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Risk Perception of Coastal Communities and Authorities on Harmful Algal Blooms in Ecuador

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The ocean is intrinsically linked to human health as it provides food and wellbeing, yet shifts in its dynamics can pose climate-ecological risks, such as harmful algal blooms (HABs) that can impact the health and economy of coastal communities. For decades, Ecuadorian coastal communities have witnessed seasonal algal blooms, events that are driven by factors including complex ocean–climate interactions, nutrient availability, and ecological variables. However, little is known about the risk perceived by coastal populations regarding such events. Understanding how specific groups of people in specific places perceive HABs risks is critical for communicating, promoting, and regulating public health measures. This study assessed the knowledge, attitudes, and practices of fishermen, restaurant owners, and coastal authorities in relation to HABs, or 'red tide' events, in coastal Ecuador. Methods utilized in this study include a non-probabilistic sampling approach for the two studied populations: coastal communities comprised of fishermen and restaurant owners (N_1 = 181), and authorities comprised of coastal officials in the sectors of health, and environment and risk management (N_2 = 20). Using contingency tables, chi-square test, Cramer's V correlation statistic, and multiple correspondence analysis, this study compared the responses of these two groups, coastal communities and authorities, to determine whether principal activity, or livelihood, affected risk perception in each group. This project implemented four workshops to interact with coastal stakeholders and more deeply understand risk perception within studied populations. Results demonstrated that principal activity indeed influenced risk perception of red tides, and that fishermen, restaurant owners, and health authorities had limited knowledge and low risk perception of red tide impacts on human health. Recommendations produced from this research include tailored workshops and improved communication between authorities and coastal communities to enhance algal bloom monitoring and coastal management during future red tide events.

Keywords: coastal authorities, fishermen, human health, knowledge, attitudes and practices (KAP), red tides

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INTRODUCTION

The ocean is intrinsically linked to human health by providing food and wellbeing, but can also pose climate-ecological risks such as harmful algal blooms (HABs), which are considered natural events that can flourish in response to warm sea surface temperatures, thermocline shoaling, coastal upwelling, and other factors not yet well understood (Moore et al., 2008; Fleming et al., 2014; McCabe et al., 2016). However, climate variability such as El Niño-Southern Oscillation (ENSO), along with climate change and the expansion of nutrient enrichment, increase the frequency of algal blooms with toxins that impact the livelihood and health of coastal communities (Backer and McGillicuddy, 2006; Heisler et al., 2008; Moore et al., 2008; Hallegraeff, 2010; Fleming et al., 2014; Glibert et al., 2014). This was evidenced by the anomalously warmer conditions in the eastern Pacific Ocean in 2015–2016, from Alaska to Chile (McCabe et al., 2016; National Oceanic and Atmospheric Administration [NOAA], 2016; Guzman et al., 2017). During the so-called 'Blob,' Pseudo-nitzschia blooms off the shores of Washington, Oregon, and California reached record-breaking production of the toxin domoic acid, and prompted coastal managers to close beaches, discard thousands of clams, and apply communication strategies to prevent human health impacts (McCabe et al., 2016). During this era, the coast of southern Chile experienced anomalous climate-ocean conditions that triggered harmful flagellate blooms, causing massive deaths of salmon from aquaculture farms and raising public health concerns (Clément et al., 2017).

Harmful algal blooms have been recognized as global threats to human health, requiring international cooperation, interdisciplinary approaches, and local-context strategies for effective management (Moore et al., 2008; Bauer et al., 2010; Fleming et al., 2014). Previous social research on HABs have recognized the importance of risk perception approaches in shifting the way the public thinks and behaves during HAB events. Risk perception is a complex process by which individuals acquire and interpret information and knowledge through the contexts of lived experiences, personality, and culture (Slovic, 1987, 2000; Boholm, 1998; Finkel, 2008; Brisson et al., 2017). Thus, understanding how specific groups of people, in specific places, perceive HAB risks is critical for communicating, promoting, and regulating public health measures. HAB studies conducted in Florida applied a broader framing and theoretical framework that included risk perception, social amplification of risk, and place-specific context, and developed strategies for HAB risk communication, planning, and outreach to the general public (Kuhar et al., 2009; Nierenberg et al., 2010; Kirkpatrick et al., 2014). In Washington State, a cross-cultural study analyzed the health risk perception of domoic acid ingestion through razor clam consumption within groups of coastal Native American nations and recreational razor clam harvesters. An ethnographic study on Quebec, Canada, applied a risk perception approach to gain a better understanding of the attitudes of citizens toward cyanobacteria and public health measures (Brisson et al., 2017). These studies have demonstrated that it is critical to incorporate the knowledge, awareness, and actions of coastal communities into response practices to prevent negative economic, ecological, and human health impacts (Nierenberg et al., 2010; Kirkpatrick et al., 2014; Taylor et al., 2014). In this research, we applied the knowledge, attitude, and practices (KAP) framework in the context of red tide risk perception to gauge this information within groups of coastal communities. This research framework is widely used to study human behavioral changes in response to a problem or disease (World Health Organization [WHO], 2008; Wan, 2014; Rav-Marathe et al., 2016), and we leveraged KAP surveys to understand place-based information that can contribute to local HAB policy formation.

Within the eco-toxicological realm of HABs, prior studies have identified five syndromes linked to these events, including ciguatera poisoning, paralytic shellfish poisoning (PSP), neurotoxic shellfish poisoning (NSP), amnesic shellfish poisoning (ASP), and diarrheic shellfish poisoning (DSP) (García et al., 2005; Grattan et al., 2016). There is evidence that those who come into contact with toxic algae may experience skin irritation, gastroenteritis, respiratory problems, and even liver failure (Rose et al., 2001; Fleming et al., 2002; Kuhar et al., 2009). At this time, no routine clinical tests exist to identify these symptoms, and there are no known antidotes for these illnesses (Grattan et al., 2016). Thus, it is extremely difficult to ascertain the effects, duration, and remedies to HAB-related syndromes.

Along coastal Ecuador, communities have witnessed 'red tides' for decades (Torres, 2013, 2015, 2017). However, there is little awareness on the links between HABs and the potential production of toxins in the algae and accumulation in shellfish. Ecuadorian researchers have recorded around 150 red tide events from 1968 to 2015, resulting in 30 reported mortalities of fish, shrimp, and shrimp larvae. The most notable red tides occurred in 1985, 2003, and 2007, with seasonal peaks in March, April, and May. The Gulf of Guayaquil was recorded to have the greatest number of events within the existing Ecuadorian red tides records. Out of 71 species identified during the red tides events, 33 were potentially toxic. Within this group, 23 dinoflagellates potentially toxic included: *Gymnodinium* sp., *Margalefidinium catenatum* (Okamura, 1916) F. Gómez, Richlen and D. M. Anderson, 2017, *Cochlodinium* sp., *Prorocentrum maximum* (Gourret) Schiller, 1937, *Prorocentrum micans* Ehrenberg, 1834, *Tripos furca* (Ehrenberg) F. Gómez, 2013, *Scrippsiella trochoidea* (Stein) Loeblich III, 1976, *Prorocentrum cordatum* (Ostenfeld) J. D. Dodge, 1975, *Karenia brevis* (C. C. Davis) Gert Hansen and Ø. Moestrup, 2000, *Dinophysis caudata* Saville-Kent, 1881, three diatom pennate including *Pseudo-nitzschia* sp., *Pseudo-nitzschia pungens* (Grunow ex Cleve) G. R. Hasle, 1993, *Pseudo-nitzschia delicatissima* (Cleve) Heiden, 1928, four Cyanobacterias that are *Trichodesmium erythraeum* Ehrenberg ex Gomont, 1892, *Raphidiopsis curvata, Nodularia* sp., *Oscillatoria limnetica* var. *acicularis* Nygaard, 1950. Others groups registered were *Prymnesiophyte, Raphidophyte,* and *Haptophyta* that are *Phaeocystis* sp., *Chattonella subsalsa* B. Biecheler, 1936, *Cocolitus* sp. (Jiménez, 1989, 1993, 1996; Torres and Palacios, 2007; Torres, 2013; Torres, 2017, unpublished data; WoRMS Editorial Board, 2018).

Several of the aforementioned algal species have been proven to negatively impact human health, including *Pseudo-nitzschia*, which has been associated with ASP, *Gymnodinium*, which is associated with PSP, *Dynophisis*, associated with DSP, and recently *Ostreopsis* cf. *ovata,* associated with the production of a palytoxin-like condition (Torres, 2013, 2015, 2017; Carnicer et al., 2016). Despite the relevance to public health concerns, there are no established monitoring programs of HABs that assess the toxicity of lipophilic shellfish in Ecuador. There is limited local knowledge on HABs and their impacts on the health and livelihood of coastal communities, which contributes to the lack of monitoring, surveillance, and awareness strategies for HAB responses in this region (Torres, 2013, 2017).

This study utilizes the KAP behavioral framework to understand the underlying mechanisms that inform HAB health educational interventions, risk communication, and management. Global research has identified the importance of a broader social framework to manage HABs risk, and this research seeks to understand risk perception among coastal communities (fishermen, restaurant owners, and authorities in the health, environmental, and risk sectors), as a part of a larger study on the ocean climate drivers of HABs, on the coast of Ecuador. In addition, this study developed a stakeholder engagement process to discuss responses and communication strategies to raise awareness and inform future HAB events. Results from this study can provide insight into the current perceived risks of HABs by key stakeholder groups, and help to define strategies and policies to manage HABs in the coastal zone of Ecuador.

MATERIALS AND METHODS

Study Area

The study area comprises part the coastal zone of the Gulf of Guayaquil including four cities: Posorja and Playas in the Guayas province, and La Libertad and Santa Elena in the Santa Elena province (**Figure 1**). These cities range from about 18,000 and 24,000 in Posorja and Playas, respectively, to 96,000 in La Libertad and 144,000 inhabitants in Santa Elena (Independent National Electoral Commission [INEC], 2010a,b; Ricaurte-Quijano, 2013). The main economic activities of these cities include artisanal fisheries in Posorja, and tourism and commerce in Playas, Santa Elena, and La Libertad. These economic activities, which involve tourism, fisheries, and shrimp farming, and these peak in the rainy season from December to April (Hernández and Zambrano, 2007). Seafood cuisine such as clams, shellfish, crabs, and fish are an economic staple in these provinces, and are heavily consumed by tourists and locals.

Design Sampling and Interviews

To understand the underlying mechanisms of HAB risk perception on the coast of Ecuador, we employed a knowledge, attitudes, and practices (KAP) framework to this study (See **Supplementary Materials**). To do this, we created semi-structured surveys that explored the knowledge (K) of HABs, the attitudes (A) toward the occurrence of HABs, and the practices (P) or preventive behavior conducted in efforts to minimize potential health risks of HABs (World Health Organization [WHO], 2008; Kirkpatrick et al., 2014). The objective of the KAP survey was to identify knowledge levels and actions of different stakeholders during HAB events. The target population included fishermen, restaurant owners, and coastal authorities in the cities of Playas, Posorja, Santa Elena, and La Libertad in Ecuador.

Surveys were applied using a non-probabilistic sampling approach for two groups of stakeholders: (1) fishermen ($n = 120$) and restaurant owners ($n = 61$, total $N_1 = 181$), and (2) coastal authorities in the sectors of health ($n = 8$), environment and risk management ($n = 12$, total $N_2 = 20$) during the first 6 months of 2016. Most members of the authorities were heads of departments in health, environment, risk management, and marine protected areas. From this point forward, this group will be referred to as 'authorities.' The coastal community group was comprised of restaurant owners and fishermen, who were part of local associations in each respective study site.

The involvement process with the stakeholders included formal letters and introductory meetings to explain the objectives, methodology, and scope of the project by the researchers. Regional and local government offices, as well leaders of fishermen and restaurant associations were contacted in advance with that purpose in each locality. Surveys and interviews between researchers and the studied populations were conducted in-person for approximately 30 min each. Surveys included 23 questions that were divided into several sections: (1) demography and background information; (2) knowledge, attitudes, and practices related to red tides for each group; (3) climate perception related to red tides, and (4) health perception related to red tides. The term 'red tide' was used to signify an indicator of potential HABs. Most of the questions were closed answers of nominal, single scale, or selection by Likert scale. This scale is a five-point bipolar response range from a group of categories, asking people to indicate how much they agree or disagree, or believe to be true or false (Likert, 1932; Jamieson, 2004). The surveys were based on previous risk perception studies applied in Florida, and were tested with a small sample group of coastal public officers (Moore et al., 2008; Nierenberg et al., 2010; Kirkpatrick et al., 2014). A limitation of this study is the inclusion of coastal authorities, fishermen, and restaurant owners, and the exclusion of hotel managers, tourists, and other residents, in our surveys. A possible bias toward public interviewees vs. institutional agents need to be considered in the interpretation of the results.

Statistical Analyses

This study utilized contingency tables, Pearson's chi-square tests, and multiple correspondence analysis (MCA). The contingency tables were applied to explore if there was a significant relationship between the activity of the group (authorities, fishermen and restaurant owners) and subgroups (environmental and risk managers, health staff) and responses regarding their knowledge, attitudes, and practices to red tide events. The Cramer's V statistic was used to corroborate the independence or dependence of the two variables analyzed in each contingency table. This statistic is a measure of association, or correlation, between two categorical or nominal variables. The result is a score between 0 and 1, with 0 indicating no correlation and 1

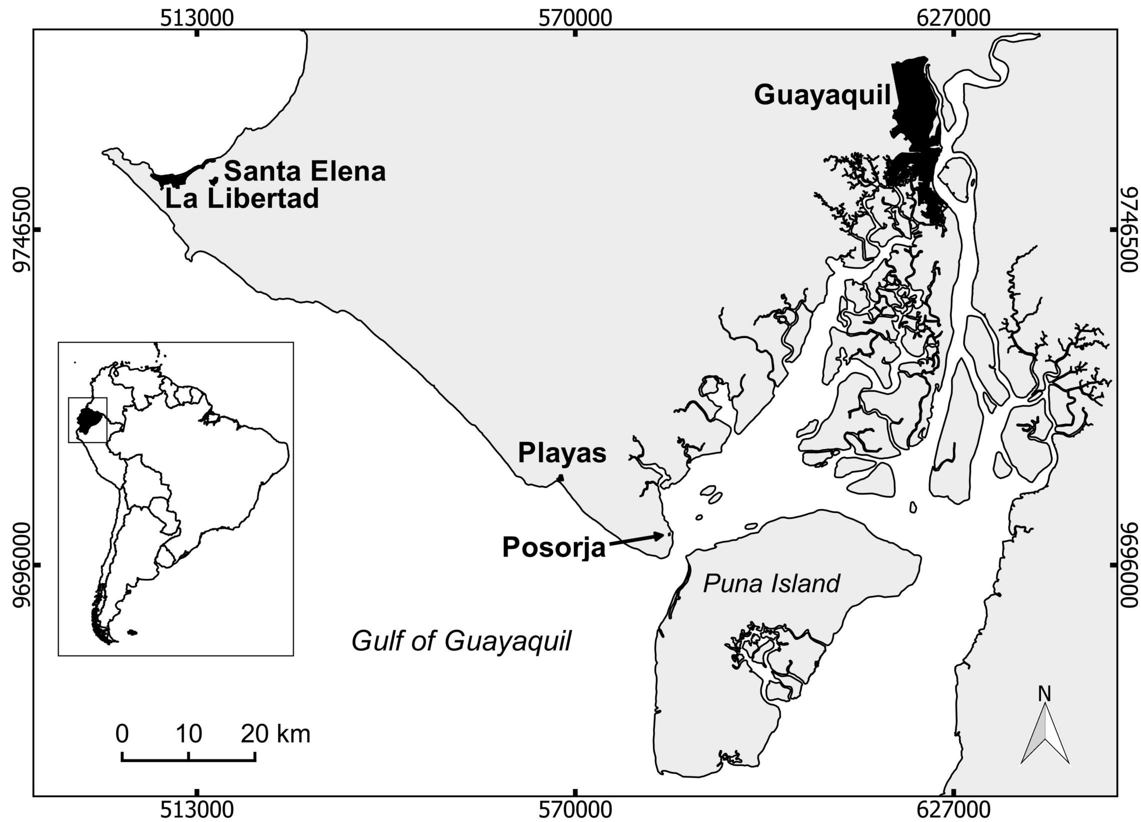

FIGURE 1 | Map of the study area including interview locations of Santa Elena, La Libertad, Playas, and Posorja in Ecuador.

indicating perfect correlation (Hope, 1968; Husson et al., 2011; Navarro, 2014). The null hypothesis of this study is that survey responses from both groups are independent of their respective principal activities or occupations. A MCA was used to determine the associations between the responses to the KAP surveys by the activity group, level of education, and if they considered themselves to be affected by red tides. Statistical software (R Program) was used for all statistical analyses.

Workshops for Coastal Stakeholders and Health Practitioners: Feedback, Communication, and Outreach

After the completion of interviews and surveys regarding red tides, a series of workshops were developed in the study sites to present the results and educate communities about drivers of potential HABs, related marine toxins, and specific climatic and oceanic events that occurred within local coastal areas. A total of four workshops were given: two workshops for fishermen and restaurant owners, and two for coastal managers regarding the environment, disaster risk reduction, and public health. In addition to presentations in the fields of biology, biomedicine, and oceanography, a discussion session was developed to learn about experiences and local knowledge of red tides within different stakeholder groups. Excerpts and experiences of several stakeholders are presented in this study.

RESULTS

Demography and Background

In the authorities, 12 (60%) were from health offices, and 8 (40%) were from environmental and risk management agencies. Within the coastal communities group, 120 (66%) respondents were fishermen, whereas 61 (34%) were restaurant owners. Fishermen and restaurant owners were older than authorities by an average of 10–15 years, and many members of this group had been living in the community for about 15 years longer than members of the authorities (**Table 1**). Most of the fishermen and restaurant owners had received some education, with a majority finishing elementary (52%) or high school (29%). All authorities had received post-secondary degree (100%). Men greatly outnumbered women in the fishermen and restaurant owner group at nearly 80%, while women comprised the majority of the authorities at 55%.

Knowledge, Attitudes, and Practices of Ecuadorian Red Tide

Knowledge varied greatly between the two groups (fishermen and restaurant owners, and authorities, $p < 0.001$) (**Table 2**). The authorities had greater knowledge of the causes of red tides (70% had an awareness of red tides on nearby beaches, and 100% had heard or seen of them), while approximately half

TABLE 1 | Demography and background information.

Demography and background	Fishermen and restaurant owners $n = 181$, n (%)	Authorities $n = 20$, n (%)
1. Age		
15–29	16 (8.84)	1 (5)
30–44	63 (34.81)	11 (55)
45–59	74 (40.88)	7 (35)
60–74	23 (12.71)	1 (5)
75–78	4 (2.1)	0 (0)
No response	1 (0.55)	0 (0)
2. Gender		
Female	37 (20.44)	11 (55)
Male	143 (79.01)	9 (45)
No response	1 (0.55)	0 (0)
3. Education level		
Primary school	94 (51.93)	0 (0)
High school	53 (29.28)	0 (0)
Post-secondary	9 (4.97)	20 (100)
No education	11 (6.08)	0 (0)
No response	14 (7.73)	0 (0)
4. Residence time		
0–14	18 (9.94)	7 (35)
15–29	40 (22.10)	5 (25)
30–44	48 (26.52)	4 (20)
45–59	39 (21.55)	3 (15)
60–74	15 (8.29)	1 (5)
75–78	2 (1.10)	0 (0)
No response	19 (10.50)	0 (0)

Question 4 demonstrates that the amount of time an interviewee had lived in the community was dependent on principal activity (p-value < 0.05). Cramer's V = 0.337 suggests moderate correlation.

(49%) of fishermen and restaurant owners had seen or heard of them, and roughly half (46%) had not. Finally, most authorities believed red tides do not occur frequently in coastal Ecuador (60%), while most fishermen and restaurant owners did not know (61%).

Attitudes pertaining to red tides within coastal Ecuador also varied between the two groups (**Table 2**). Regarding the option to avoid the beach if algae were present on the shore, the biggest response within the authorities was 'Strongly Agree' (35%), while the majority of fishermen and restaurant owners strongly disagreed with this response (55%). Additionally, when asked about avoiding the beach due to dead fish on the shore, the largest response from the authorities was 'Strongly Agree' (40%), while half of fishermen and restaurant owners strongly disagreed with this statement (50%).

There was a large difference in red tide practices between the two groups (**Table 2**). When asked if respondents would avoid eating seafood or fish in the event of a red tide, authorities were evenly divided (50% yes, 50% no), while the largest response within the fishermen and restaurant owner group was 'I don't know' (39%).

Subgroup Analyses: Fishermen vs. Restaurant Owners and Health vs. Environmental-Risk Management

Results show that the risk and environment subgroup was well informed about the causes of red tides (92% attributed these events to climate change and nutrients), while the majority of health authorities did not know the causes (63%) (**Table 3**). Attitudes also differed greatly, as the majority of risk and environment officials responded that they would avoid eating seafood or fish if there were red tides (67%), while the majority of health officials would not (75%). Both subgroups had similar responses in managing red tides, both had the largest responses in avoiding the beach when there are red tides. However, a greater percentage of risk and environment officials felt they had been affected by red tides (42% o) versus just 13% of health officials.

Figure 2 describe the responses of different groups (fisherman = F, restaurant owners = Ro, environment and risk authorities = E, and health officers = H) to the questions: what are the causes of HABs, how they perceived to be affected by HABs, and if they think they have been poisoned by seafood contaminated with toxins. Regarding the causes of red tides, environment and risk authorities were very knowledgeable about the drivers of HABs. They identified climate change as the first cause, followed by nutrients, while health officers (60%), restaurant owners (50%), and fishermen (90%) have a poor knowledge about the causes of HABs. When asked if they had been affected by the red tides, most health officials said no (85%), followed by the environment officers (65%), risk authorities (60%), and fishermen (50%). These results suggest low risk perception of HABs. Regarding if the groups think if they have been poisoned by seafood contaminated with toxins restaurant owners (75%) and fishermen (70%) believed they do not have been poisoned.

Women and men from both groups (fishermen and restaurant owners, and authorities) performed similarly in risk perception responses (**Table 3**). Women and men from the authorities had substantial knowledge of the possible causes of red tides (64% of women and 77% of men attributed it to climate change and nutrients), whereas the majority of women and men from the fishermen and restaurant owners group did not know potential causes (89% of women and 78% of men). Also, the majority of men and women in both groups felt they had not been affected by red tides (89% of women and 74% of men in the restaurant owners and fishermen group, and 73% of women and 67% of men from the authorities).

Climate and Human Health

When stakeholders were asked if climate had changed over the years, most of the respondents agreed that the climate is changing, including all of the authorities (100%) and most of the fishermen and restaurant owners (89%). When asked specifically about changes in temperature and precipitation, 59% of fishermen and restaurant owners and 60% of authorities perceived that these climate variables have changed (**Table 4**).

Health knowledge within the two groups was very similar; the majority of both groups believed that shellfish consumption

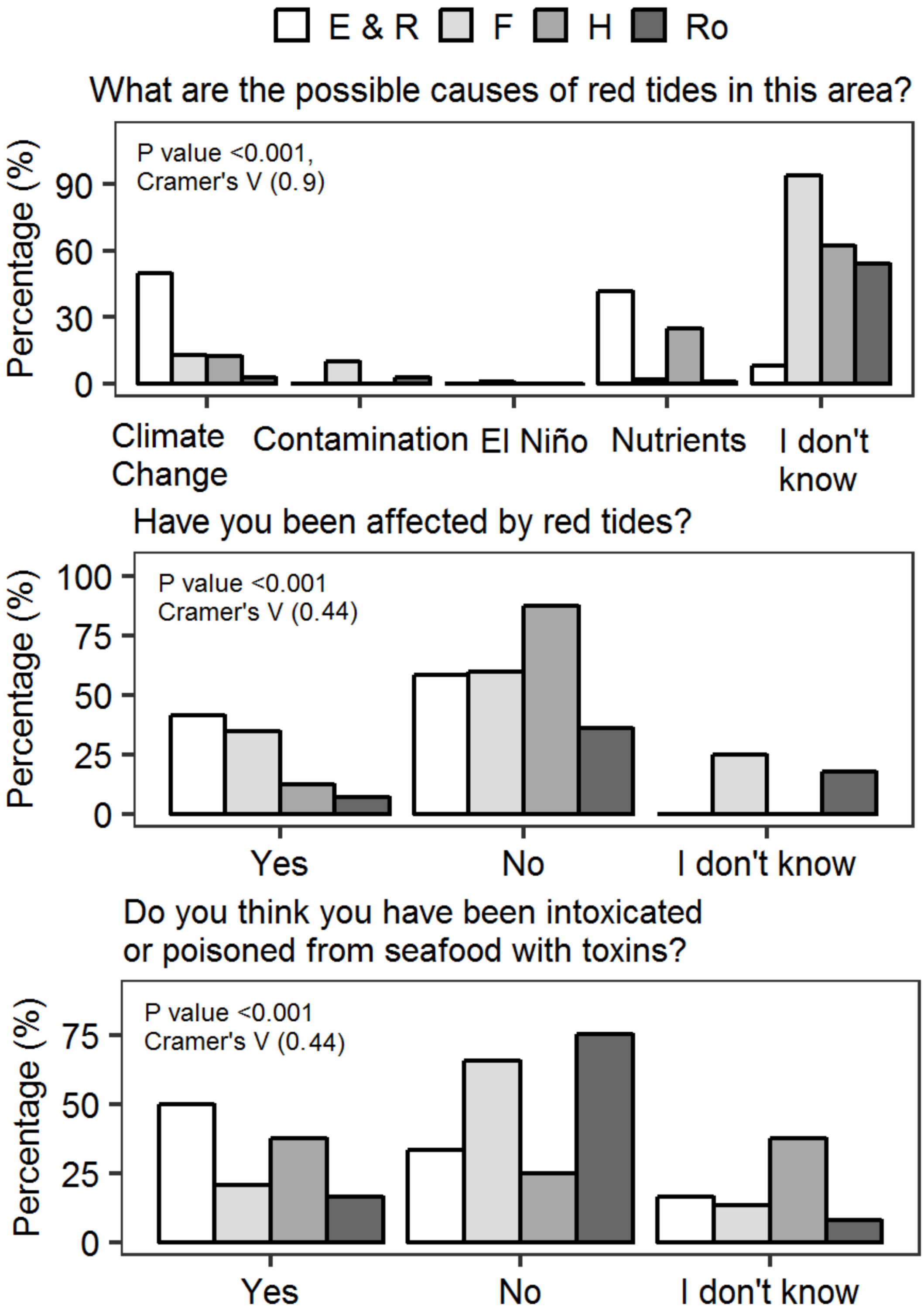

FIGURE 2 | Describes the response to tree questions as a function of group activity: fisherman (F), Ro (restaurant owners), environment and risk authorities (E), and health officers (H). Questions are related to causes of HABs, if they perceived to be affected by HABs, and if they think they have been poisoned by seafood contaminated with toxins.

TABLE 2 | Knowledge, attitudes and practices in fishermen and restaurant owners and authorities.

Knowledge	**Fishermen and restaurant owners *n* = 181, *n* (%)**	**Authorities *n* = 20, *n* (%)**	***p*-Value**	**Cramer's V correlation**
5. Have you seen or heard of red tides on this beach?				
Yes	88 (48.62)	20 (100)		
No	83 (45.86)	0 (0)	<0.001	0.581
I don't know	10 (5.52)	0 (0)		
6. What are the possible causes of red tides in this area?				
Climate change	16 (8.84)	7 (35)		
Contamination	13 (7.18)	0 (0)		
El Niño	1 (0.55)	0 (0)	<0.001	0.608
Nutrients	3 (1.66)	7 (35)		
I don't know	148 (81.77)	6 (30)		
7. Do red tides occur naturally?				
Yes	52 (28.73)	17 (85)		
No	29 (16.02)	1 (5)	<0.001	0.563
I don't know	100 (55.25)	2 (10)		
8. Do red tides occur frequently?				
Yes	14 (7.73)	8 (40)		
No	56 (30.94)	12 (60)	<0.001	0.674
I don't know	111 (61.33)	0 (0)		
Attitudes	**Fishermen and restaurant owners *n* = 181, *n* (%)**	**Authorities *n* = 20, *n* (%)**	***p*-Value**	**Cramer's V correlation**
9. I avoid the beach because of the presence of algae on the shore.				
Strongly disagree	99 (54.70)	6 (30)		
Disagree	4 (2.21)	3 (15)		
Neither agree nor disagree	8 (4.42)	2 (10)	<0.001	0.341
Agree	6 (3.31)	2 (10)		
Strongly agree	54 (29.83)	7 (35)		
I don't know	10 (5.52)	0 (0)		
10. I avoid the beach because of the dead fish on the shore.				
Strongly disagree	91 (50.28)	5 (25)		
Disagree	2 (1.10)	3 (15)		
Neither agree nor disagree	14 (7.73)	3 (15)	<0.001	0.359
Agree	4 (2.21)	1 (5)		
Strongly agree	59 (32.60)	8 (40)		
I don't know	11 (6.08)	0 (0)		
Practices	**Fishermen and restaurant owners *n* = 181, *n* (%)**	**Authorities *n* = 20, *n* (%)**	***p*-Value**	**Cramer's V correlation**
11. Would you avoid eating seafood or fish if there are red tides?				
Yes	62 (34.25)	10 (50)		
No	49 (27.07)	10 (50)	<0.001	0.483
I don't know	70 (38.67)	0 (0)		

An assessment of KAP within the study groups shows that all answers were dependent upon principal activity (p-value < 0.05). The null hypothesis (H0: X1 and X2 are independents) of this study is that survey responses from the stakeholders (X1), are independent of their respective principal activities (X2), this was rejected. Responses in the Knowledge and Practices sections had relatively strong correlations (Cramer's V = 0.483 – 0.674), whereas the Attitudes section had more moderate correlations (Cramer's V = 0.341–0.359).

can cause intoxication or illness (87% of restaurant owners and fishermen and 80% of authorities) (**Table 4**). However, the majority of restaurant owners and fishermen did not believe they had experienced seafood poisoning (69%), whereas the largest response group for authorities believed they had (45%). This question was oriented in general to respondents' experiences of seafood-related illnesses, and was not necessarily associated with consumption of seafood during red tides events.

Using a graphical representation of a MCA, we identified the correspondence between economic activity and level of education, for two main questions: "What are the causes of red tides?" and "Have you been affected by the red tides?" The **Figure 3** shows that fishermen are highly associated with the

TABLE 3 | Subgroup analysis of authorities in risk and environment and health.

Authorities	Risk and environment *n* = 12, *n* (%)	Health *n* = 8, *n* (%)	*p*-Value	Cramer's V correlation
12. What are the possible causes of red tides in this area?				
Climate change	6 (50)	1 (12.5)		
Nutrients	5 (41.67)	2 (25)	<0.001	0.576
I don't know	1 (8.33)	5 (62.5)		
13. Would you avoid eating seafood or fish if there are red tides?				
Yes	8 (66.67)	2 (25)		
No	4 (33.33)	6 (75)	<0.001	0.413
14. Options for managing red tides: When there is a red tide, I do not. . .				
Go to the beach	6 (50)	3 (37.5)		
Fish	0 (0)	1 (12.5)		
Eat seafood	0 (0)	1 (12.5)		
All of the above	4 (33.33)	2 (25)	<0.001	0.512
Fish or eat seafood	2 (16.67)	0 (0)		
I don't know	0 (0)	1 (12.5)		
15. Have you been affected by red tides?				
Yes	5 (41.67)	1 (12.5)		
No	7 (58.33)	7 (87.5)	<0.001	0.321
Gender: Women	**Fishermen and restaurant owners *n* = 37, *n* (%)**	**Authorities *n* = 11, *n* (%)**	***p*-Value**	**Cramer's V correlation**
16. What are the possible causes of red tides in this area?				
Climate change	2 (5.41)	4 (36.36)		
Nutrients	2 (5.41)	3 (27.27)	<0.001	0.539
I don't know	33 (89.19)	4 (36.36)		
17. Have you been affected by red tides?				
Yes	4 (10.81)	3 (27.27)		
No	33 (89.19)	8 (72.73)	0.003	0.198
Gender: Men	**Fishermen and restaurant owners *n* = 144, *n* (%)**	**Authorities *n* = 9, *n* (%)**	***p*-Value**	**Cramer's V correlation**
18. What are the possible causes of red tides in this area?				
Climate change	15 (10.42)	3 (33.33)		
Nutrients	14 (9.72)	4 (44.44)	<0.001	0.571
I don't know	115 (79.86)	2 (22.22)		
19. Have you been affected by red tides?				
Yes	38 (26.39)	3 (33.33)		
No	106 (73.61)	6 (66.67)	0.284	0.027

The subgroup analyses on authorities (risk and environment, and health) and gender (fishermen and restaurant owners, and authorities) demonstrate that responses are dependent on principal activity (p-value < 0.05), except for the analysis on whether men from the two groups (fishermen and restaurant owners, and authorities) felt they have been affected by red tides (p-value = 0.284). There was a relatively strong correlation for most questions (Cramer's V > 0.413).

category 'I don't know' (in regards to the possible causes of red tides), 'Primary school' in terms of educational level, and the category 'No' in relation to being affected by red tides.

Authorities are somewhat associated with the 'nutrient' category of possible causes that generate red tides, and the 'Post-secondary' (high school or beyond) category of education level. In the case of health officers and environment and risk authorities, both well-educated groups, they had better knowledge of the complex interactions of HABs with nutrients. This result suggests that authorities may be willing to include nutrient management as part of a HABs management program. However, given that health and environment-risk authorities do not self-identify as affected by red tides suggests that they may have little interest in taking action to develop and implement a HABs management program.

DISCUSSION

The KAP surveys applied in this study contribute to our understanding of HABs risk perception, providing local socio-ecological information that can be used to inform policy development of ocean and human health on the coast of Ecuador and other similar tropical coastal countries. The study site has historically experienced red tides, and coastal communities such as fishermen, restaurant owners, and coastal managers are more

TABLE 4 | Perceptions on climate and health for groups of fishermen and restaurant owners and coastal authorities.

Climate and health	Fishermen and restaurant owners *n* = 181, *n* (%)	Authorities *n* = 20, *n* (%)	*p*-Value	Cramer's V correlation
20. During the time that you've lived here, have you noticed changes in the climate?				
Yes	161 (88.95)	20 (100)		
No	18 (9.94)	0 (0)	0.003	0.221
I don't know	2 (1.10)	0 (0)		
21. What changes have you noticed in the climate?				
Change in rainfall	26 (14.36)	3 (15)		
Change in air temperature	23 (12.71)	5 (25)		
Change in both	106 (58.56)	12 (60)	<0.001	0.278
No response	26 (14.36)	0 (0)		
22. Shellfish consumption causes intoxication.				
Yes	158 (87.29)	16 (80)		
No	22 (12.15)	4 (20)	0.249	0.062
I don't know	1 (0.55)	0 (0)		
23. Do you think you have been intoxicated or poisoned from seafood with toxins?				
Yes	35 (19.34)	9 (45)		
No	125 (69.06)	6 (30)	<0.001	0.553
I don't know	25(11.60)	5 (25)		

Climate and health analysis indicates that principal activity does affect interviewee responses (p-value < 0.05), except regarding whether or not shellfish consumption causes intoxication (p-value = 0.249). Correlations were relatively weak to moderate (Cramer's V = 0.062–0.278), except when interviewees were asked if they had been poisoned from seafood with toxins (Cramer's V = 0.553).

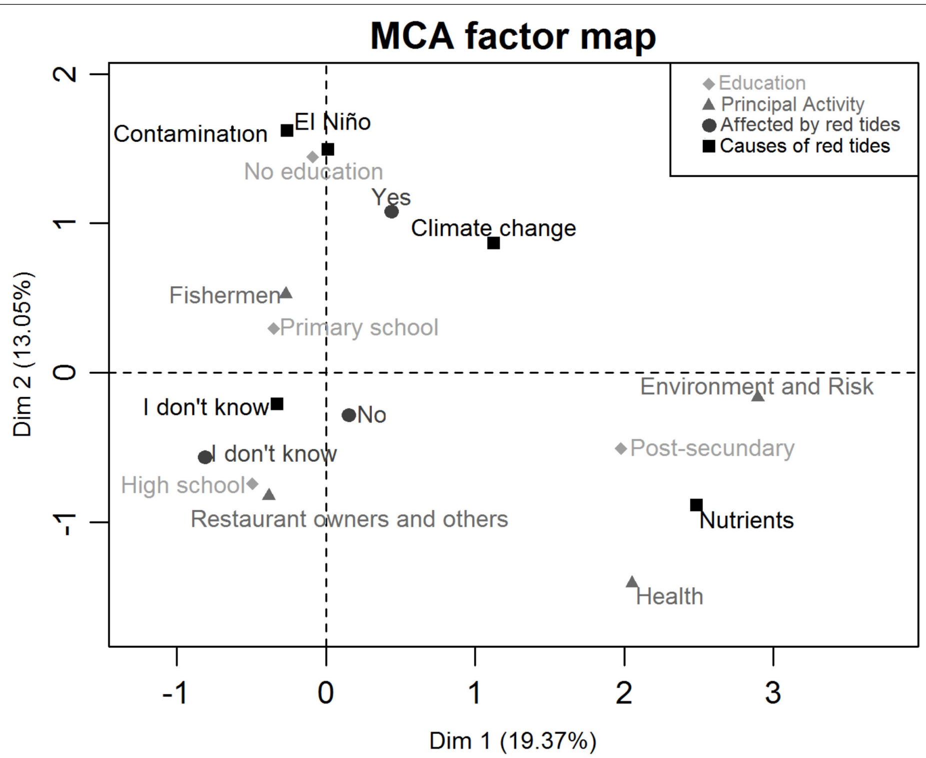

FIGURE 3 | Multiple correspondence analysis (MCA) using the 201 interviews considering four groups: fishermen, restaurant owners, health authorities, environment officers, and risk authorities, considering their activity and level of education in regards of two questions: What are the causes of red tides?" and "Have you been affected by the red tides?"

aware of their occurrences than their causes. Furthermore, there is a low risk perception of health-related consequences and, instead, greater concern with the aesthetic of the beaches and the impact on tourism. Interestingly, fishermen have developed adaptation strategies during the red tide events that reduce their HABs impact perception.

The coast of Ecuador has historically experienced red tides, and coastal communities such as fishermen, restaurant owners, and coastal managers are more aware of their occurrences than their causes. Furthermore, there is a low risk perception of health-related consequences and, instead, greater concern with the aesthetic of the beaches and the impact on tourism. Results from this study confirm that responses of individuals depend on their life experiences, livelihood or profession, and cultural values, thus coastal authority responses pertaining to HABs differed greatly from those of restaurant owners and fishermen. Additionally, responses from the authorities were tightly linked to members' previous experiences managing HABs and lessons learned regarding best practices (Taylor et al., 2014; Van Dolah et al., 2016). Furthermore, understanding the interaction between ecosystems and stakeholder activities is important in reducing the vulnerability of exposed populations to HABs, and monitoring coastal hazards and research of coastal ecosystems is an opportunity for stakeholder engagement.

Fishermen and Restaurant Owners: Experience and Livelihood

Risk perception is a social construction influenced by human factors, such as an individual's culture, gender, education level, socio-economic status, worldview, and previous experiences (Leiserowitz, 2006; Lin et al., 2011; Taylor et al., 2014; Van Dolah et al., 2016). In general, results demonstrate that risk perception of the respondents does indeed depend on the primary activity (livelihood or profession), education level, and life experience of each individual. MCA demonstrates that lack of education, lack of awareness of the origin of red tides, and low risk perception of these events coincide. However, this study identified that most of the fishermen who had lived 30 years or more along the coast were very aware of the existence of red tides, leading to the conclusion that greater observation and interaction with red tides promotes higher risk perception of the impact of HABs on livelihoods, but low risk perception of the impact of HABs on human health. Most knowledge in this group is derived by experiences from fishing efforts and observations of climate patterns and changes along the coastal zone. There is great uncertainty within coastal communities regarding the risk of eating shellfish during episodes of red tides; fishermen and restaurant owners do not consider it a risk (34%), and almost 40% of this group would not know what to do if there were a red tide.

Life experience is the main factor that influenced behavior and response to red tides in the fishermen and restaurant owners group in this study. Members of this group were influenced by their livelihoods, which were directly related to subsistence fishing and tourism. Most respondents are not willing to alter their practices during a HAB event for fear of loss of income. This group's low concern for the effects of red tides on human health was confirmed when 90% of this group felt they had not been affected by a HAB. During the workshop, respondents who felt that they had been affected by red tides mentioned several impacts: lack of fish, warmer ocean temperatures during the events, and the need to travel greater distances in search of a good catch. An aged fisherman expressed: "Red tides reduce fishing, and they come every time the weather is stronger, every 5 or 6 years." Another statement that is related to extreme events and climate change include: "The red tides appear from the currents of El Niño, and when they appear, the shellfish die," and "Climate change has affected marine currents because it brings very high temperatures and no fish."

About their practices, fishermen say: "When the red tides appear, I fish away from the coast to obtain my catch," or "Red tides are temporary and when they happen, many red crabs appear and I can catch them." About their practices, fisherman say: "When the red tides appear, I fish away from the coast to obtain my catch," or "Red tides are temporary and when they happens, many red crabs appear and I can catch them." Interestingly, one of the most important finding in this study is that fishermen have identified adaptation practices to respond to and reduce the impact of HABs on their livelihoods.

In relation to the health impacts, a fisherman said, "We have eaten fish during red tides and nothing has happened to us." This excerpt demonstrates that there was a misconception that both shellfish and fish are affected by red tides, thus potentially reducing risk perception among fishermen. On the other hand, several restaurant owners felt that HAB events had affected tourism: "Yes, we have been affected by red tides because customers are leaving." Or "Yes, algae affects us because the sea looks dirty, and tourists do not like it." Some respondents recommended that management options be established: "The Ministry of the Environment must create a measure to counteract the red tide; one of the possible causes of the red tide is the pollution of the rivers that flow into the sea." In relation to potential shellfish contaminated with toxins, restaurant owners said, "We eat all kinds of seafood at all times of the year, but seafood poisonings are produced by improper food storage and food in poor condition," suggesting that seafood-borne illnesses are dependent on seafood freshness and handling, but not related to HABs. The main concern of fishermen and restaurant owners is the protection of their livelihoods, and they expect local authorities to protect their activities from hazardous coastal events such as red tides and marine pollution.

Coastal Authorities: Awareness and Monitoring

Incorporating risk perception of coastal authorities into preventative measures and risk communication is critical during extreme events such as HABs. This study found that most of the authorities working in risk management and the environment believed that climate change and nutrients coming from wastewater from the cities and rivers were important drivers of red tides. Furthermore, there was a lower level of uncertainty regarding the causes of red tides within this subgroup compared to the health subgroup in relation to human health impacts. Members of the environment and risk subgroup are first responders and monitors of coastal hazards, and are key components to early warning systems of coastal hazards within the communities and health sector. Their experiences managing and responding to red tides, along with their previous education, contributed to their greater knowledge and higher risk perception to these events. When the authorities was asked about options for managing red tides, they responded that they would avoid going to the beach, as well as eating seafood or fish during red tide events, and that it would be necessary to develop a communication strategy for the general public during HAB events. Currently, there are no regulations on food safety of wild shellfish, nor are there any programs on communication of coastal risks such as HABs, in Ecuador.

Health sector authorities and staff were found to be less informed than their counterparts in the environmental and risk sectors about red tides and their links to diarrheic, amnesic, neurologic, and paralytic syndrome produced by HABs. No cases of any of the syndromes have been reported or identified in emergency rooms in Ecuador. Additionally, there was a common misconception within the health group that cooking the shellfish would eliminate toxins. Moreover, the public health subgroup did not consider themselves to have been affected by HABs events (88%) and most would not stop eating seafood or fish during red tide events (75%). A very low risk perception of HABs on human health is related to limited awareness and understanding of red tides causes, processes, and impacts on the coastal area. However, at one workshop, health stakeholders expressed their concern and interest in knowing more about unusual cases of shellfish poisoning, and some local physicians and clinical staff expressed: "There is not a specific protocol of interventions during red tides," and "It would be very difficult to identify some of the diseases brought by the red tides."

Research in Latin America and in other locations across the world indicates the need to generate better scientific evidence for the potential presence of algal bloom toxins. Therefore, it is important to expand the existing monitoring of phytoplankton along the coast of Ecuador, and to implement testing that allows scientists to assess the presence, frequency, and levels of toxins in wild shellfish through an integrated risk assessment of human and coastal ecosystem health (Fleming et al., 2002; Heisler et al., 2008; Berdalet et al., 2015; Van Dolah et al., 2016; Vila et al., 2016; Torres, 2017). For the first time in Ecuador, we detected the presence of toxins from domoic acid in samples of *Anadara tuberculosa* in Santa Elena and Puerto Bolivar area (unpublished data). These toxins can produce DSP and are produced by a community of dinoflagellates (Grattan et al., 2016). Further monitoring and toxins analysis in seafood is recommended as part of a coastal monitoring program.

In regards to practices implemented by stakeholders to address the dangers of red tide events, our results suggest that while education within both subgroups contributed to a greater understanding of the ecological processes of red tides, personal experience of red tides and their impacts produced greater motivation to enact preventative measures. Therefore, a tailored training for emergency room staff, health promoters, and coastal managers should be part of a future communication and awareness program of HABs in Ecuador.

In the analysis on gender's role in HAB risk perception, results show that most women and men, independent of their livelihoods, did not believe that they had been affected by red tides (over 70%). Furthermore, it appeared that education, more so than gender, was a relevant factor in affecting survey responses within the group of authorities, as 60% were women with post-secondary (high school or higher) levels of education. Educated respondents identified climate change and nutrients as drivers of red tides during the surveys.

A main limitation of this study was the exclusion of services sectors like tour operators, hotel owners, permanent and seasonal residents. Those stakeholders are also affected by HABs events; interventions and preventive actions need to be considered for these and other populations living on the coast. In addition, may be a bias toward public interviewees versus institutional agents; however, we consider the assessment of the perception of public agents as a key step toward HABs policy development and implementation. Future research on the perceptions of coastal communities could include a more diverse stakeholders.

CONCLUSION

This study documents stakeholder's perceptions regarding HABs in a broad socio-cultural context in the Gulf of Guayaquil area. Our findings revealed relevant social issues related to general public awareness, risk perception, health and governance matters. These findings will help to strengthen strategic planning, which will contribute to the enhancement of current measures of monitoring and limiting the potential negative impacts of HABs on the population. The KAP surveys analyses demonstrate that limited awareness on the health and economic implications of HABs on coastal communities prevent authorities from developing integrated strategies that establish protocols of action for each sector. Communities are more concerned with the aesthetic quality of the beach than health impacts, as the display of red tides can detrimentally impact their tourism and fishing activities. And fishermen who have identified adaptation strategies to respond to HABs, do not think they are a problem to their livelihoods.

In addition, this study highlights the need for an integrated socio-ecological approach to face coastal hazards, which include HABs, coastal pollution, and others extreme events. Recommended future actions include: (a) a stakeholder engagement processes to delineate measures of monitoring coastal ecosystems and developing communication strategies between sectors, (b) develop scientific evidence of the presence of toxins by monitoring phytoplankton as well other indicators of marine ecosystem health, and (c) a HABs education and outreach program for public health practitioners, coastal managers, and community groups that helps to raise awareness and reduce potential public health and economic impacts during red tide events. This study contributes to the understanding of perceptions, cultural values, and perceived risks of HABs by key stakeholders, which can help define strategies and policies to better manage HABs in the coastal zone of Ecuador.

AUTHOR CONTRIBUTIONS

MB-C was responsible for the study design, fieldwork implementation, research development, data analysis, and wrote the report. MP-C designed surveys, fieldwork implementation with communities, developed focus group, collated the data, and contributed to the study design. AC-M designed surveys and implemented the surveys with authorities, and data analysis. CK data analysis, literature review, and helped write the report. GMS design surveys, statistical analysis, and data interpretation. ME-C collated the data, literature review, and helped to write the report. RL field work implementation with health officers and authorities, developed focus group, and data analysis. OR-B statistical design and data interpretation. GT contributed to the study design, fieldwork implementation, developed focus groups, data interpretation, socialized results, and helped to write the report. All authors contributed to the study design, discussed the results, and reviewed and approved the final report.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2018.00365/full#supplementary-material

REFERENCES

Backer, L. C., and McGillicuddy, D. J. (2006). Harmful algal blooms: at the interface between coastal oceanography and human health. *Oceanography* 19, 94–106. doi: 10.5670/oceanog.2006.72

Bauer, M., Hoagland, P., Leschine, T. M., Blount, B. G., Pomeroy, C. M., Lampl, L. L., et al. (2010). The importance of human dimensions research in managing harmful algal blooms. *Front. Ecol. Environ.* 8, 75–83. doi: 10.1890/070181

Berdalet, E., Fleming, L. E., Gowen, R., Davidson, K., Hess, P., Backer, L. C., et al. (2015). Marine harmful algal blooms, human health and wellbeing: challenges and opportunities in the 21st century. *J. Mar. Biol. Assoc. U.K.* 2015, 61–91. doi: 10.1017/S0025315415001733

Boholm, A. (1998). Comparative studies of risk perception: a review of twenty years of research. *J. Risk Res.* 1, 135–163. doi: 10.1080/136698798377231

Brisson, G., Dubé, K., Doyon, S., and Lévesque, B. (2017). *Social Construction of Cyanobacteria Blooms in Quebec: A Matter of Perceptions and Risk Management*. Thousand Oaks, CA: SAGE Publications, doi: 10.1177/2158244017697361

Carnicer, O., García-Altares, M., Andree, K., Diogene, J., and Fernández-Tejedor, M. (2016). First evidence of *Ostreopsis* cf. ovata in the eastern tropical Pacific Ocean. Ecuadorian coast. *Bot. Mar.* 59, 267–274. doi: 10.1515/bot-2016-0022

Clément, A., Lincoqueo, M., Saldivia, M., Brito, C. G., Muñoz, F., Fernandez, C., et al. (2017). "Climatic anomalies and harmful flagellate blooms in Southern Chile," in *Marine and Fresh-Water Harmful Algae. Proceedings of the 17th International Conference on Harmful Algae*, eds L. A. O. Proença and G. M. Hallegraeff, Wellington.

Finkel, A. M. (2008). Perceiving others' perceptions of risk. *Ann. N. Y. Acad. Sci.* 1128, 121–137. doi: 10.1196/annals.1399.013

Fleming, L. E., Backer, L., and Rowan, A. (2002). "The epidemiology of human illnesses associated with harmful algal blooms," in *Handbook of Neurotoxicology*, ed. E. J. Massaro (Totowa, NJ: Humana Press)

Fleming, L. E., McDonough, N., Austen, M., Mee, L., Moore, M., Hess, P., et al. (2014). Oceans and human health: a rising tide of challenges and opportunities for Europe. *Mar. Environ. Res.* 99, 16–19. doi: 10.1016/j.marenvres.2014.05.010

García, C., Lagos, M., Truan, D., Lattes, K., Véjar, O., Chamorro, B., et al. (2005). Human intoxication with paralytic shellfish toxins: clinical parameters and toxin analysis in plasma and urine. *Biol. Res.* 38, 197–205. doi: 10.4067/S0716-97602005000200009

Glibert, P. M., Icarus, J., Artioli, Y., Beusen, A., Bouwman, L., Harle, J., et al. (2014). Vulnerability of coastal ecosystems to changes in harmful algal bloom distribution in response to climate change: projections based on model analysis. *Glob. Chang. Biol.* 20, 3845–3858. doi: 10.1111/gcb.12662

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

Guzman, L., Espinoza-Gonzalez, O., Pinilla, E., Martínez, R., Carbonell, P., Calderón, M. J., et al. (2017). "The *Alexandrium catenella* and PSP Outbreak in the Chilean Coast, the first in the Open Coast of the South East Pacific Ocean," in *Proceedings of The 7th International Conference on Harmful Algae*, (Florianopolis: ICHA Brazil).

Hallegraeff, G. M. (2010). Ocean climate change, phytoplankton community responses, and harmful algal blooms: a formidable predictive challenge. *J. Phycol.* 46, 220–235. doi: 10.1111/j.1529-8817.2010.00815.x

Heisler, J., Gilbert, P., Burkholder, J., Anderson, D., Cochlan, W., Dennison, W., et al. (2008). Eutrophication and harmful algal blooms: a scientific consensus. *Harmful Algae* 8, 3–13. doi: 10.1016/j.hal.2008.08.006

Hernández, F., and Zambrano, E. (2007). Inicio, duración y término de la estación lluviosa en cinco localidades de la costa ecuatoriana. *Acta Oceanogr. Pac.* 14, 7–11.

Hope, A. C. A. (1968). A simplified Monte Carlo significance test procedure. *J. R. Stat. Soc. Ser. B* 30, 582–598.

Husson, F., Le, S., and Pages, J. (2011). Exploratory multivariate analysis by example using R. *J. Stat. Softw.* 40, 1381–1385.

Independent National Electoral Commission [INEC] (2010a). *Fascículo Provincial Santa Elena*. Abuja: INEC.

Independent National Electoral Commission [INEC] (2010b). *Resultados Censo Poblacional Guayas*. Abuja: INEC.

Jamieson, S. (2004). Likert scales: how to (Ab)use them. *Med. Educ.* 38, 1217–1218. doi: 10.1111/j.1365-2929.2004.02012.x

Jiménez, R. (1989). "Red tide and shrimp activity in ecuador," in *Establishing a Sustainable Shrimp Mariculture Industry in Ecuador*, eds S. Olsen and L. Arriaga (Narragansett, RI: Coastal Resources Center, University of Rhode Island), 185–194.

Jiménez, R. (1993). "Ecological factors related to *Gyrodinium instriatum* "bloom" in the inner estuary of Gulf of Guayaquil," in *Toxic Phytoplankton "bloom"s in the Sea*, eds T. J. Smayda and Y. Shimizu (New York, NY: Elsevier).

Jiménez, R. (1996). "Annual cycle of *Prorocentrum* maximum red tides in the inner Estuary of the Gulf of Guayaquil Ecuador," in *Harmful and Toxic Algal "bloom"s*, eds T. Yasumoto, Y. Oshima, and Y. Fukuyo (Paris: UNESCO).

Kirkpatrick, B., Kohler, K., Byrne, M. M., and Studts, J. (2014). Florida red tide knowledge and risk perception: is there a need for tailored messaging? *Harmful Algae* 32, 27–32. doi: 10.1016/j.hal.2013.09.008

Kuhar, S. E., Nierenberg, K., Kirkpatrick, B., and Tobin, G. A. (2009). Public Perceptions of Florida red tide risks. *Risk Anal.* 29, 963–969. doi: 10.1111/j.1539-6924.2009.01228.x

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: the role of affect. *Imagery Values Clim. Chang.* 77, 45–72. doi: 10.1007/s10584-006-9059-9

Likert, R. (1932). A technique for the measurement of attitudes. *Arch. Psychol.* 140:55.

Lin, Y., Huang, L., Nie, S., Liu, Z., Yu, H., Yan, W., et al. (2011). Knowledge, Attitudes and Practices (KAP) related to the Pandemic (H1N1) 2009 among Chinese general population: a telephone survey. *BMC Infect. Dis.* 11:128. doi: 10.1186/1471-2334-11-128

McCabe, R. M., Hickey, B. M., Kudela, R. M., Lefebvre, K. A., Adams, N. G., Bill, B. D., et al. (2016). An unprecedented coastwide toxic algal bloom linked to anomalous ocean conditions. *Geophys. Res. Lett.* 43, 366–310. doi: 10.1002/2016GL070023

Moore, S. K., Trainer, V. L., Mantua, N. J., Parker, M. S., Laws, E. A., Backer, L. C., et al. (2008). Impacts of climate variability and future climate change on harmful algal blooms and human health. *Environ. Health* 7(Suppl. 2):S4. doi: 10.1186/1476-069X-7-S2-S4

National Oceanic and Atmospheric Administration [NOAA] (2016). *West Coast Harmful Algal Bloom: NOAA Responds to Unprecedented Bloom that Stretches from Central California to the Alaska Peninsula*. Available at: https://oceanservice.noaa.gov/news/sep15/westcoast-habs.html.

Navarro, D. J. (2014). *Learning Statistics with R: A Tutorial for Psychology Students and Other Beginners, Version 0.5*. Adelaide: University of Adelaide.

Nierenberg, K., Byrne, M., Fleming, L. E., Stephan, W., Reich, A., Backer, L. C., et al. (2010). Florida red tide perception: residents versus tourists. *Harmful Algae* 9, 600–606. doi: 10.1016/j.hal.2010.04.010

Rav-Marathe, K., Wan, T. H., and Marathe, S. (2016). A systematic review on the KAP-O Framework for diabetes education and research. *Med. Res. Arch.* 4, 1–22.

Ricaurte-Quijano, C. (2013). *Self Organisation in Tourism Planning: Complex Dynamics of Planning, Decision-making, and Tourism Governance in Santa Elena, Ecuador*. Ph.D. thesis, University of Brighton, Brighton.

Rose, J. B., Epstein, P. R., Lipp, E. K., Sherman, B. H., Bernard, S. M., and Patz, J. A. (2001). Climate variability and change in the United States: potential impacts on water- and foodborne diseases caused by microbiologic agents. *Environ. Health Perspect.* 109(Suppl. 2), 211–221.

Slovic, P. (1987). Perception of risk. *Science* 236, 280–285. doi: 10.1126/science.3563507

Slovic, P. (2000). *Risk, society, and policy series. The perception of risk*. London, England: Earthscan Publications.

Taylor, A. L., Dessai, S., and Bruine de Bruin, W. (2014). Public perception of climate risk and adaptation in the UK: a review of the literature. *Clim. Risk Manag.* 4, 1–16. doi: 10.1016/j.crm.2014.09.001

Torres, G. (2013). Eventos de mareas rojas: estrategias de manejo preventivas en Ecuador. *Rev. Univ. Guayaquil.* 2001, 1–14.

Torres, G. (2015). Evaluación de mareas rojas durante 1968-2009 en Ecuador. *Acta Oceanogr. Pac.* 20, 89–98.

Torres, G. (2017). *Evaluación del Fitoplancton como un mecanismo preventivo a la ocurrencia de floraciones algales frente a las costas de Esmeraldas, Manta, La Libertad y Puerto Bolívar en Ecuador 2013- 2015*. Ph.D. thesis, Universidad Nacional Mayor de San Marcos, Lima.

Torres, G., and Palacios, C. (2007). . "Bloom" de Noctiluca scintilans y Ceratium dens en el Golfo de Guayaquil (2004). Informe científico. *Acta Oceanogr. Pac.* 14, 125–130.

Van Dolah, E. R., Paolisso, M., Sellner, K., and Place, A. (2016). Employing a socio-ecological systems approach to engage harmful algal bloom stakeholders. *Aquat. Ecol.* 50, 577–594. doi: 10.1007/s10452-015-9562-z

Vila, M., Abós-Herràndiz, R., Isern-Fontanet, J., Àlvarez, J., and Berdalet, E. (2016). Establishing the link between *Ostreopsis* cf. ovata blooms and human health impacts using ecology and epidemiology. *Sci. Mar.* 80(Suppl. 1), 107–115.

Wan, T. T. (2014). A transdisciplinary approach to health policy research and evaluation. *Int. J. Public Pol.* 10, 161–177. doi: 10.1504/IJPP.2014.063094

World Health Organization [WHO] (2008). *Advocacy, Communication and Social Mobilization for TB control: A Guide to Developing Knowledge, Attitude and Practice Surveys*. Geneva: World Health Organization.

WoRMS Editorial Board (2018). *World Register of Marine Species*. Available from http://www.marinespecies.org at VLIZ [accessed September 04, 2018]

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