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EXPLORING MANAGEMENT AND MONITORING OF HARMFUL ALGAL BLOOM EVENTS IN MALAYSIA: GOVERNMENT SECTOR

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Abstract:
Aquaculture industry is identified as one of the major sources to increase fish production to meet domestic demand and expand export potential. In Malaysia, it has a production of about 407,403 tonnes with a value of approximately RM 2,784,721 in 2016 that contributed 21 percent to the total fish production. It highly come with the risk of uncertainty that it can give an unexpected loss if there is problem arise. One of the uncertainties is harmful algal bloom. Harmful algal bloom involving fish kills has been reported since 2002 in Malaysia. A total estimated loss of almost RM 700k was reported by the Department of Fisheries Johor in 2014 in which involved eight fish cages. Given that HABs is still in the exploratory stage in the context of Malaysia, an in-depth interview with the key persons involved in HAB outbreaks was conducted to explore the handling process of HAB in preventing the fish kills in Malaysia. This paper aims to explore the monitoring program of HAB outbreaks in Malaysia in the government sector in perceive to help managing and mitigating the events of harmful algal bloom in Malaysia's aquaculture industry. This study aims to help giving an insight on the management of algal outbreak in Malaysia

Keywords: Harmful algal bloom, Management, In-depth interview

1. Introduction

Aquaculture industry is identified as one of the major sources to increase fish production to meet domestic demand and expand exportation potential (Jabatan Perikanan, 2017). The aquaculture industry resulted in a production of about 407,403 tonnes with a value of approximately RM 2,784,721 (Razali, 2016). This had contributed 21 percent to the total fish production. As such, aquaculture development has shown rapid growth with an average annual growth rate of 8 percent per annum over the last 10 years. This is supported by a statement from the Ministry of Agriculture and Agro-based Industry through that the government will be targeting production of aquaculture for 1.4 million tonnes by 2020 (Utusan Online, 2017).

However, aquaculture fisheries industry in Malaysia has been threatened by the massive fish kills in the past 40 years. Harmful Algae Bloom (HAB) involving fish kills has been reported since 2002 in Johor but it came to light in 2014 when the fish kills reported in Tanjung Kupang resulting in the total loss of the aquaculture fish (Razali, 2016). Astro Awani (2014) reported that in 2014, one caged fish farmer lost more than RM150, 000 in three days due to

the mass die-offs among the fish which was more than 90 percent in total. A total estimated loss of almost RM 700k was reported by the DOF Johor in 2014 which involved eight fish cages have become victims of this incident.

Algal bloom is a natural phenomenon including the toxic events which is called as Harmful Algal Bloom (HAB). HAB, commonly called red tides, is now grouped under the descriptor harmful algal blooms or HABs (Anderson et al, 2002). HABs have one unique feature in common that causes harm which is either due to their production of toxins or to the way the cells' physical structures or accumulated biomass affect co-occurring organisms and alter food web dynamics. Mass mortalities of wild and farmed fish and shellfish; human illness and death from toxic seafood or from toxin exposure through inhalation or water contact; illness and death of marine mammals, seabirds, and other animals; and alteration of marine habitats and trophic structure are the impacts of these phenomena (Usup et al, 2002; Lim et al, 2012; Lim et al, 2014).

In Malaysia, the HAB incident is now being monitored by the Fisheries Research Institutes (FRI) and Sabah Fisheries Department in selected areas which have been identified to a frequent HAB outbreaks. The first HAB event encountered in Malaysia was in 1970 in Sabah, in which almost 396 people were affected. The first fish kills were reported in 2002 in Kota Kinabalu, Sabah (Usup et al, 2002). Lim et al (2012) stressed that the unavailability of trained manpower and expertise in phytoplankton ecology, lack of trained personnel in species identification and enumeration can lead to misidentification of harmful species which eventually hinder the monitoring program. This situation has brought into attention among the FRI and Sabah Fisheries Department on how they can manage the HAB outbreak. Sampling interval and frequency of monitoring exercises conducted are not enough to monitor the HABs occurrence because most of the bloom occurred within a short period of time (Lim et al, 2014).

Therefore, the objective of this paper is to explore the monitoring and mitigation program of HAB outbreaks in Malaysia by the government sector. This paper presents the result of the monitoring HAB events in Malaysia that focuses on the government sector which is responsible for the fisherman and aquaculture industry of commercial fisheries in Malaysia.

2. Literature Review

Harmful phytoplankton events are regarded as a serious constraint to the sustainable development of coastal areas (Zingone and Enevoldsen, 2000). Therefore, the occurrence of fish kills has been related to harmful algal as such in 2014, Tanjung Kupang is one of the locations where fish kills caused by HAB (Razali, 2016). The species reported are *Karlodinium australe* which cause the caged fish died (Lim et al, 2014).

Besides that, one of the most noxious red tide microalgae that causes mass mortalities of both cultured and natural fish and invertebrates is *Cochlodinium polykrikoides margalef* (Imai and Kimura, 2008; Richlen et al, 2010). In 2013, it was the last HAB event in Kuala Gula, Perak that involved *Cochlodinium polykrikoides margalef*. However, in 2016, a new species namely *Noctiluca scintillans* also harmed the fish in the same area. Table I summarizes the events involving the microalgae that cause fish kills in Malaysia (Jabatan Perikanan, 2017).

The subsequent fish-kill events were recorded in the Straits of Malacca in which the location is regarded as the the most important finfish-farming area in the country (Lim et al, 2014). In

fact, the HAB events are very significant to fish breeders as they sell fish for a living. For example, some of the fish breeder in Tanjung Kupang are forced to incur significant losses for almost hundreds of thousands Ringgit Malaysia due to HAB occurrences.

Table 1: Events Involving Harmful Algal Bloom in Malaysia Related to Fish Kills

Year	Microalgae	Location	Impacts	References
2002	Procentrum minimum	Johor Bahru, Johor	Red-tide	[6]
2004	Cochlodinium polykrikoides	Kota Kinabalu, Sabah	Red-tide and fish kill	[12]
2005-2006	Cochlodinium polykrikoides	Pulau Pinang	Fish kills (estimated 6 million USD)	[7]
2007	Ceratium furca	Sungai Dinding, Pangkor, Lumut,Perak, dan Pulau Pinang	Red-tide	[1]
2008		Pangkor, Perak		
2009		Sungai Dinding, Perak		
2013	Cochlodinium polykrikoides	Kuala Gula, Perak	Fish kills	[1]
2014	Karlodinium australe (ichthyotoxic)	Tanjung Kupang Johor	Fish kills (estimated lost RM 150k each person: 10 person involved)	[8]
2015				
2016	Noctiluca scintillans	Kuala Gula, Perak	Fish kills (estimated lost RM 500k each person: 4 person involved)	[1]

3. Methodology

A qualitative approach was used in this study given that HABs is still at the exploratory stage in the context of Malaysia. Hence, in-depth interviews with the key persons involved in these HAB outbreaks were conducted to explore the handling process of HAB in preventing and managing the fish kills in Malaysia. The qualitative approach is flexible and allows for the exploration of the situation on handling the HAB incidents in more detail. A total of 6 key persons from Department of Fisheries were invited for the interview session. Prior the commencement of the interview, places where HAB cases were identified were purposely chosen. Johor was selected first as the recent HAB outbreaks reoccurred in 2015. For the starting of this study, Snowball sampling was used to determine the places in which the other places were subsequently chosen based on the information given during the interview session. Sarawak was given a different approach by giving open-ended questionnaires to respective issues related to the HAB monitoring program in Malaysia. Figure 1 shows the flow chart on how the interviews were selected for the potential interview candidates.

Figure 1: Flow Chart on selecting the interview for HAB monitoring program in Malaysia

The interviews were recorded and transcribed. The codes in the coding framework should have limitations in terms of definitions to make sure it is not switchable or redundant and they should also be narrow in scope and focus explicitly on the object of analysis (Attride-Stirling, 2001). This is to avoid coding every single sentence in the original text. The transcripts were coded based on the emerging keywords that are similar in all the six interviews. Then, these six interviews were compared to identify any similarities or/and differences. The results and discussion will be elaborated in the following section.

4. Discussion and Conclusion

The interviews revealed that there were five strategies that have been taken by the participants or its agencies in the aspects of the HAB management and monitoring. These strategies are considered as the terms for the management of HAB outbreak in Malaysia. The strategies are quality control of water, prevention, and awareness program, standard of procedure, sampling and machinery tools.

Table 2 shows how the management of the HAB outbreaks in Malaysia is summarized. Kelantan and Sabah scored the highest with 4 points in which Sabah has the quality control of water/sampling, prevention, awareness program, and machinery tools. As like Sabah, Kelantan also has quality control of water/sampling, prevention, awareness program, and the standard of procedure but not machinery tools. PH, SW and JB have the lowest point in which each is represented by machinery tools, awareness program and standard of procedure.

Table 2: Management and Mitigation of Harmful Algal Bloom in Malaysia based on Interview

No.	Department of Fisheries Involved	Quality control of water/ Sampling	Prevention	Awareness program	Standard of procedure	Machinery tools	TOTAL
1.	Gelang Patah	1				1	2
2.	Johor Bahru				1		1
3.	Sarawak			1			1
4.	Sabah	1	1	1		1	4
5.	Batu Maung	1		1	1		3
6.	Pahang					1	1
7.	Kelantan	1	1	1	1		4
	TOTAL	4	2	4	3	3	

Quality control of water means that the level of pH, temperature, salinity and DO was taken into measure for the monitoring of HAB outbreaks. While sampling water means that the water is taken for the identification of the harmful algal. In accordance to that, FRI Sabah mentioned that:

*"…*in order for the agency to check the quality control of water, we *always monitor in terms of water samples" (Interviewee FRI Sabah)*

And Sabah also mentioned about the procedure of water sampling:

> *"Take one-meter depth and 3-meters depth of sea water sample. We take on the two levels because if at the depth of 3 meters there are many more algal, meaning the event of algal bloom will last because of the algal from the bottom will rise. So, the*

period will be longer. If you look at the level of one-meter there is algal but at level 3-meters there is no algal, then possibility of the red tide will not be long." (Interviewee FRI Sabah)

This is also discussed by the Kelantan where sampling of water was taken monthly at the specific place of HAB outbreaks. In the event of a HAB, sampling of water is increased 2 times and Gelang Patah also mentioned that they frequently do the water quality monitoring which is conducted at the beginning of the year from January to March 2 times a week. As for the subsequent months, monitoring is performed once a month or based on the case. Besides that, Batu Maung also mentioned that:

"If the breeders say there are red clumps, there is a possibility of red tide. So we will take a sample of water and a fish sample to determine whether it involves fish disease by sending the samples to a nearby biosecurity center. If the HAB occurs in the northern part, the water sample to identify the HAB will be sent to FRI Batu Maung, with a toxicity test." (Interviewee FRI Batu Maung)

This highlights the facts that quality control of water or sampling is very important in the process of monitoring the HAB outbreaks. The sampling is likely to be done monthly so that if there are any changes or anomaly, the DOF will be able to give early warning to the fish breeders. This will help fish breeders from the loss by informing them about the situation earlier. Hence, this helps to identify suitable preventive measures and awareness programs, in which this strategy will be discussed in the next section.

As for prevention, it is more significant in Sabah and Kelantan as there have been many cases involving the public. Hence, both Sabah and Kelantan have tried various methods to prevent people from getting affected by the HAB effects. Kelantan has the initiative to put a signboard in various places and flyers to make sure that people are alert with the HAB outbreakk. Whilst, Sabah mentioned in the interview that:

"If it comes to a dangerous level, information is given to the village head and breeders, and they will take action in the event of a HAB. We did it in stages. If the algal is localized, we will inform the head of the village only because we do not want the public to panic. People do not want to eat fish when they know it. After that, if the neighbouring area had already worsened in the outbreak, we will make a radio announcement..." (Interviewee FRI Sabah)

Kelantan has also taken initiative whereby a group fisherman around that area also actively help in the prevention of the HAB spread to the public. It is called as SUPER which is an acronym for Sukarelawan Perikanan. Their role is to spread information about any related events to the people residing in Kelantan specifically.

Thus, it appears that prevention measurement was involved only in places where most harmful algal bloom and harm the human health only. Other places like Johor Bahru are more inclined to handle the situation through the program that can help the fish breeders to be on standby as HAB outbreaks are unpredictable. Therefore, the next section will discuss on the findings of the awareness program that has been mentioned by the DOF.

As for the awareness program, Batu Maung has the most information as mentioned in the interview that they would conduct an awareness program for their fisheries assistants in each

area involved so that they can spread the outbreak awareness to the fisherman and aquaculture breeders. This is evidenced by the quote below:

> *"Briefings are given to these fisheries assistants. Usually the fisheries assistant is close to the farmer because any business will refer to the FA such as a license or anything related. So, in the meantime this fisheries assistant can be for knowledge to breeders." (Interviewee FRI Batu Maung)*

Although there are diverse ways of prevention, clearly it is for the same purpose which is to help the public to be more aware of the HAB outbreaks and to be more alert during the occasion. The awareness program for the fisheries assistants is a good way to expose the fisherman and fish breeders to the situation and at the same time to be cautious for the upcoming HAB outbreaks.

From the interviews conducted with all the department of fisheries, three participants mentioned about the Standard of Operation (SOP) in dealing with the HAB outbreak. All of them agreed that they are using the same procedure which is the general procedure of dealing with any HAB events. In addition, Johor Bahru also mentioned that the SOP used is based on the natural occurrence occurring. In this respect, Batu Maung also mentioned about the SOP as below:

"If there is a case, the fishery department will go down the field. There is a SOP if it involves more than 4 or how many areas I do not remember, the new Department of Environment will come down.
If the case involves a single state only it involves the fishery department only and there is a SOP ..." (Interviewee FRI Batu Maung)
Whereas for the sampling method, Kelantan took not only the sample of water but also the shellfish in that area (refer appendix A for the type of sample by Kelantan). Sabah has also practised the same approach in which they took sample of shellfish from the market through the Department of Health.

Machinery Tools
Finally, machinery tools are another key finding in this study in analysing the samples. Machinery tools is defined as the work lab that are used to identify the harmful algal. The use of machinery tools was only mentioned by Pahang in which all the samples in the East Coast will be delivered to their lab for the identification of the HAB presence. It was later supported by the Kelantan in which they sent all the samples to the main lab ran by the unit called biosecurity on a monthly basis. According to Gelang Patah, Biosecurity Division which is under Johor Bahru also conducts periodic monitoring of livestock area around the Straits of Johor. Monitoring is conducted in terms of monitoring of HABs species and water quality parameters. The Gelang Patah only helps in terms of water quality monitoring.
Therefore, the lab work was not done in all the departments, rather it was centralized. As mentioned by Batu Maung, all the samples from the north region were done by Batu Maung whereas the samples from the East Coast area were done by Pahang. Sabah also has their own lab as they have their Red Tide unit in the department that only focuses on the HAB occurrence.

This paper focused on the exploration of management and mitigation of HAB outbreak and how the handling of HAB was done from the viewpoints of the government sector. The interviews were selected based on the HAB outbreaks that happen in that specific areas which

involve Johor (FRI Gelang Patah and DOF Johor), Sabah, Kuantan, Kelantan, and Sarawak. These places were identified through the articles that have been published in local newspaper. The comparison was done to identify any differences or similarities in terms of the management and budget in which the cost estimated for the water sampling and monitoring of HAB done every month.

Similarly, all departments have the same monitoring process, in which they do the sampling every month, but they will most likely increase the number of sampling during the HAB outbreaks. The increase in the number of sampling is changed from monthly to fortnightly. Furthermore, the general SOP is used, thus all departments are using the similar SOP for the HAB outbreaks. The cost estimated in the monitoring program should be revised to emphasize the need for better equipment and monitoring to help reduce the lost in the aquaculture industry in Malaysia. Plus, this cost estimated that has been revised can help with the budget for awareness and management of HAB outbreak throughout Malaysia.

In contrast, the prevention measures for publics are different according to each department. Particularly, the medium used to spread the information and awareness about the HAB is different for both SB and KN. SB is more discreet as they do not want the public to be in a panic mode whereas KN is more open where they publicly put a signboard to notify the publics about the HAB outbreaks. Other methods like flyers and radio depends on each department. Furthermore, the machinery tools such as lab work were done in a centralized manner, rather than individually.

Although the management and monitoring of HAB outbreaks are still new in Peninsular Malaysia compare to Sabah, there are experts who have been helping in terms of exploring the new species of HAB. Furthermore, due to HAB characteristics itself that is unpredicted, future research is needed in other areas such as the perception of business owners and fisherman about the issues of managing, controlling and monitoring the HAB outbreaks in Malaysia.

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