee Counties, and the project was advertised on the Sarasota County Health Department e-newsletter. Finally, multiple Mote Marine Aquarium Facebook postings advertised the study.

The Survey

Survey questions were duplicated from 2 previous studies regarding Florida red tide, knowledge, and risk perception (Nierenberg et al., 2010 and Kuhar et al., 2009). As described above, significant public outreach materials and publications on the human health impacts from the toxic aerosols have been produced since these two prior studies. The survey was participant self-administered at Mote Marine Laboratory and delivered via laptop computer, taking approximately 45 minutes to complete. Research team members were available to answer questions, if necessary.

Statistical Analysis

Descriptive statistics (means and standard deviations, or percentages) were calculated for all demographic variables. For some of the knowledge questions that had multiple correct responses, different strategies can be used to assign a score. Participants could be scored as getting the question "completely correct", "partially correct", or "not at all correct" (for example, if the participant correctly identified only 1 of the impacts of a red tide). We counted a correct answer as only those answers that were "completely correct (all correct choices were selected)." Percentages of correct answers for each of the knowledge questions for each of our subpopulations were calculated, and compared using chi-squared tests. Perceived risk questions were assessed on a 5 point Likert scale with 1=strongly disagree and 5=strongly agree. Means and standard deviations were calculated for each subpopulation and compared using t-tests.

Logistic regression models were conducted to determine whether there were demographic or subgroup differences in knowledge of Florida red tide. Responses to the perceived risk questions were dichotomized and logistic regressions run to examine potential demographic or subgroup differences in Florida red tide risk perception.

Finally, we compared our results with data from two previous surveys: 2005 (Nierenberg et al., 2010) and 2007 (Kuhar et al., 2009). Both of these surveys included residents and tourists, with tourists defined as those residing in Florida less than a month. Thus, we restricted all comparisons to residents. We compared demographics (2005 and 2007), knowledge (2005), and perceived risk (2007).

Results

Demographics

Demographic characteristics are shown in Table 1. Of note, the snowbird population is skewed to the elderly ages, as few younger people have the financial ability or time to relocate for 3 months or longer per year. More females participated than males, and snowbirds, particularly asthmatic snowbirds, had a higher percentage of participants with advanced degrees (Master's degree or higher).

Florida Red Tide Knowledge

The Florida red tide knowledge questions are shown in Table 2. No significant differences were found between residents and snowbirds, or between asthmatics and healthy people in Florida red tide knowledge. In the logistic regression models, no differences were found among the 4 subpopulations or with age, gender, and education.

Florida Red Tide Risk Perception

When perceived risk results were analyzed (see Table 3), results showed that asthmatics demonstrated significantly higher risk perception regarding the severity of health impacts, concern about red tide, concern over increased frequency and severity of red tides, and desire to use any means possible to prevent red tides. The only significant difference between residents and snowbirds as groups was the concern regarding seafood consumption with snowbirds expressing more concern over seafood consumption during a Florida red tide. Logistic regression models that included age, gender and education across the 4 subpopulations (healthy resident, asthmatic resident, healthy snowbird, and asthmatic snowbird) revealed that older individuals reported that eating seafood is more risky and they are more concerned about Florida red tide. Older individuals were more likely to agree that any method should be used to prevent Florida red tide, and although not a significant difference, women also strongly agreed that any means of prevention should be used.

Comparing 2005 and 2012 surveys: Knowledge

Table 4 shows a comparison of the demographics of the 2005 and 2012 survey participants but including only Florida residents. Of note, the 2012 survey population is significantly older than the 2005 respondents. Participant names were not recorded in the 2005 survey. It is possible that an individual may have participated in both surveys. Education level was not collected in 2005 and so could not be compared.

Table 5 compares specific Florida red tide knowledge questions in the 2005 study to the 2012 study. More 2012 participants knew that Florida red tide is an algae ($p<0.001$) and fewer responded ‘don’t know’ ($p<0.013$). Regarding the safety of catching and eating finfish during a red tide there was no difference between the 2 groups. When asked about harvesting and consuming shellfish during a red tide, the 2005 group answered correctly more often compared to the 2012 group ($p=0.017$) and more in 2012 responded they did not know (15.4% compared to 29.4%). In addition, when queried about swimming safety during a red tide, the 2012 group answered incorrectly more often than the 2005 group ($p<0.001$).As shown in Figure 1, when asked to identify the human health symptoms that are caused by a Florida red tide, the respiratory symptoms associated with the toxic aerosols were well identified by both groups. Vomiting and diarrhea were identified by the 2012 group significantly more often than the 2005 group, and headache identified more often by the 2005 group.

In Figure 2, the responses to the query of when Florida red tides occur are shown. The 2005 group selected the correct answer of ‘year round’ as a response more often than the 2012 group.

The results to the query ‘what is the cause of Florida red tide’ are shown in Figure 3. The 2005 group identified that weather and bacteria do not cause Florida red tides more often than the 2012 group, and very high correct responses were given to possible anthropogenic causes such as fertilizers and pollution (70–80% responded no).

Figure 4 displays the responses to the impacts caused by Florida red tide. Economic and health impacts were correctly identified more often by the 2012 group along with weather changes not caused by Florida red tide.

Comparing 2007 and 2012 surveys: Risk perceptions

Table 6 compares the 2007 and 2012 survey participants. In both surveys, females were the majority of the respondents, and again the 2012 population was older than the early participants. There was no significant difference in education level between the two groups.

As shown in Table 7, there were significant differences in responses to almost all risk perception questions when comparing the two surveys, although the direction of the difference was not consistent. The 2007 participants were more strongly agreed with statements that red tide blooms were natural, more frequent, and longer and more severe. The 2012 participants more strongly agreed with statements regarding health impacts during a red tide, risks of seafood consumption during a red tide, and overall concerns about red tide.

Discussion

The primary purpose of recruiting the four different subpopulations of people was to assess whether different groups had different knowledge regarding Florida red tide, and if so, to identify those differences so tailored outreach materials could be created to improve outreach effectiveness. Overall, however, we found that knowledge was consistent across our selected groups and also did not vary by age, gender and education level. Thus, we did not identify a need for substantially different messaging content across groups. Some interesting confounders add to the richness of this new data and the comparison with previous studies. The first is the presence and absence of Florida red tide. The 2005 red tide, was a significant bloom lasting a little over a year and impacted beaches from Tampa to Naples – an area of approximately 150 miles of shoreline. In 2006, a shorter Florida red tide took place over a 2 month span and in 2007, the bloom duration and beach impacts were a matter of a few weeks in October (http://myfwc.com/research/redtide/events/status/statewide/). The Nierenberg survey data was collected in 2005 and 2006, and the Kuhar study in 2007. With the current survey, data were collected in 2011 and 2012. There was not an onshore Florida red tide with impacts at the beaches in either 2010 or 2011. It is a safe assumption that the length of a bloom in relation to these different surveys could have significantly impacted the results.

Another factor that could influence the current survey results was a substantial Federal research project, led by Dr. Dan Baden at the University of North Carolina Wilmington, which has been investigating the human health impacts to the aerosolized Florida red tide toxins. The research group published over 80 peer reviewed publications on the topic. The media covered the epidemiologic beach studies over the 10 year period. And the group had a rigorous outreach component of the project culminating in medical grand rounds presentations at Sarasota Memorial Hospital, Sarasota, Fl and an outreach picnic to share the results and thank the asthmatic participants for their participation in the study (Nierenberg et al., 2011). This could explain the heightened risk perception concern reported by 2012 participants with the asthma as well as the desire to prevent Florida red tide using any method. Of note, respondents did not want red tide control measures with unknown consequences used.

The absence of a Florida red tide in the years leading up to the current survey and the work of the NIEHS study team could significantly impact results. Individuals will have less impetus for seeking information on Florida red tide when a bloom is not present and may

forget information about it over time. As described in the results section, the 2012 group answered incorrectly and/or responded that they did not know the public health message regarding seafood consumption during a Florida red tide compared to the 2005 group. This was also true when queried about swimming safety.

Of note, there has not been an epidemiologic study addressing swimming during a red tide. Anecdotal reports of skin rashes and swelling of the eyes and lips have been reported, but the true incidences of these are not known. Therefore, with no scientific studies to date, the public health message is that it is safe to swim. Also, these two factors also seem to be reflected in the risk perception comparison in Table 7. The 2007 respondents more strongly agreed that blooms are more frequent and more severe, corresponding with the 2005 extensive red tide and the 2006 red tide. The 2012 respondents ranked health impacts and overall concern higher, perhaps reflecting increased generalized concern when an entity is more “unknown” or unfamiliar. The seafood consumption risk perception was also higher in the 2012 participants, reflecting that only half of the respondents indicated that it was safe (51%) to eat fish during a red tide.

Conclusion

The toxic aerosols from Florida red tide have been identified as a significant public health concern. The scientific research that led to this conclusion has been conducted in the last decade. Since many groups of people frequent Florida’s beaches, we examined if knowledge on Florida red tide and its related health risks was different across health status and also resident status. The results demonstrated that the messaging is not differentially reaching the unique groups examined and specific outreach materials tailored for these different groups are not needed. Regarding seafood consumption during a red tide bloom, no progress has been made to public awareness. Overall, although the knowledge of red tide impacts has not significantly changed, regardless of the episodic nature of red tides, the Florida red tide risk perceptions have increased, particularly among individuals with asthma. Public health workers charged with communicating information about Florida red tide and related human health concerns need to continue to pursue more effective outreach methods and products, but these data suggest that broad-spectrum efforts might be a feasible approach.

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highlights

- Groups studied were residents, snowbirds, asthmatics and those without.
- Found specific outreach materials tailored for these different groups are not needed.
- We also compared our results to two previously published studies.
- Red tide risk perceptions have increased, specifically among individuals with asthma.
- Continued development of effective outreach tools and delivery methods still needed.

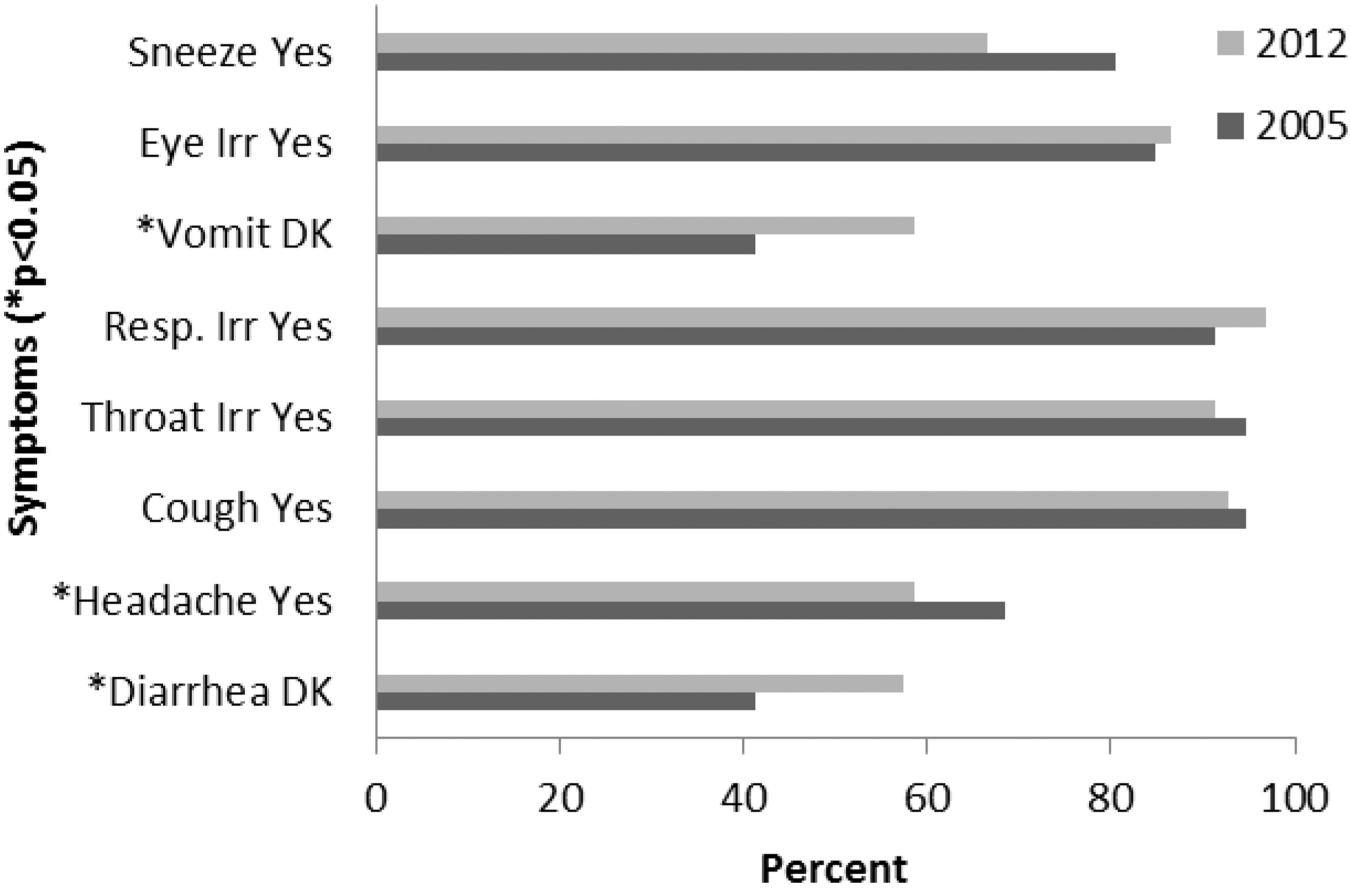

Figure 1.
Human Health Symptoms

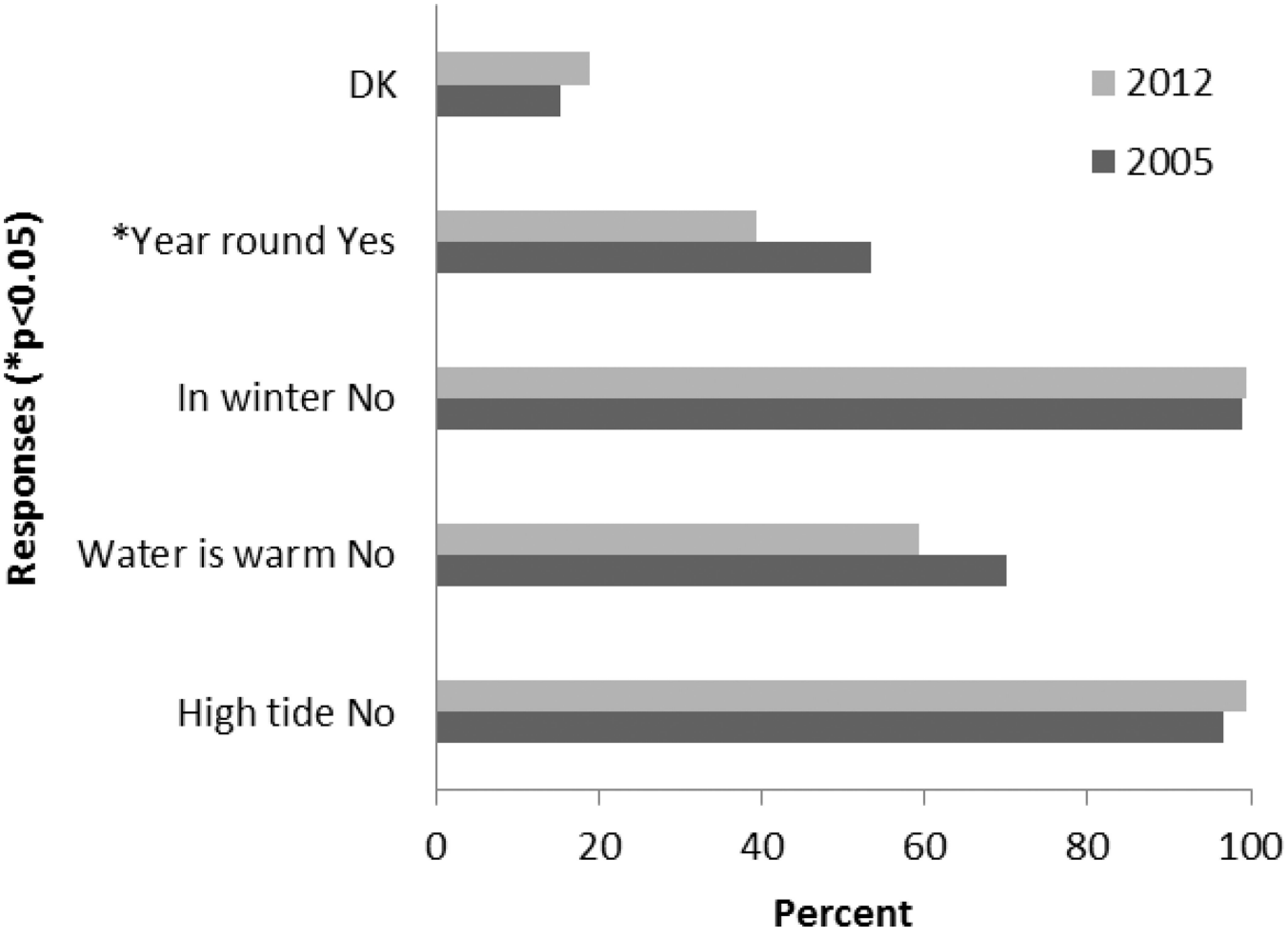

Figure 2.
Occurrence of Florida red tide

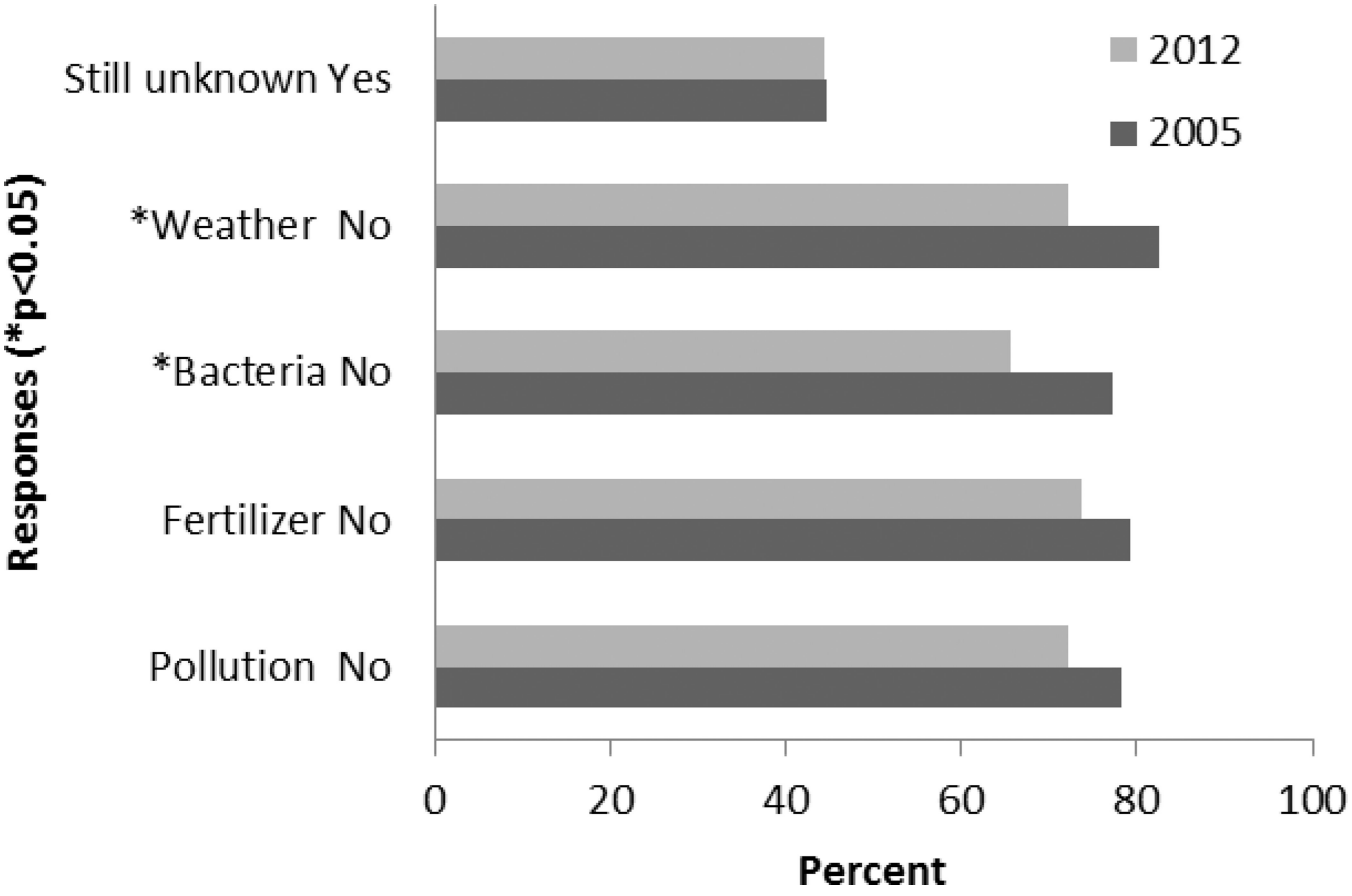

Figure 3.
Cause of Florida red tide

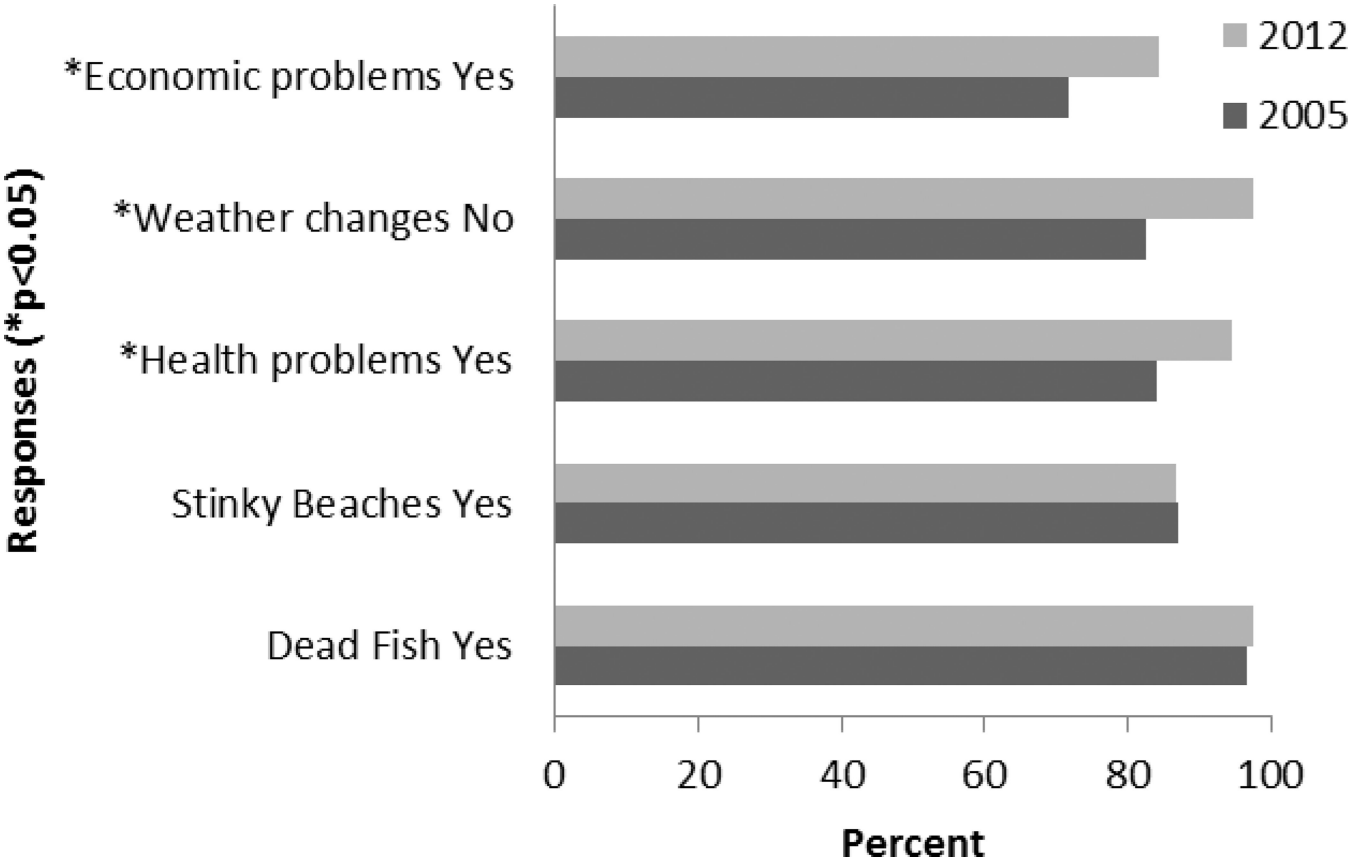

Figure 4.
What Florida red tide causes

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Table 1

Demographics

n= 303		**Healthy Residents n (%)**	**Asthmatic Residents n (%)**	**Healthy Snowbirds n (%)**	**Asthmatic Snowbirds n (%)**	**X^2**	**P**
		117	101	55	30		
Age	18–29	8 (6.8)	5 (4.9)	0	0	49.61	<0.0001*
	30–49	49 (41.9)	29 (28.7)	2 (3.6)	2 (6.7)		
	50–69	53 (45.3)	55 (54.5)	35 (63.6)	21 (70.0)		
	70–89	7 (6.0)	12 (11.9)	18 (32.7)	7 (23.3)		
Female		67 (57.3)	74 (73.3)	28 (50.9)	18 (60.0)	9.44	0.024*
Education	High School Diploma or less	17 (14.5)	10 (9.9)	1 (1.8)	1 (3.3)	23.73	0.001*
	Some higher education	76 (65.0)	74 (73.3)	30 (54.5)	17 (56.7)		
	Masters/Doctorate	24 (20.5)	17 (16.8)	24 (43.6)	12 (40.0)		

Table 2

Red Tide Knowledge Questions

1. What is the make up of Florida red tide?
2. What causes a Florida red tide
3. Is Florida red tide something new?
4. When can Florida red tides occur?
5. Florida red blooms cause: (impacts)
6. In the following list, identify human health symptoms related to Florida red tide exposure.
7. Is it safe to catch and eat fish during a Florida red tide?
8. Is it safe to harvest and eat shellfish such as clams, oysters, and mussels during a Florida red tide bloom?
9. Is it safe to swim during a Florida red tide bloom?
10. Is it safe to go to the beach during a Florida red tide bloom?

Knowledge Questions **- Response options with correct answer(s) in bold**	**Healthy Residents % correct**	**Asthmatic Residents % correct**	**Healthy Snowbirds % correct**	**Asthmatic Snowbirds % correct**
What is the make up of Florida red tide? - **Algae**, bacteria, virus, don't know	58.12	51.49	58.18	56.67
What causes a Florida red tide? - **Still unknown**, weather, bacteria, fertilizer, pollution	29.91	29.70	23.64	30.00
Is Florida red tide something new? - Yes/ **no**	88.89	96.04	94.58	90.00
When can Florida red tides occur? - **Year round**, in winter, when water is warm, high tide	36.78	42.57	38.18	40.00
What does Florida red tide cause (impacts)? - **Economic problems**, weather changes, **health problems, stinky beaches, dead fish**	70.09	77.23	76.36	60.00
In the following list, identify human health symptoms related to Florida red tide exposure. - **Sneeze, eye irritation**, vomiting, **respiratory irritation, throat irritation, coughing**, headache, diarrhea	2.56	3.96	1.82	6.67
Is it safe to catch and eat fish during a Florida red tide? - **Yes**/no	18.8	14.9	12.7	13.3
Is it safe to harvest and eat shellfish such as clams, oysters, and mussels during a Florida red tide bloom? - Yes/**no**	59.8	63.4	69.1	56.7
Is it safe to swim during a Florida red tide bloom? - Yes/no	18.0/65.8	25.7/56.4	20.0/58.2	6.7/56.7
Is it safe to go to the beach during a Florida red tide bloom? - Yes/no	55.6/26.5	47.5/38.6	47.3/38.2	40.0/36.7

Table 3

Perception of Risk

Risk Perception 2012	Resident	Snowbird	t-test	p	Healthy	Asthmatic	t-test	p
Health impacts during a red tide	3.02 (1.18)	2.76 (1.31)	1.50	0.067	2.53 (1.08)	3.52 (1.16)	7.07	<0.001*
Seafood consumption risk during a red tide	3.51 (1.14)	3.94 (1.09)	2.96	0.002*	3.63 (1.15)	3.64 (1.14)	0.10	0.460
Concern about red tide	4.13 (1.02)	4.29 (0.94)	1.30	0.098	4.06 (1.00)	4.32 (0.99)	2.23	0.013*
Red tides are natural	3.14 (1.10)	3.16 (1.08)	0.19	0.423	3.02 (1.14)	3.31 (1.00)	0.04	0.010*
Red tides are more frequent	3.16 (1.00)	3.07 (0.91)	0.33	0.247	3.03 (0.95)	3.27 (1.00)	2.12	0.017*
Blooms longer and more severe	3.20 (0.89)	3.09 (0.89)	0.91	0.183	3.09 (0.87)	3.27 (0.91)	1.70	0.046*
Use of any method to prevent red tide	3.98 (1.10)	4.13 (0.99)	1.11	0.134	3.92 (1.12)	4.15 (1.00)	1.89	0.030*
Use of control methods with unknown impacts	2.46 (1.20)	2.49 (1.22)	0.23	0.41	2.53 (1.19)	2.39 (1.23)	1.00	0.159

Table 4

Demographics: 2005 survey respondents with 2012 Survey respondents

	2005	2012	p
n	92	218	
Gender (female)	49 (53%)	141 (64.6%)	0.059
Age group			
18–24	9 (9.8%)	5 (2.3%)	0.001 (2012 older)*
25–29	7 (7.6%)	8 (3.6%)	
30–49	28 (30.4%)	78 (35.5%)	
50–69	33 (35.9%)	108 (49.5%)	
70–89	15 (16.3%)	16 (7.3%)	
90+	0	3 (1.4%)	

Table 5

2005 residents only survey responses compared to 2012 resident only survey responses

n	92	218	
What is red tide? **Algae**	55 (59.8%)	178 (81.6%)	<0.001*
What is red tide? DK	10 (10.9%)	8 (3.7%)	0.013*
Is red tide new? **No**	88 (95.7%)	201 (92.2%)	0.360
Is it safe to catch/eat fish during a red tide? **Yes**	16 (17.6%)	36 (16.5%)	0.084
Is it safe to catch/eat fish during a red tide? No	57 (62.6%)	112 (51.4%)	
Is it safe to catch/eat fish during a red tide? DK	18 (19.8%)	70 (32.1%)	
Is it safe to harvest and eat shellfish during red tide? Yes	6 (6.6%)	20 (9.2%)	0.017*
Is it safe to harvest and eat shellfish during red tide? **No**	71 (78.0%)	134 (61.5%)	
Is it safe to harvest and eat shellfish during red tide? DK	14 (15.4%)	64 (29.4%)	
Safe to swim during a red tide? **Yes**	44 (48.4%)	47 (21.6%)	<0.001*

Table 6

Demographics of 2007 compared to 2012

	2007	2012	p
n	43	218	
Gender (female)	25 (58.1%)	141 (64.7%)	0.415
Age group			
18–25	2 (4.7%)	6 (2.8%)	<0.001*
26–35	12 (27.9%)	27 (12.6%)	
36–45	5 (11.6%)	45 (20.9%)	
46–55	16 (37.2%)	30 (14.0%)	
56–65	4 (9.3%)	67 (31.2%)	
66–75	3 (7.0%)	36 (16.7%)	
76 and above	1 (2.3%)	4 (1.9%)	
Education group			
Less than HS education	0 (0%)	3 (1.4%)	0.781
HS diploma or equivalent	6 (14.0%)	24 (11.0%)	
Some college	14 (32.6%)	83 (38.1%)	
4 year college degree	16 (37.2%)	67 (30.7%)	
Masters or doctorate	7 (16.3%)	41 (18.8%)	

Table 7

2007 Risk Perception compared to 2012

Risk Mitigation 2007 vs 2012	2007	2012	t test
n	43	218	
Health impacts during a red tide	2.02 (1.39)	3.02 (1.18)	<0.001*
Seafood consumption risk during a red tide	2.93 (1.71)	3.51 (1.14)	0.006*
Concern about red tide	3.62 (1.11)	4.13 (1.02)	0.003*
Red tides are natural	3.60 (1.35)	3.14 (1.10)	0.015*
Red tides are more frequent	4.05 (1.09)	3.16 (1.00)	<0.001*
Blooms longer and more severe	3.93 (1.12)	3.20 (0.89)	<0.001*
Use of any method to prevent red tide	3.56 (1.39)	3.98 (1.10)	0.031*
Use of control methods with unknown impacts	2.23 (1.39)	2.46 (1.20)	0.274