

'MyRedTides' a fast and easy tool for sharing harmful algal bloom information in Sabah, Malaysia

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Abstract

The coastal waters of the Malaysian state of Sabah are frequently affected by harmful algal blooms (HABs) mainly caused by *Pyrodinium bahamense* var. *compressum* and *Margalefidinium polykrikoides*, that have negative impacts on the aquaculture industry and human health. The project aims to develop a Public Information Map using ArcGIS to increase the effectiveness of sharing and communication of HAB information among relevant stakeholders and the community. The Department of Fisheries Sabah (DOFS) also participated in the project and knowledge transfer was done through a two-day on-line training. The output of the project are WebApps called MyRedTides. Altogether, two WebApps were developed: 1) cell density of *P. bahamense* and *M. polykrikoides* and 2) paralytic shellfish poisoning (PSP), i.e., toxin concentration of various coastal locations in Sabah. The developed WebApps contain useful information to the users such as the species responsible, recent, and previous HAB cases, as well as providing a platform for the sharing and exchange of information. Nevertheless, the use of this online WebApps as an early warning system is still at the preliminary stage because the acceptance and reaction of the stakeholders and local communities need to be evaluated. This is important to ensure that the HAB information is handled in the most effective manner.

Keywords: Early warning system, red tide, ArcGIS, knowledge transfer, MyRedTides

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Introduction

Harmful algal blooms (HABs) have been reported in Sabah coastal waters since 1976. Initially, the first HAB species identified to cause the problem was a toxic *Pyrodinium bahamense* var. *compressum* that causes paralytic shellfish poisoning (PSP) (Roy, 1977, Adam *et al.*, 2011; Mohammad-Noor *et al.*, 2018). Since then, many reports of human illnesses including death have been reported. In 2005, another HAB species that is a fish killer was also identified in the area, namely *Margalefidinium polykrikoides* (Anton *et al.*, 2008; Adam *et al.*, 2011; Mohammad-Noor *et al.*, 2014). The algal blooms have caused mass mortality of caged fish, with losses estimated in the millions of Malaysian Ringgits. Till today, both species continue to have devastating impacts in the Sabah coastal waters. Furthermore, with the rapid development of Kota Kinabalu, the capital of Sabah which is located near to the coastal area and climate change, there is positive sign that more HAB problem will occur in the future.

To decrease the impacts of these HAB species to human health and the aquaculture industry, the Department of Fisheries Sabah (DOFS) has carried out monitoring since 1976 (Jipanin *et al.*, 2019). The monitoring covers 13 districts in Sabah with a total of 69 sampling stations. Samples collected at each district are sent to the Sabah Biosecurity Fisheries Division for analysis of cell density and toxin concentration. If PSP is detected, it will take 3 days before the result in Microsoft Word format can be released to the district officers, village heads, village community Chairmen and District Health offices (Jipanin *et al.*, 2019). Therefore, it is imperative to improve the HAB data management and presentation

to emphasize important results while making it easy and interesting to understand and disseminate.

The Public Information Map, which is based on the WebApps responsive web design (RWD) and developed with ArcGIS, is a current technique for the dissemination and sharing of information. Online information, such as HAB data, can be made available to the public in website form, RWD and sharing-based social media links. Therefore, this platform can be used to increase the effectiveness of sharing and communication of HAB information to relevant stakeholders and the public. By adopting this approach, this project aims to develop WebApps to share HAB results i.e., cell density and PSP concentration (STX) in scale format, collected from Sabah coastal waters with the stakeholders (Department of Fisheries and Ministry of Health), fishermen and local community. Through this sharing platform, hopefully, the impact of HAB can be minimized and provide valuable information for those who are directly or indirectly involved with HAB.

Material and Methods

Public information map

The WebApps application is a recent technology developed by ArcGIS (Esri, California, U.S.A.) that can be used to disseminate and share information via an online public information system. It can be used to retrieve survey locations, update HABs information and provide a warning system. The online information can be made available to the public in various forms and platforms.



The numerical forecasting results can also be viewed and explored in the WebApps. By selecting a variable and a date in the widgets, the spatial distribution of the variable will be visualized in the map viewer. The system provides a web-based environment to monitor and forecast HABs by leveraging layers of external data and information from various fields. The system allows end users to view the *in situ* observations, remote sensing maps and numerical model forecasts in a geospatial context (Olson, 2019). By leveraging WebApps technologies, the web portal of the system provides a single map-based interface, in which data of different types (point time series, vector, and raster) can be visualized and analyzed through interactive tools (Yong and Mutao, 2019).

Knowledge transfer to Sabah Fisheries staff

A workshop was carried out in July 2021 to train the DOFS staff on the development of the WebApps for HABs in Sabah's coastal waters. The two-day workshop was done virtually with the participation of 15 DOFS personnel. During the workshop, the participants were given a step-by-step guidance on how to develop the WebApps. During the first day, the participants were introduced to the ArcGIS Online WebApps which includes the registration of an online ArcGIS account and explanations about the licensing, development of the database and group authorizations of data. In the second day, participants were requested to use their HAB data to develop their own WebApps. This is to ensure that the participants have a full understanding on how to create and handle the WebApps.

Development of Web App for HAB, Sabah

The cell densities of *P. bahamense* var

compressum and *M. polykrikoides*, and toxin concentrations collected from 13 Sabah districts were used to build the WebApps separately. The data, together with the latitude and longitude were arranged in a text file and imported into the ArcGIS. The monthly data was presented in a range, and each was added as a layer to the WebApps database. Information about the HAB species, actions that should be taken if a HAB is spotted or the occurrence of PSP symptoms were added in detail. Other important information added were the phone number and email address of the person to be contacted to lodge a complaint or to make a suggestion. A link was produced for each WebApps and can be shared through many platforms, including WhatsApp, Instagram and Facebook.

Data collection for WebApps development

Samples were collected once per month or twice per month from 13 Sabah districts. At each sampling station, the sample was collected using a Van Dorn water sampler at 1 m depth. Samples were brought to the laboratory of the Sabah Biosecurity Fisheries Division for enumeration. For toxin concentration, shellfish were collected from breeders, purchased from wet markets and shellfish collectors. Samples were kept at < 9°C and transported to the laboratory to analyze for saxitoxin using ELISA.

Results and Discussion

Based on the training conducted, WebApps were successfully developed for cell densities of *P. bahamense* var. *compressum* and *M. polykrikoides* (Fig. 1), and for PSP i.e., toxin concentration (Fig. 2) by DOFS staff. The developed WebApps are known as MyRedTides. This name was chosen due to



two reasons: 1) the term ‘Red Tides’ has been used colloquially since the first bloom was recorded, 2) the local community in Sabah is familiar with it and understand clearly the meaning of Red Tides. The developed WebApps are very informative because they contain basic and important information on HABs, especially for local communities. For example, users can access information on the HAB cell density or level of PSP for a specific month, understand the occurrence pattern which will give an indication on the potential occurrence of HABs. This will allow them to take the necessary actions to safeguard human health and the aquaculture industry. This can be done by avoiding the risky areas or to develop adaptive strategies (Guillotreau *et al.*, 2021). This is because the shellfish closure or ban on collecting shellfish can cause huge economic losses to aquaculture farmers and fish mongers. In addition, the ban can cause loss of confidence among the public thus led to drop in fish price and sale. Although, the DOFS has already started to educate the public on HABs (Jipanin *et al.*, 2019), this application can further enhance their work by being a more efficient way to disseminate information. Through this user-friendly application, the community can share their experiences or report HAB occurrences to the DOFS through platform provided within the WebApps.

The developed WebApps are useful to the DOFS because the collected HAB data can be shared faster in a more meaningful and interesting way. Furthermore, the DOFS can control the data input, data sharing and data to be shown. This will ensure the security of the HAB data is at its optimum level, as this data is confidential to a certain extent. Nevertheless, the usage of WebApps is at the preliminary

stage because the acceptance and the reaction of stakeholders and local communities have yet to be evaluated. Access to the WebApps is currently restricted to the DOFS staff and selected stakeholders. Through this practice, the WebApps can be further improved to produce a better application.

Overall, the developed WebApps are useful, though they need further fine tuning to suit the local situations and needs. The applications provide a better way to present data, whereby HAB information can be displayed on a map, frequently updated and shared online, as well as to be employed as an early warning system.

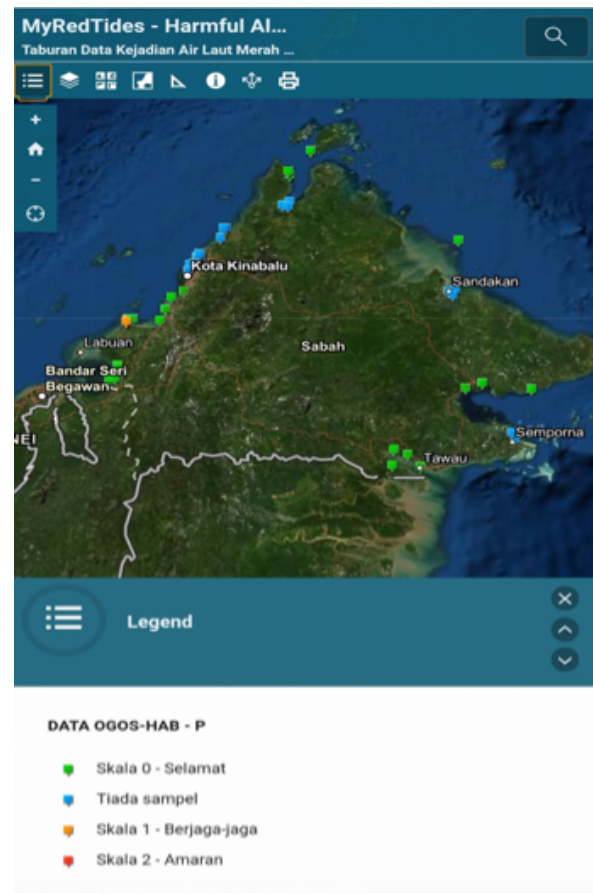


Fig. 1. WebApp for cell densities of *P. bahamense* var. *compressum* and *M. polykrikoides*. Legend showing the level of HAB alert based on colors: green – safe, blue – no sample, orange – attention, red – warning.





Fig. 2. WebApp for toxin concentration of PSP. Layers showing month selected (tick) for toxin concentration. The user can select a specific month to see the toxin concentration.

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