Iranian Journal of Fisheries Sciences 19(1) 471-487 2020
DOI: 10.22092/ijfs.2019.119690.

A study on red tide risk and basic understanding of fishermen and residents in Bandar Abbas, Hormozgan Province, Iran (Persian Gulf)

Mirza Esmaeili F.[1]; Mortazavi M.S.[2]*; Arjmandi R.[1]; Lahijanian A.[1]

Received: August 2017 Accepted: January 2018

Abstract

Harmful algal bloom can be regarded as a persistence environmental problem in the Persian Gulf. This region has experienced many problematic human and social issues, economic damages, and environmental problems caused by red tides. However, no coherent study has been devoted to shed light on perceptions of red tide risks in the Persian Gulf. In response to the mentioned gap, the present study aimed to investigate residents and fishermen perceptions of red tide risks in Bandar Abbas. To meet the mentioned objective, a total of 247 and 145 subjects filled out structured questionnaires in two coastal parks and Bandar Abbas Fishermen, respectively. The obtained results indicated that the demographic factors along with experience and human health issues of red tides affected subjects' risk perception. This study also revealed that fishermens and residents intensify the risk of red tides, such as seafood consumption, occurrence of red tides and their progress towards coast. Negative media coverage, limited information, and lack of any support of fishermen by government are some of the factors affecting individuals' reaction and concerns towards red tide.

Keywords: Halo effect, Harmful algal bloom, Hormozgan, Red tide, Risk perception

1-Department of Environmental Management, Faculty of Natural Resources and Environment, Science and Research Branch, Islamic Azad University, Tehran, Iran

2-Persian Gulf and Oman Sea Ecology Research Center, Iranian Fisheries Science Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Bandar Abbas, Hormozgan, Iran

*Corresponding author's Email: mseddiq1@yahoo.com

Introduction

Large-scale fish mortality, human poisoning syndromes, losses of economic and natural resources, and damage of tourism businesses are some examples of dramatic consequences of many harmful algal blooms (HABs) events (Grattan *et al*., 2016; Roncalli *et al*., 2016).

Annual occurrence of algal blooms in the Persian Gulf has been reported in a number of studies (Zhao and Ghedira, 2014). The Bandar Abbas coast located in the north region of the Strait of Hormuz and Persian Gulf occasionally along with the Persian Gulf coasts experiences fish and marine organism kills resulting from blooms of widely diverse HABs species (Thangaraja *et al*., 2007; Dorgham, 2013). The outbreak of HABs in the waters of the Persian Gulf coasts has increased the frequency and geographic distribution as well as their impacts and persistence in this region (Nezlin *et al*., 2010; Saeedi *et al*., 2011). For example, in 2008, the Persian Gulf red tide was the proposed name for blooms of the dinoflagellate *Cochlodinium polykrikoides*, which occur at more than 1200 km of coastlines of Iran along the Persian Gulf Coast (Matsuoka *et al*., 2010; Richlen *et al*., 2010) and last for almost 9 months to expand and affect larger areas of the Persian Gulf (Fatemi *et al*., 2012). The bloom is remarkable for its size and intensity (Richlen *et al*., 2010). Persian Gulf red tide causes the most significant economic, environmental, public health, and social problems that are the main focus of this study.

Environmental health problems include coral reef damages, thousands of tons of wild fishes, marine mammals, and other marine organisms kills, decreased aquatic life, reduced water quality, and discoloration of the sea (Bauman *et al*., 2010; Saeedi *et al*., 2011; Coles *et al*., 2015).

Economic problems comprise damages to the massive aquaculture industries and coastal economies, restricted fishing activities, restricted tourism and tourism-related businesses, suspension of desalination plant' operations increased monitoring and management costs. However, the negative economic impacts of algal bloom require to be fully assessed (Al-Shehhi *et al*., 2014; Zhao *et al*., 2015).

With respect to human health and social problems, population's irritation of eyes and respiratory systems, restricted recreational activities, coastal school closings, and decreased fish consumption and demand can be referred to (Al Gheilani *et al*., 2011; Al Shehhi *et al*., 2014).

The coastal waters of the Persian Gulf have been exposed to a variety of environmental pressures and pollutants including dust storms, very low levels of precipitation, global warming, pollution caused by oil, agricultural, and aquaculture operations, industrial and domestic wastewater inputs, shipping traffic, and desalination effluents (Sheppard *et al*., 1992; Marcella and Eltahir, 2008; Gherboudj and Ghedira, 2014).

There are pieces of evidence indicating that the main factor leading to occurrence of the Persian Gulf red

tide over the Persian Gulf with 9 months duration in 2008-9 is the presence of high levels of nutrient concentration in its water bodies (Fatemi *et al*., 2012; Hamzehei *et al*., 2013). The main sources of nutrient fluxes into the Persian Gulf are natural sources such as dust deposition and seabed (Al Shehhi *et al*., 2014) and anthropogenic sources such as industrial wastewater, urban sewages, aquaculture and agriculture runoff (Heil *et al*., 2001; Richlen *et al*., 2008).

Many publications addressing the occurrence of red tides in the Persian Gulf accentuate settlement, management, and control of red tide events as harmful algae blooms appear throughout nearly all coastal countries in the Persian Gulf and Oman Sea. These events cause fish mortality and economic impacts (Al Gheilani *et al*., 2011). Hence, control and tracing of HABs are of great significance.

Some studies have focused on perceptions of HABs and their environmental threats and risk. Tyler *et al*. (2009) indicated that majority of respondents (66%) believed that there were risks associated with cyanobacteria blooms, and 43% did not feel comfortable about these risks at Loch Leven. Kuhar *et al*. (2009) specified that the underlying foundations of the social amplification of the risk framework were applicable to understand how individuals form perceptions of risks related to red tide events. Moreover, key differences were observed between individuals' spatial locations and their corresponding perceptions, indicating that place-specific contexts are essential to understand how individuals receive and interpret risk information. In another study, Whitehead *et al*. (2003) described that announcement of a fish kill increases the perceived risks of seafood dishes and decreases the demand for them. The magnitude of the *Pfiesteria*-related fish kill as distinguished by a major and minor fish kill is a significant determinant of risk perceptions. Information in the form of educational brochures sent to seafood consumers actually increased the perceived risk of eating seafood dishes. Increased risk perceptions indicated that consumers revealed a significant adverse reaction to the prepared educational brochure. Hunter *et al*. (2012) described that 55% of respondents were willing to pay for a reduction in the number of days per year (from 90, to either 45 or 0 days) that cyanobacteria posed a risk to human health at Loch Leven. Furthermore, the respondents' willingness this regard was strongly dependent on socio-demographic characteristics, economic status, usage of the water body, and individual-specific attitudes towards and perceptions of health risks.

Roberts *et al*. (2016) found that cultural and community specific contexts impacted the perception of risk of domoic acid (DA) - related health problems. Native American nations worried more about ocean pollution, attributed DA risks to climate changes, expressed concerns about the possible impact of DA on future generations, and felt to be better informed in

comparison with the Community Recreational Harvester (CRH) group. The CRH group was more likely to attribute the DA problem to anthropogenic or industrial causes.

Many investigations have suggested that "certain characteristics" imperative factors affecting risk perception (Gustafson, 1998; Slimak and Dietz, 2006). For instance, gender and age range influenced respondents' perception of risks associated with introduced marine species (Trenouth and Campbell, 2013).

Risk perception of red tides

In general, risk perception can be considered as an individual's interpretation or impression based on their understanding of a particular threat that may potentially cause loss of life or property. There are many formal definitions of risk perception presented in the pertinent literature (Wildavsky and Dake, 1990; Boholm, 1998; Raaijmakers *et al*., 2008).

A report provided by Hormozgan University of Medical Sciences indicates that a few cases of respiratory complaints and eye irritation have been reported as the symptoms were so weak and short to inform the medical (HG, 2009). At the same time, due to the frequently blowing wind over the coastal region, an unpleasant odor was spread far and wide and became the source of nuisance and discomfort (Al Shehhi *et al*., 2014). These health risks led to change of outdoor activities such as people's refusal to go to the coast, and decrease of marine sports and recreational fishing activities in Bandar Abbas. Ministry of Hormozgan Education closed primary schools to protect ill students (HG, 2009). These health risks and reactions may influence how individuals perceive HABs risks and management strategies.

The behavior and reaction of individuals in response to the Persian Gulf red tide is a good example of what has become known as "halo effect". In general, the halo effect refers to a repercussion of the public's aversion to seafood not affected by red tides or from areas not impacted by blooms (Nisbett and Wilson, 1977; Coombs and Holladay, 2006). Individuals' behavior may influence the economic issues during and after a bloom (Kuhar *et al*., 2009).

Local fishery impacts included price decrease due to reduced demand and harvest decline due to decreased fish supply. Small and large pelagic fish harvest level decreased to 11.4% and 1.6% of the total annual harvestings, respectively. Crab harvest decreased from 60275 kg per year in 2006 to 10446 kg per year in 2007. The losses were equal to about 20% of the annual crab harvest during the occurrence of Persian Gulf red tide (Fisheries Statistical Yearbook, 2009; Esmaeili, 2012).

Economic impact of blooms led to price decrease of $2720 (3000 dollar) in Hormozgan Province in 2008-09. As economic impact was not well documented, thus was reduced too much in this study (Esmaeili, 2012), though it was still more than the price reduced in other rejoins (Cato, 1998). Hormozgan Fisheries Organization

(HFO) also showed that although people consumed fish after blooms and as a result its price increased, reduction of fishermen's income continued for several months due to reduction of harvest (HFO, 2010).

Halo effect could trigger a chain of reactions that might eventually lead to adverse impacts on the economy at a larger scale, which is known as the "butterfly effect" (Jaaskela and Kulish, 2010). During the occurrence of red tide in the Persian Gulf, public did not consume tuna fish, as a result of which tuna factories suffered from great economic losses.

The role of media in reporting environmental controversy and public health risk news has received considerable recent scholarly attention in a number of studies (e.g., Morgan *et al*., 2011; Campbell, 2014).

Negative media coverage has been shown to be a major cause of adverse consumer reactions (e.g., Griffith, 1999; Wessells *et al*., 1995). Many researchers revealed strong public reaction to inaccurate media coverage in comparison with other previously hypothesized factors (Kempton and Falk, 2000; Whitehead *et al*., 2003). Negative media coverage of Persian Gulf red tide could form public perceptions and decrease the seafood purchases in spite of lack of scientific evidence in relation to these outbreaks to human illness. It caused social and economic impacts, a process known as the social amplification of risk (Kasperson *et al*., 1988).

During Persian Gulf red tide, people became more or less informed about clay dispersions. It increased fish consumption and decreased halo effect and concerns about bloom spread in social. Clay dispersions might affect risk perception. Negative media coverage caused concerns among people and influenced fish consumption, red tide risk perception, and HABs management strategies.

As fishers spend most of their time in sea, they know the blooms better than the commons. Fishers are afraid of decreased harvest and income, which may influence their red tide risk perceptions and participation in algae blooms management. There are not any environmental and health impact studies including surveys addressing risk perception in the Persian Gulf Bandar Abbas.

To researchers' knowledge, the present study is the first comparative one addressing public and fishermen' perceptions of red tide risks in the Persian Gulf. In the present study, the risk perceptions of fishermen as people who have direct contact with the sea and residents as people who live near the coast were compared. This assessment can greatly inform the various agencies to make more appropriate decisions with respect to controlling, monitoring, and information dissemination of red tide by identifying certain groups for effective risk communication and public education programs, increasing their participation, and identifying the sources people prefer to use to obtain information on HABs.

Materials and methods

In this paper, perceptions of residents, individuals live in Bandar Abbas, and fishermen, members of fishing cooperative, were compared. The eligibility criterion for participation was being at least 18 years of age.

The residents were selected using a convenience sampling. In detail, the beachgoers at the Dowlat and Suru parks of public beaches in Bandar Abbas, Hormozgan, were involved in the study. The mentioned two parks were easily accessible and widely used by the public. The questionnaires were filled out on weekends in these two study sites from June to July 2016. Fishermen filled out the questionnaire from 21 to 29 July 2016 when they referred to Hormozgan Fisheries Department (HFD) to receive their fishing permissions. It should be noted, in the process of collecting data, blooms occurred during some days of 2016 in this area. To achieve a high response rate and to provide assistance in answering the questions, the researcher was present in the data collection process to increase openness and trigger memories, photos of blooms were taken advantage of, and the local word "Heiz Darya" was used instead of red tide.

Moreover, similar qualitative perceptions of risk were used for those who participated in previous studies (Kuhar *et al*., 2009; Hunter *et al*., 2012; Huang *et al*., 2013; Marcon *et al*., 2015). Similar factors with little differences in their composition were obtained in the present study. The questionnaire was approved by Islamic Azad University, Tehran, Iran and the Persian Gulf and Sea of Oman Ecological Research Institute.

The questionnaire consisted of 17 items and four dimensions: questions addressing demographic information (3 items), human health effects (3), sources of knowledge about red tides (1 item with 6 choices), and degrees of concerns (10 items). The subjects had to answer the items utilizing five-point Liker scales and yes/no options in some cases. Approximately 30 minutes was considered to fill out the questionnaires.

All analyses were done using the Statistical Package for Social Science (SPSS) software, version 20. Nonparametric statistical tests were used to produce contingency tables. Moreover, Spearman's rho was used to determine whether human health effects and several demographic variables affect subjects' perception of red tide risks. Moreover, Mann-Whitney (U) tests were used to determine whether there were significant differences between residents and fishers' perceptions of red tide risks.

Results

Demographics and information resource

Table I shows the demographic traits of the survey population. The number of residents and fishers participating in this study was 247 and 145, respectively. Resident subjects were within the age range of 18-78, and 53% of them were male. Fisher subjects were within the age range of 28-72, and all of them were male. Most of the residents (47%) had college degree,

while most of the fishers (87%) had less than a high school education. One of the other items asked where the respondents had received most of their information about red tides. As Table 1 indicates, most of the residents referred to Internet or Virtual Social Networks (VSN) as the main resources, while most of the fishers took advantage of colleagues, or workplaces (Bandar Abbas Fisheries organization) to obtain information in this regard (Table 1).

Table 1: Demographics of subjects and selected sources to receive red tide information.

Variable (N)		Resident n=247	Fishermen n=145
Gender (%)	Female	115 (46.6)	0
	Male	132 (53.4)	145 (100)
Age (%)	18–25 years	26 (10.5)	0 (0)
	26–35 years	94(38.1)	31(21.4)
	36–45 years	89(36.0)	67(46.2)
	46–55 years	22(8.9)	34(23.4)
	56+ years	16(6.5)	13(9.0)
Education (%)	Less than high school education	102 (41.3)	175(87.6)
	Master degree	116(47.0)	18(12.4)
	Bachelor degree and doctorate	29(11.7)	0
Sources of information (%)	Newspaper	18 (7.3)	0
	TV or radio	91(36.8)	30 (20.7)
	Internet or virtual social networks	103 (41.7)	10 (6.9)
	Colleagues or workplace	35 (14.2)	105(72.4)

Human health questions

Another question was about the effect of red tide on human health. As Table 2 demonstrates, most of the subjects claimed that they were affected by red tides. In response to the following question "What are the health symptoms?" 47.6 % of fishers' named skin itching, whereas half of the residents referred to headache and nuisance. 16% of the residents and half of the fishers believed that health symptoms were very severe (Table 2).

Table 2: Effects of red tides on subjects' human health.

Variable (N)		Resident n=247	Fishermen n=145
Are you affected by red tides?	Yes	184 (74.5)	138 (95.2)
	No	63 (25.5)	7 (4.8)
What are health symptoms?	Stress	63(25.5)	45(31.0)
	Headache and nuisance	124 (50.2)	13(9.0)
	Sneezing and coughing	13 (5.3)	6(4.1)
	Skin itching	16 (6.5)	69(47.6)
	Itchy and red eyes	24 (9.7)	5(3.4)
Rate of impacts	Very little	7(2.8)	5 (3.4)
	Little	35 (14.2)	6 (4.1)
	Moderate	35 (14.2)	13 (9.0)
	Somewhat severe	79 (32.0)	35(24.1)
	Severe	16 (6.5)	79 (54.5)

Perception and concerns

The subjects were asked a number of questions, which focused on the potential control and mitigation actions (Questions 1–3), perception and awareness of the traits of red tides in the Persian Gulf (Questions 4-6), and concerns about red tides (Questions 7–10). The first set of questions focused on potential control and mitigation actions. In response to the question of "how much do you agree that people be educated or informed about red tides?" the majority of the residents and fishermen (57.1% and 76%, respectively) answered "strongly agreed." There was a significant difference (p=0.005) between residents and fishers' opinions. The significant difference was observed between residents and fishers' believes regarding whether managers must prevent disposal of sewage into sea (p<0.0001). 50.6% of residents and 74.4% of fishers believed red tide is the consequence of sewage disposal.

This question also showed a significant difference (p=0.000) between residents and fishermen opinions about how much they agree to use control methods even though their side effects are unknown. 11.3% of residents and half of the fishers believed that any control methods should be used to decrease the effects of red tide. Although some control methods had the potential to indiscriminately kill many co-occurring algae species and other organisms (Sengco *et al*., 2005), they tend to use any control methods with no attention to their negative effects due to economic effects of red tides (Table 3).

Table 3: Descriptive analysis of subjects' answers to the questions addressing perceptions of red tide risks and tests indicating significant differences between Bandar Abbas residents and fishermen.

1. How much do you agree that people should be educated or informed about red tides?						
	Strongly Disagree	Somewhat Disagree	Neutral/Not Sure	Somewhat Agree	Strongly Agree	Mean Score
residents	16(6.5)	2(8)	11(4.5)	77(31.2)	141(57.1)	186.03
fishermen	0	18 (12.3)	11(7.5)	5(3.4)	111(76.0)	214.33
	p value(.005)*	Mann-Whitney U(15321.5)				
2. How much do you agree that managers must prevent disposal of sewage into sea?						
Table 3 continued:						
	Strongly Disagree	Somewhat Disagree	Neutral/Not Sure	Somewhat Agree	Strongly Agree	Mean Score
residents	12(4.9)	8(3.2)	8(3.2)	75 (30.4)	125(50.6)	179.05
fishermen	8(5.5)	0	0	22(15.2)	109(74.4)	226.23
	p value(.000)*	Mann-Whitney U(13596. 5)				
3. How much do you agree that control methods should be used even if the side effects of doing so are unknown?						
	Strongly Disagree	Somewhat Disagree	Neutral/Not Sure	Somewhat Agree	Strongly Agree	Mean Score
residents	21(8.5)	35(14.2)	50(20.2)	113(45.7)	28(11.3)	144.61
fishermen	24(16.4)	15(10.3)	16(11)	6(4.1)	84(57.5)	284.89
	p value(.000)*	Mann-Whitney U(5091.5)				
4. How much do you agree that red tides in the Persian Gulf are long-lasting and intense?						
	Strongly Disagree	Somewhat Disagree	Neutral/Not Sure	Somewhat Agree	Strongly Agree	Mean Score
residents	27(10.9)	67(27.1)	79(32.0)	53(21.5)	21 (8.5)	190.21
fishermen	38(26.2)	15(10.3)	17(11.7)	25(17.2)	50 (34/5)	207.21
	p value(.142)	Mann-Whitney U(16355.0)				
5. How much do you agree that red tides occur frequently in the Persian Gulf?"						
	Strongly Disagree	Somewhat Disagree	Neutral/Not Sure	Somewhat Agree	Strongly Agree	Mean Score
residents	10(4.0)	25(10.1)	74(30.0)	104 (42.1)	34 (13.8)	182.39
fishermen	7(4.8)	34(23.3)	52(35.6)	0	52 (35.6)	220.53
	p value(.001)*	Mann-Whitney U(14423.5)				

Table 3 continued:

6. How much do you agree that red tides in the Persian Gulf cause human health problems?						
	Strongly Disagree	Somewhat Disagree	Neutral/Not Sure	Somewhat Agree	Strongly Agree	Mean Score
residents	10(4.0)	25(10.1)	74(30.0)	104(42.1)	34 (13.8)	161.57
fishermen	0	17(11.6)	16(11)	11(7.5)	101 (69.2)	256.00
	p value(.000)*	Mann-Whitney U(9279.5)				
7. How much are you concerned about eating seafood dishes during the occurrence of a red tide?"						
	not at all concerned	Very little concerned	little concerned	Very concerned	Extremely concerned	Mean Score
residents	9(3.6)	42(17.0)	75(30.4)	45(18.2)	76(30.8)	177.21
fishermen	26(17.8)	0	15(10.3)	0	104(71.2)	229.36
	p value(.000)*	Mann-Whitney U(13142.5)				
8. How much are you concerned about red tide occurrence?						
	not at all concerned	Very little concerned	little concerned	Very concerned	Extremely concerned	Mean Score
residents	11 (4.5)	35(14.2)	87(35.2)	65(26.3)	49(19.8)	175.15
fishermen	0	0	6(4.1)	12(8.2)	127(87.0)	232.87
	p value(.000)*	Mann-Whitney U(12634.5)				
9. How much are you concerned about the economic effects of red tides?						
	not at all concerned	Very little concerned	little concerned	Very concerned	Extremely concerned	Mean Score
residents	27 (10.9)	58 (23.5)	58 (23.5)	36 (14.6)	36 (14.6)	144.38
fishermen	0	0	0	29 (19.9)	116 (79.5)	285.28
	p value(.000)*	Mann-Whitney U(5034.5)				
10. How much are you and your family concerned about going to the coast?						
	not at all concerned	Very little concerned	little concerned	Very concerned	Extremely concerned	Mean Score
residents	16 (6.5)	23(9.3)	44 (17.8)	121(49.0)	43 (17.4)	138.79
fishermen	15 (10.3)	52(15.6)	40 (27.4)	23(35.8)	16 (11.0)	294.80
	p value(.000)*	Mann-Whitney U(3654.0)				

*significant differences at 0.01 and 0.05 levels.

When asked "how much tides in the Persian Gulf are long-lasting and intense?" no significant difference was observed between residents and fishermen' answers; however, both residents and fishers answered "I strongly disagree" (10.9 % and 26.2 %, respectively) that the occurrence of red tide is long-lasting and intense.

For the question "how much do you agree that red tide occurs frequently in the Persian Gulf?" 35.6% of the fishermen and 13.8% of residents answered "I am strongly agreed". The majority of fishermen (69.2%) and only 13.8 % of residents were strongly agreed that red tides in the Persian Gulf caused human health problems. There were significant differences between residents and fishermen' opinions regarding Questions 5-6 (p=0.01 and p=0.00, respectively) (Table 3).

Table 3 indicates the subjects' responses to questions about red tides in the Persian Gulf. When the subjects were asked "how much are you concerned about eating sea food dishes during the occurrence of red tide?" a significant difference was observed between residents and fishermen' answers (p<0.0001); however, both fishermen and residents answered "very concerned" (71.2% and 30.8%, respectively). Although there were not any reports of human illness or death resulting from red tide occurrence in Bandar Abbas and the Persian Gulf, a few fishermen and residents were not concerned about eating sea food dishes (17.8% and 3.6%, respectively). The responses indicated much halo effect during red tide occurrence in the Persian Gulf. With respect to " how much are you concerned about red tide occurrence?" residents and fishermen'

responses were significantly different (p<0.0001) as, 87.0% of fishers and 19.8% of residents responded "very concerned", and no fishermen and 4.5% of residents responded "not at all concerned". Table 3 shows the number and percentage of residents and fishermen' answers to questions regarding the concerns about the economic effects of red tides? 79.5% of the fishers and 14.6% of the residents were very concerned (p<0.0001), and no fishermen and 10.9% of residents responded that "not at all concerned". The last question was "how much are you and your family concerned about going to coast?" More than 49% of residents and 35% of the fishermen believed that this behavior was unsafe and they were concerned about going to the coast. The differences between the residents and fishermen' answers were significant in this regard (p<0.0001) (Table 3).

The responses to questions addressing red tide risk perceptions were analyzed based on several demographic and human health impact variables as possible factors affecting subjects' perception. These factors included sex, age, and education, being affected by red tides, and severity of health symptoms. As shown in Table 4, most of the variables, (i.e. sex, age, education, severity of health symptoms) affected the respondents' perceptions in this regard. Male, younger, and less educated respondents experienced higher levels of concerns in comparison with women, older, and more educated respondents. There were significant differences between the male and female subjects' responses. Men were more likely to state that they prevent to sewage into sea, use control methods with unknown impacts and human health effects, experience higher levels of concerns about eating sea food dishes, are concerned about occurrence of red tides, are affected by health-economic effects of red tides, and are concerned about going to the coast (data of this section is not presented).

The number of individuals affected by red tides and their impacts was increased. They had higher levels of concerns, were more likely to be aware of the traits of red tides and potential control and mitigation actions in the Persian Gulf in comparison with non-affected respondents and those reporting less health problems.

Discussion

There were significant differences between Bandar Abbas residents and fishers' perceptions of the potential control and mitigation actions, perception and awareness of the traits of red tides, and level of concerns about red tides in the Persian Gulf. Fishers had deeper understanding in this respect that red tides occur more frequently and cause human health effects. Moreover, the involved fishermen were in favor of training and receiving information, prevented to dispose sewage into sea, used control methods with unknown side effects, and were more concerned about occurrence of red tides, eating sea food dishes, being affected by health and economic effects, and going to the coast.

Perhaps, fishermen exaggerated about these concerns and perceptions as they were more frequently affected by economic consequences of red tides. Red tides occurred annually along the Persian Gulf and the coast of Bandar Abbas, the areas in which the fishermen did their fishing. Red tides caused mortality of fish and decrease of fish harvesting.

Due to changes taking place in water and environments caused by red tides, sea food dishes were not delicious and pleasant. That is why public were not willing to buy and consume fish during the occurrence of red tides. In future, the price of fish decreases, which results in decrease of fishers' income. In comparison with residents, fishers were more concerned about the consumption of fish as they could better distinguish quality of fish. Fishers were affected by red tides more frequently because they were directly connected to sea and fish. Moreover, they were more concerned about their family going to the coast. Higher levels of agreement with respect to application of control methods may be explained by considering the fact that as the government provides no support to fishers regarding the occurrence of red tides, any decisions taken by the government could be very important for them.

The data also indicated that residents of Bandar Abbas experienced the human health effects of red tides, which may affect individuals' concerns about eating sea- food and going to the coast. These individuals may pass the information about red tide risks to other individuals who were not knowledgeable about the subject, the resulting behavior of which could contribute to the "halo effect."

The results of both quantitative and the qualitative analyses revealed that individuals' perception of red tide risk was affected by subjects' demographic characteristics (e.g., male, female, age, and education categories). The findings showed that men were more concerned than women in this regard. The mentioned point proved the theory that women and men could have different levels of concerns over the same set of risks (Gustafson, 1998). However, the reasons for this issue were somewhat unclear, and the obtained findings would reflect that men had to protect their families at risk. Moreover, making such decisions on the part of men is affected by their role in the family context.

The coefficients of the age variables were negative, indicating that age levels increased as concerns of red tides decreased, which was not in accord with other research studies (Lind, 2002; Burningham *et al*., 2008; Huang *et al*., 2013). The mentioned finding can explain regional differences in individuals' perceptions of risk.

Residents and fishers, who had experienced human health effects of red tides, would be more likely to seek out information concerning red tides, particularly when such effects were severe. Residents of Bandar Abbas preferred to get more information via Internet or social networks and TV or radio. The data indicated that fishers of Bandar Abbas preferred to get more

information by colleagues or fishing cooperatives.

Social networks have both positive and negative effects on risk perception. Positive impacts include people easier access to information about red tides and easier share of their information and experiments. Moreover, social networks can change individuals' perceptions of risk and increase their knowledge about the causes and control methods of red tides. Moreover, the information provided by social networks can be used in individual decision-making.

Negative impacts include obtaining more false information, as a result of which individuals will be more concerned about the risk of eating seafood dishes or going to coast during a bloom. The resulting behaviors of such decisions could lead to significant economic losses in tourism, seafood industries, and fishermen's income.

According to a study conducted in 2009, local TV and radio were the main sources presenting news about red tide (HG, 2009). Negative media coverage of Persian Gulf red tide could increase the social amplification of risk. However, the control of government over social networks was less than television programs; hence, there was no guarantee that appropriate information was distributed by networks. The mentioned point increased "halo effect." Hence, local TV news had to disseminate the red tide information that is broadcasting over the internet and social networks so that there was less confusion and dilution of the key safety messages.

As fishers preferred to gain their information about red tide from their workplaces (fishers' cooperative) and colleagues, Fishers Organization could play a significant role in increasing their perception and decreasing their concerns about red tide risks.

This study explored Bandar Abbas public and fishers' perceptions of red tides occurring in the Persian Gulf annually. Perceptions of red tide risk management have become increasingly important as the public overreactions lead to halo effect, which is important for fishermen, local jobs, seafood producers, and recreation services. Moreover, perceptions in this regard are of great value to develop red tide management plans. Lack of managers' thorough understanding leads to failure of economic, social, and mitigation policies in this respect.

The present study presents several important findings that should be highlighted. First, fishers and residents exaggerated the risks of red tides such as seafood consumption, occurrence of red tides, and going to the coast during red tide occurrence. However, fishers were more concerned than residents due to nature of their jobs. In addition, red tides cause huge direct and indirect economic effects. However, there appears to be insufficient transfer of information regarding the safety of eating seafood and going to the coast during the red tide occurrence in the Persian Gulf. Many studies showed that improving access to education and providing better risk communications to increase sensitivity in this regard will reduce high-risk behaviors (Huang *et*

al., 2010; Marchwinska *et al*., 2012). Conducting more studies addressing residents and fisher's knowledge, with application of different education methods and types of information is required to improve seafood consumptions, add to individuals' red tide knowledge, and affect their risk perceptions.

Second, a number of studies should be devoted to examine how demographic factors and experiences of red tides affect risk perception. For instance, gender, age, and education are important factors that influence the red tide risk perceptions. Identification of the main categories is urgently needed to improve education and decrease halo effect. This study revealed that men and younger subjects were the main individuals affected by occurrence of red tides. Based on the mentioned findings, some recommendations can be provided to identify which factors influence the public' behaviors and risk perceptions of red tides. Furthermore, it is important to improve red tide management strategies.

Finally, the internet and social networking services are cited as the most widely used information sources by residents. Social networks provide a potential new way to have access to a large number of people sharing information about red tides and their human health experiences, which can be used in individual decision-making processes. However, such sources can be limited in their usefulness as there is no guarantee that useful information will be distributed. Hence, misleading information and rumor may be distributed which increase "halo effect." Moreover, it is clear that stronger efforts are needed to disseminate the information to fishermen and residents through short message service (SMS), TV and radio, internet webpage, toll-free number.

The researchers' recommendations are first to start an information release program and conduct more evaluations about preferred formats and sources for disseminating red tide messaging on a regular basis, as there are changes over time to both informational content and sources.

Additionally, in order to improve information release programs, more coordination is required among scientists, policy makers, and government agencies, as responsible agents for dissemination of red tide information.

Acknowledgements

The authors would like to thank all the volunteers who provided information to us. Moreover, we wish to thank Ebrahim Alizadeh from Hormozgan Fisheries Department, for his assistance in collecting the data.

References

Al-Gheilani, H.M., Matsuoka, K., AlKindi, A.Y., Amer, S. and Waring, C., 2011. Fish kill incidents and harmful algal blooms in Omani Waters. *Agricultural and Marine Sciences*, 16, 23-33.

Al-Shehhi, M.R., Gherboudj, I. and Ghedira, H., 2014. An overview of historical harmful algae blooms outbreaks in the Arabian Seas.

Marine Pollution Bulletin, 86, 314–324. DOI: org/10.1016/j.marpolbul

Bauman, A.G., Burt, J.A., Feary, D.A., Marquis, E. and Usseglio, P., 2010. Tropical harmful algal blooms: An emerging threat to coral reef communities. *Marine Pollution Bulletin*, 60(**11**), 2117–2122.

Boholm, A., 1998. Comparative studies of risk perception: a review of twenty years of research. *Journal of Risk Research,* 1(**2**), 135-163.

Burningham, K., Fielding, J. and Thrush, D., 2008. "It'll never happen to me": Understanding public awareness of local flood risk. *Disasters*, 32, 216–238.

Campbell, V., 2014. Framing environmental risks and natural disasters in factual entertainment television. *Environmental Communication,* 8(**1**), 58–74.

Cato, J.C., 1998. Seafood safety: Economics of hazard analysis and critical control point (HACCP) programs. Food and Agriculture Organization. pp. 51-54.

Cheng, Y.S., Villareal, T.A., Zhou, Y., Gao, J., Pierce, J.H. and Wetzel, D., 2005. Characterization of red tide aerosol on the Texas coast. *Harmful Algae*, 4(**1**), 87–95.

Coles, S.L., Looker, E. and Burt, J.A., 2015. Twenty-year changes in coral near Muscat, Oman estimated from manta board tow observations. *Marine Environmental Research,* 103, 66-73.

Coombs, W.T. and Holladay, S.J., 2006. Unpacking the halo effect: Reputation and crisis management. *Journal of Communication Management,* 10(**2**), 123–137.

Dorgham, M.M., 2013. Plankton research in the ROPME sea area, achievements and gaps. *International Journal of Environmental Research,* 7(**3**), 767–778.

Esmaeili, A.K., 2012. The direct economic damage assessment and short-term red tide on marine fishing in the provinces of Hormozgan and Bushehr. Iranian Fisheries Research Organization. Tehran. 87 P.

Fatemi, S.M.R., Nabavi, S.M.B., Vosoghi, G., Fallahi, M. and Mohammadi, M., 2012. The relation between environmental parameters of Hormuzgan coastline in Persian Gulf and occurrence of the first harmful algal bloom of *Cochlodinium polykrikoides* (Gymnodiniaceae). *Iranian Journal of Fisheries Sciences,* 11, 475–489.

Fisheries Statistical Yearbook, I.W., 2009. Fisheries Administration, council of agriculture, executive Tehran. 113 P.

Gherboudj, I. and Ghedira, H., 2014. Spatial temporal assessment of dust loading over the United Arab Emirates. *International Journal of Climatology,* 34(**12**), 3321-3335. DOI: 10.1002/joc.3909.

Grattan, L.M., Holobaugh, S. and Glenn Morris, J.G. Jr., **2016.** Harmful algal blooms and public health. *Harmful Algae,* 57(**B**), 2–8. DOI:10.1016/j.hal.2016.05.003.

Griffith, D., 1999. Exaggerating environmental health risk: The case of the toxic *Dinoflagellate pfiesteria*.

Human Organization, 58(**2**), 119–127.

Gustafson, P.E., 1998. Gender differences in risk perception: Theoretical and methodological perspectives. *Risk Analysis,* 18, 805–811 [PubMed: 9972583].

Hamzehei, S., Bidokhti, A.A., Mortazavi, M.S. and Gheiby, A., 2013. Red tide monitoring in the Persian Gulf and Gulf of Oman using MODIS sensor data. *Tech J Engin and App Sci,* 3(**12**), 1100-1107.

Heil, C.A., Glibert, P.M., Al-Sarawl, M.A., Faraj, M., Behbehani, M. and Husain, M., 2001. First record of a fish-killing *Gymnodinium* sp bloom in Kuwait Bay, Arabian Sea: Chronology and potential causes. *Mar. Ecol. Prog. Ser,* 214, 15–23.

Hormozgun Fisheries Organization (HFO)., 2010. Red tide in Hormozgun province during 2008-2009. Annual report of Report of HFO on the Persian Gulf and the Oman Sea. Bandar Abbas, IRAN. 200 P (written in Persian).

Hormozgun Governor (HG)., 2009. Harmful algal blooms in Hormozgun coastal waters. Hormozgun Governor., Bandar Abbas. IRAN, 170 P (written in Persian).

Huang, L., Sun, K., Ban, J. and Bi, J., 2010. Public perception of blue-algae bloom risk in Hongze Lake of China. *Environ Manage,* 45, 1065–1075. DOI: 10.1007/s00267-010-9480-8.

Huang, L., Han, Y., Zhou, Y., Gutscher, H. and Bi, J., 2013. How do the Chinese perceive ecological risk in freshwater lakes? *PLoS ONE,* 8(**5**), e62486. DOI:10.1371/journal.pone.0062486.

Hunter, H.N., Czajkowski, M., Mearns, K., Tyler, A.N., Carvalho, L. and Codd, G.A., 2012. The effect of risk perception on public preferences and willingness to pay for reductions in the health risks posed by toxic cyanobacterial blooms. *Science of the Total Environment,* 1(**426**), 32-44. DOI: 10.1016/j. scitotenv.

Jaaskela, J.P. and Kulish , M., 2010. The butterfly effect of small open economies. *Journal of Economic Dynamics and Control*, 34(**7**), 1295–1304.

Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X. and Ratick, S., 1988. The social amplification of risk: A conceptual framework. *Risk Analysis,* 8(**2**), 177–187.

Kempton, W. and Falk, J., 2000. Cultural models of *Pfiesteria*: toward cultivating more appropriate risk Perceptions. *Coastal Management,* 28, 273–85.

Kuhar, S.E., Nierenberg, K., Kirkpatrick, B. and Tobin, G.A., 2009. Public perceptions of Florida red tide risks. *Risk Anal,* 29, 963–969.

Lind, N., 2002. Social and economic criteria of acceptable risk. *Reliability Engineering and System Safety,* 78, 21–25.

Marcella, M.P. and Eltahir, E.A., 2008. The hydroclimatology of Kuwait: Explaining the variability of rainfall at seasonal and inter annual

time scales. *Journal of Hydrometeorology*, 9(**5**), 1095-1105.

Marchwinska-Wyrwal, E., Teaf. C.M., Dziubanek, G. and Hajok. I., 2012. Risk assessment and risk communication in environmental health in Poland. *European Journal of Public Health*, 22, 742–744.

Marcon, A., Nguyen, G., Rava, M., Braggion, M., Grassi, M. and Zanolin, M.E., 2015. A score for measuring health risk perception in environmental surveys. *Science of the Total Environment*, 527–528, 270-278.

Matsuoka, K., Takano, Y., Kamrani, E., Rezai, H., Sajeevan, T.P. and Al Gheilani, H.M., 2010. Study on *Cochlodinium polykrikoides Margalef (Gymnodiniales* Dinophyceae*)* occurring in the Oman Sea and the Persian Gulf from August of 2008 to August of 2009. *Current Development in Oceanography*, 1(**3**), 153–171.

Morgan, K.L., Larkin, S.L. and Adams, C.M., 2011. Empirical analysis of media versus environmental impacts on park attendance. *Tourism Management*, 32, 852–859.

Nezlin, N.P., Polikarpov, I.G., Al-Yamani, F.Y., Rao, D.V.S. and Ignatov, A.M., 2010. Satellite monitoring of climatic factors regulating phytoplankton variability in the Arabian (Persian) Gulf. *Journal of Marine Systems*, 82, 47–60.

Nisbett, R.E. and Wilson, T.D., 1977. The halo effect: Evidence for unconscious alteration of judgments. *Journal of Personality and Social Psychology*, 35(**4**), 250.

Pierce, R.H., Henry, M.S., Blum, P.C., Lyons, J., Cheng, Y. and Yazzie., 2003. Brevetoxin concentrations in marine aerosol: Human exposure levels during a *K. brevis* harmful algal bloom. *Bulletin of Environmental Contamination and Toxicology*, 70(**1**), 161–165.

Raaijmakers, R., Krywkow, J.R. and Veen, V.D., 2008. Flood risk perceptions and spatial multi-criteria analysis: An exploratory research for hazard mitigation. *Natural Hazards*, 46, 307–322.

Richlen, M.L., Morton, S.L., Jamali, E.A., Rajan, A. and Anderson, D.M., 2010. The catastrophic 2008–2009 red tide in the Arabian gulf region with observations on the identification and phylogeny of the fish-killing dinoflagellate *Cochlodinium polykrikoides*. *Harmful Algae*, 9, 163–172. DOI:10.1016/j.hal.2009.08.013.

Roberts, S. M., Grattan, L.M.,Toben, A. C., Ausherman. C., Trainer, V., Tracy, K. and Glenn Morris, J.G. Jr., 2016. Perception of risk for Domoic Acid related health problems: A Cross-cultural study. *Harmful Algae*, 57(**B**), 39–44. DOI:10.1016/j.hal.2016.03.007.

Roncalli, V., Turner, J.T., Kulis, D., Anderson, D.M. and Lenz, P.H., 2016. The effect of the toxic dinoflagellate *Alexandrium fundyense* on the fitness of the calanoid copepod Calanus finmarchicus. *Harmful Algae*, 51, 56–66.

Saeedi, H., Kamrani, E. and Matsuoka, K., 2011. Catastrophic impact of red tides of *Cochlodinium polykrikoides* on the Razor Clam Solen dactylus in Coastal Waters of the Northern Persian Gulf. *Journal of the Persian Gulf*, 2, 13–20.

Sengco, M.R., Hagström, J.A., Granéli, E. and Anderson, D.M., 2005. Removal of *Prymnesium parvum* (Haptophyceae) and its toxins using clay minerals. *Harmful Algae*, 4, 261–274.

Sheppard, C.R.C., Price, A.R.G. and Roberts, C.M., 1992. Marine ecology of the Arabian region: Patterns and processes in extreme tropical environments. Academic Press, London. 336 P.

Slimak, M.W. and Dietz, T., 2006. Personal values, beliefs, and ecological risk perception. *Risk Analysis*, 26, 1689–1705.

Thangaraja, M., Al-Aisry, A. and Al-Kharusi, L., 2007. Harmful algal blooms and their impacts in the middle and outer ROPME sea area. *International Journal of Oceans and Oceanography*, 2, 85–98.

Trenouth, A.L. and Campbell, M.L., 2013. Perceptions of ecological risk associated with introduced marine species in marine protected areas. *Management of Biological Invasions*, 4(**1**), 7–24. DOI: 10.3391/mbi.2013.4.1.03

Tyler, A.N., Hunter, P.D., Carvalho, L., Codd, G.A., Elliott, J.A., Ferguson, C.A., Hanley, N.D., Hopkins, D.W., Maberly, S.C., Mearns, K.J. and Scott. E.M., 2009. Strategies for monitoring and managing mass populations of toxic cyanobacteria in recreational waters: A multi-interdisciplinary approach. *Environmental Health*, 8(**1**), 1-11. DOI: 10.1186/1476-069X-8-S1-S11.

Wessells, C.R., Miller, C.J. and Brooks, P.M., 1995. Toxic algae contamination and demand for shellfish: A case study of demand for mussels in Montreal. *Marine Resource Economics*, 10(**2**), 143–159.

Whitehead, J.C., Haab, T.C. and Parsons, G.R., 2003. Economic effects of *Pfiesteria*. *Ocean and Coastal Management*, 46, 845–858.

Wildavsky, A. and Dake, K., 1990. Theories of risk perception: Who fears what and why? *Daedalus*, 119(**4**), 41- 60.

Zhao, J. and Ghedira, H., 2014. Monitoring red tide with satellite imagery and numerical models: A case study in the Arabian Gulf. *Marine Pollution Bulletin*, 79, 305–313. DOI: 10.1016/j.marpolbul.2013.10.057

Zhao, J., Temimi, M. and Ghedira, H., 2015. Characterization of harmful algal blooms (HABs) in the Arabian Gulf and the Sea of Oman using MERIS fluorescence data. *ISPRS Journal of Photogrammetry and Remote Sensing*, 101, 125–136.