Chapter in Book

MEDUSA-LINK MAPS: Advanced Geodatabase for Addressing the Challenges of Harmful Jellyfish Encounters and Supporting Sustainable Coastal Management

Aimie Rifhan Hashim[1,*], Sharir Aizat Kamaruddin[2], Mohd Syuib Umar[3], and Che Ismail Che-Zulkifli[4]

1 Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Perlis, Kampus Arau, 02600, Arau, Perlis, Malaysia; 2021403326@student.uitm.edu.my; ORCID ID (https://orcid.org/0000-0003-3765-1803)
2 Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Perlis, Kampus Arau, 02600, Arau, Perlis, Malaysia; shariraizat@uitm.edu.my; ORCID ID (https://orcid.org/0000-0001-7323-2556)
3 Centre of Studies for Surveying Science & Geomatics, Fac. of Architecture, Planning & Surveying, Universiti Teknologi MARA, Cawangan Perlis, Arau, Malaysia.; 2021217328@student.uitm.edu.my
4 Crustacean Aquaculture Research Division, Fisheries Research Institute (FRI) Pulau Sayak, 08500, Kota Kuala Muda, Kedah; ORCID ID (https://orcid.org/0000-0001-5109-8421)
* Correspondence: shariraizat@uitm.edu.my; +604 988 2157.

Abstract: *Jellyfish blooms are becoming increasingly common worldwide, causing disruptions, injuries, and fatalities in coastal regions that depend on fishing industries, seaside activities, and tourism. However, no effective methods or tools have been used to predict their occurrence based on environmental cues or to manage biological risks in the coastal area. The MEDUSA-LINK maps address this critical need by integrating spatial and temporal information on jellyfish distribution with water physicochemical parameters using Geographic Information System (GIS) technologies. The maps aim to benefit the general public, local marine communities, authorities, policy-makers, and tourists, aligning with the United Nations' Sustainable Development Goals, particularly SDG 14 (Life below water), SDG 3 (Good health and well-being), and SDG 13 (Climate action and Industrial Revolution 4.0). By harnessing Big Data (IR 4.0) to fulfill predictive demands and maintenance, MEDUSA-LINK maps offer an innovative and effective solution to mitigate the impact of jellyfish blooms and promote sustainable coastal management practices.*

Keywords: Jellyfish Blooming; Water Quality Monitoring; Sustainable Coastal Activities.

1. INTRODUCTION

The phenomenon of jellyfish blooming has become increasingly widespread in recent years, with coastal areas that rely on fishing, tourism, and other seaside activities being particularly vulnerable to its effects. The overlap between human activities and jellyfish populations has resulted in significant socio-economic impacts, including commotion, casualties, and fatalities. This phenomenon has been linked to several factors, including eutrophication, overfishing, habitat modification for aquaculture, and climate change (Hashim et al., 2022; Purcell et al., 2012; Purcell et al., 2007; Richardson et al., 2009). Furthermore, human activities such as excessive seafood harvesting, removal of jellyfish predators, and poor aquaculture practices have unintentionally contributed to jellyfish blooming (Hashim et al., 2022; Purcell et al., 2012). Researchers, environmentalists, and authorities are now actively exploring various monitoring approaches to address this issue and prevent it from escalating further. Therefore, several jellyfish monitoring strategies are presented to address these problems before they escalate.

Numerous approaches have been implemented to tackle jellyfish blooming worldwide effectively. Kennerley et al. (2021) reported that a jellyfish monitoring program had been developed in the United Kingdom and Ireland, which involves mapping the habitat suitability for jellyfish in the North Atlantic. Additionally, the Southeastern Pacific researched the stranding of jellyfish species seen on the shore throughout seasonal variations (Fierro et al., 2021). Unmanned Aerial Vehicles (UAVs) were utilized in northern Queensland to monitor the distribution of box jellyfish, a species responsible for over 60 fatalities in the area over the years (Rowley et al., 2020). Despite the strategies mentioned above, little research has been done to determine the species composition, abundance, and interactions of jellyfish with the marine environment. Additionally, the Southeastern Pacific researched the stranding of jellyfish species seen on the shore throughout seasonal variations. (Suriyan et al., 2019). Therefore, water quality mapping is proposed as a medium to solve the jellyfish blooming problem in Malaysia.

In Malaysia, the current status of water quality mapping is inadequate. A robust water quality mapping approach is necessary to comprehensively understand the origin of contamination, whether it arises from natural or human activities. Employing geographical and temporal analysis for each water parameter can enhance the accuracy and depth of the latest water quality mapping, leading to a more comprehensive understanding (Hashim et al., 2022; Kamaruddin et al., 2021; Kamaruddin et al., 2022; Kamaruddin et al., 2022). However, water quality mapping related to jellyfish species has never been reported so far using any applications to the best of the author's knowledge. This emphasizes the uniqueness of the suggested innovation approach. Implementing the jellyfish distribution mapping and water quality analysis through MEDUSA-LINK maps addresses the issue of jellyfish blooming and its impact on coastal activities, fisheries, and tourism. This innovative approach is consistent with the United Nations' Sustainable Development Goals, including SDG 14: "Life below water," SDG 3: Good health and well-being, and SDG 13: Climate action. Harnessing Big Data (IR 4.0) to fulfill predictive demands and maintenance offers an efficient and sustainable solution for managing jellyfish blooms and maintaining a healthy marine ecosystem. It is crucial to recognize the significance of this innovative approach, as it aligns with the goals set forth by the United Nations to ensure a sustainable future for all.

2. METHOD & MATERIAL

The MEDUSA-LINK map results from thorough revising and improving the current water quality map. It incorporates the most recent data on jellyfish distribution, physicochemical and water nutrient parameters, species dominance, and species diversity index, all integrated through geospatial technology. The visually appealing digital maps are created using Geographic Information System (GIS) software. The MEDUSA-LINK software provides preventative measures based on environmental cues, effectively reducing the risk of jellyfish encounters in busy coastal areas. Spatial statistics tools, such as pattern analysis, surface modeling, and statistical modeling, were utilized for various studies. MEDUSA-LINK also offers a comprehensive database of jellyfish native to Malaysian Seas with detailed information on each species, based on the Field Guide to the Jellyfish of Western Pacific. (Centre for Marine and Coastal Studies, 2012).

3. FINDINGS

MEDUSA-LINK's significant finding results from a comprehensive collection of water quality data that includes a spatiotemporal variation of jellyfish distribution, physicochemical and water nutrient parameters, species dominance, and the species diversity index, all mediated by geospatial technology. The software's accessibility on paper and digitally has the potential to revolutionize how coastal areas manage jellyfish blooms, reducing the economic and social costs of jellyfish attacks. The capability of MEDUSA-LINK to predict and manage jellyfish encounters proactively promotes safety and sustainability in marine activities, thus reducing the risk of casualties and fatalities in the coastal region. MEDUSA-LINK offers a promising solution for coastal communities worldwide by preventing accidents and unintentional jellyfish encounters. Overall, the complete collection of data on water quality and jellyfish distribution, combined with MEDUSA-LINK's innovative approach to managing jellyfish blooms, significantly benefits coastal communities.

3.1 Product Objectives

With the use of geospatial software, the spatiotemporal distribution of jellyfish, and the physicochemical characteristics of water, MEDUSA-LINK has been designed to address the problem statement. MEDUSA-ultimate LINK's goals are:

a) To provide predictive information about jellyfish blooms based on environmental cues and water quality parameters

b) To utilize digitized maps to manage biological hazards in coastal tourism and promote safety for local marine communities.

3.2 Product Idea

MEDUSA-LINK maps are an innovative solution to the growing problem of jellyfish blooms in coastal regions. Using cutting-edge Geographic Information System (GIS) technology, MEDUSA-LINK maps integrate the spatiotemporal changes in jellyfish distribution with water quality parameters to provide comprehensive and up-to-date information on jellyfish distribution. With the recent jellyfish blooming incidents causing concern among local communities, MEDUSA-LINK maps can help provide timely and relevant information to the public and authorities, enabling them to take appropriate measures to manage and mitigate the impact of these blooms.

MEDUSA-LINK maps are particularly relevant for coastal communities that rely on tourism, as jellyfish encounters can lead to safety hazards and deter visitors. By providing accurate and reliable information on jellyfish distribution, MEDUSA-LINK maps can help coastal tourism managers make informed decisions on beach closures and issue timely warnings to visitors. The product is also helpful for local governments, socio-economic stakeholders, and local maritime communities, who can use the information provided by MEDUSA-LINK maps to manage the impact of jellyfish blooms on fisheries, aquaculture, and other marine industries. MEDUSA-LINK maps are available in both print and digital formats, making them accessible and affordable to a wide range of stakeholders. They are the only water quality maps for jellyfish species produced by a research and environmental organization in Malaysia. Overall, MEDUSA-LINK maps are essential for managing and mitigating the impact of jellyfish blooms in coastal regions.

3.3 Product Diagram

Figure 1. MEDUSA-LINK Maps Logo and Front Page

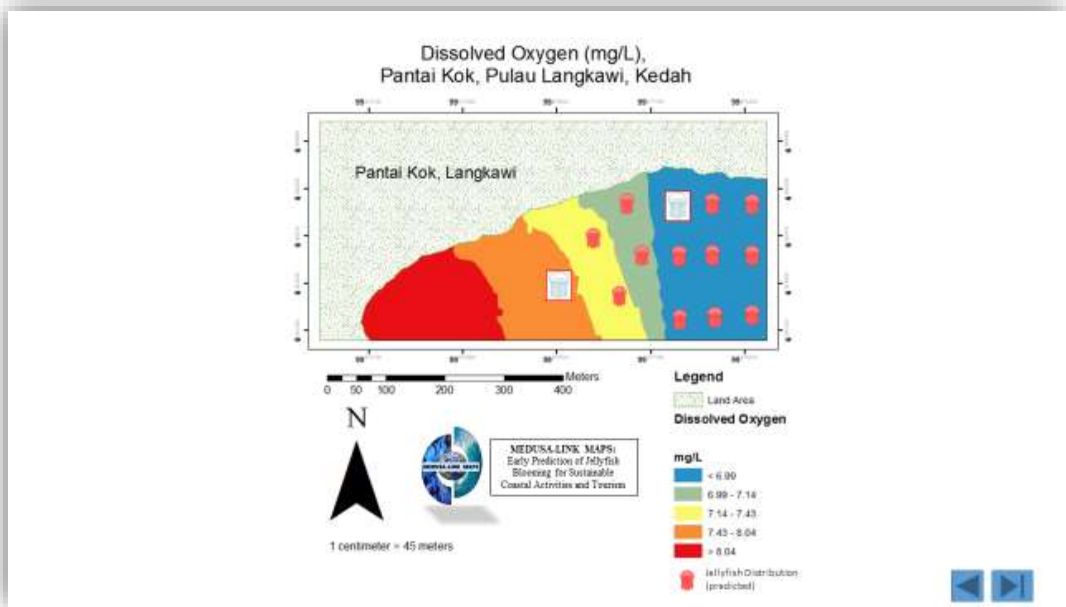

Figure 2. MEDUSA-LINK Maps For Dissolved Oxygen (mg/L) and Jellyfish Distribution of Pantai Kok, Pulau Langkawi, Kedah

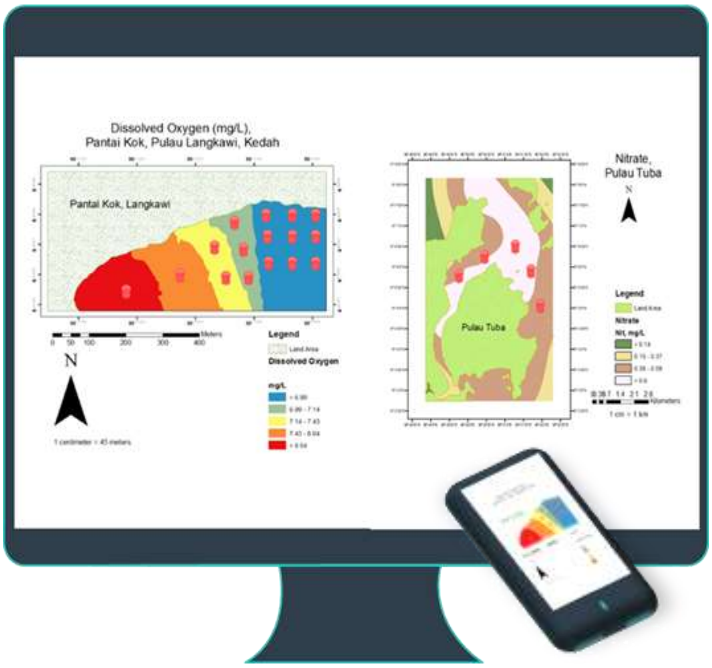

Figure 3. MEDUSA-LINK Maps Interface in Electronic Devices

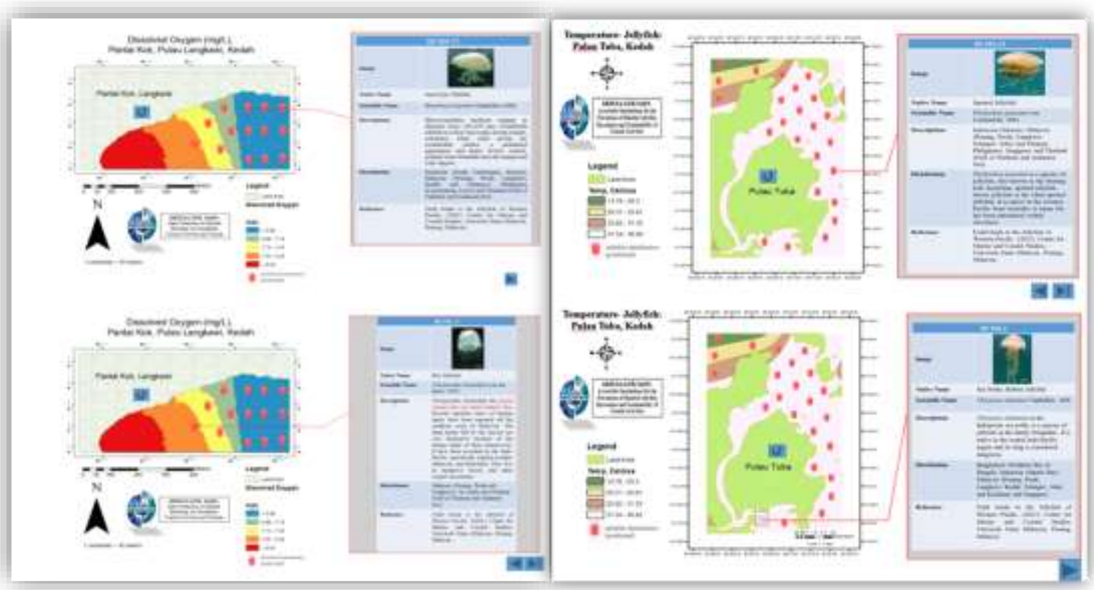

Figure 4. Pop-Up Screen (After Clicking Button) Provide Information About Jellyfish Residing in the Area

4. DISCUSSION

Jellyfish blooms are a significant concern for coastal-dependent communities worldwide. Implementing MEDUSA-LINK maps in Malaysia is a potential solution to mitigate the impact of jellyfish blooms on the sustainability of fisheries, coastal activities, and tourism. MEDUSA-LINK maps provide comprehensive and up-to-date information on jellyfish distribution, utilizing advanced GIS technology and integrating spatiotemporal changes in jellyfish distribution with water quality parameters. This approach enables early prediction of jellyfish blooms, reducing the risk of jellyfish encounters and their impact on coastal-dependent activities.

One of the most critical issues with jellyfish blooms is the negative impact on fisheries. Through predation and competition, jellyfish blooms can reduce fish larvae (Condon et al., 2013). A rise in jellyfish populations can directly affect fish larvae through predation and indirectly affect fish larvae by feeding on zooplankton and ichthyoplankton, potentially acting as both predators and competitors of fish (Purcell et al., 2007). For instance, the social-ecological model was developed to account for the consequences of variations in *Pelagia noctiluca* abundance on local fisheries. The outcomes of the various scenarios demonstrate that *P. noctiluca* impacted Catalonia's small pelagic fisheries (Tomlinson et al., 2018). The reduction in fish catches can significantly lower the socio-economic incomes of coastal-dependent areas, making jellyfish blooms a significant concern for coastal fisheries. Therefore, early prediction using MEDUSA-LINK maps can help mitigate the impact of jellyfish blooms on fisheries and ensure the sustainability of coastal-dependent communities.

In addition to the impact on fisheries, jellyfish blooms disrupt coastal activities and tourism. Coastal activities and tourism depend entirely on each other, and an unwanted encounter with harmful jellyfish can present commotion, casualties, and even fatalities (Centre for Marine and Coastal Studies, 2019). For example, a sixth-grader stung by a jellyfish while swimming in Teluk Bahang fell into a three-day coma. After experiencing agony for over a week, the patient was hospitalized, grabbing the public's attention (Centre for Marine and Coastal Studies, 2019; The Star, 2017). In Pulau Langkawi, Kedah, the peak time for jellyfish stings was between 12:00 and 6:59 pm, coinciding with the bulk of seawater activity. Activities including swimming, entering, and standing in the water were linked to a higher risk of stings (Mohd Suan et al., 2016; Mubarak et al., 2021). The cases of jellyfish envenomation call for action and monitoring of jellyfish blooms to ensure the safety of coastal activities and tourism.

Even though jellyfish monitoring has been carried out globally, Malaysia in particular has not developed or implemented suitable or effective techniques to stop jellyfish blooming from causing another terrible disaster. The MEDUSA-LINK map is a brilliant solution to the jellyfish blooming issue because it uses a Geographic Information System (GIS) to combine data on jellyfish spatiotemporal variation with environmental cues, like water quality parameters, to present ideal digital maps for early jellyfish blooming prediction. Therefore, only MEDUSA-LINK maps can provide early blooming forecasts, preventing casualties, reducing chaos, and saving lives.

In conclusion, the implementation of MEDUSA-LINK maps in Malaysia can have a significant positive impact on coastal-dependent communities by mitigating the adverse effects of jellyfish blooms. The early prediction of jellyfish blooms using MEDUSA-LINK maps can help protect fisheries, coastal activities, and tourism and ensure the sustainability of coastal-dependent communities. It is crucial to acknowledge the importance of these innovative solutions in addressing environmental issues and take action to implement them. By working together and utilizing technology, we can create a better future for coastal communities and protect our oceans' ecosystems. With the application of MEDUSA-LINK maps, we can look towards a brighter future where jellyfish blooms no longer threaten the sustainability of coastal-dependent activities.

5. CONCLUSION

MEDUSA-LINK maps are consistent with the Sustainable Development Goals established by the United Nations, SDG 14: "Life below water," SDG 3: Good health and well-being, and SDG 13: Climate action and Industrial Revolution 4.0, Big Data in fulfilling predictive demands and maintenance.

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